VALUE OF THORACIC CT IN THE MANAGEMENT OF SEVERE HEMOPTYSIS

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INTRODUCTION

Severe hemoptysis is a life-threatening situation for which emergent management is necessary. Respiratory distress occurs from blood filling the alveoli. The short-term evolution is unpredictable and repeat bleeding may occur (1). Pre-treatment diagnostic work-up, often in unstable patients, must be optimized and allow prompt symptomatic treatment. Bronchial fiberoptic endoscopy (BFE) along with chest radiographs is the first line evaluation technique to confirm the presence of bleeding and localize the process to the bronchial system. The value of CT for diagnosis of the etiology of hemoptysis, irrespective of the degree of clinical severity, has been assessed (2). However, the value of CT for localization of bleeding and detection of underlying etiology has not been extensively evaluated, and often was limited to the evaluation of severe hemoptysis from systemic origin (3).

The purpose of this study was to assess the value of thoracic CT before bronchial fiberoptic examination for the management of severe hemoptysis.
MATERIALS AND METHODS

Population
Between January 1997 and January 2001, 62 patients (20 females, 42 males) aged 11 to 72 years (mean of 57 years) were admitted to our institution for management of severe hemoptysis (>300 cc/24 hours).

Patient monitoring
Patients were always evaluated while monitored to ensure airway patency and hemodynamic stability. All patients had a secured peripheral IV access as well as continuous EKG and peripheral O2 saturation monitoring. Oxygen was administered for patients with decreased O2 saturation. Airway suction was performed as needed to maintain airway patency.

Work-up protocol
The first examination performed for all patients was a frontal chest radiograph, either in the sitting or supine position. The work-up protocol was applied only to patients that had not already undergone CT or BFE at another center. Patients first underwent BFE followed by chest CT.

Bronchial fiberoptic endoscopy
An experienced senior staff member using a flexible bronchoscope and local anesthesia performed BFE on an emergency basis. Adrenaline was available for local application in patients with active bleeding.

Computed-Tomography of the chest
All CT examinations were performed using a GE Prospeed CT unit (Milwaukee, USA). Contra-indications included known renal failure and history of laryngospasm or laryngeal edema from previous intravenous iodinated contrast administration. A spiral CT angiography examination was acquired through the entire chest using a slice thickness of 3mm and couch motion of 5mm with images reconstructed at 3mm intervals. Breath hold acquisitions were preferred. A total of 90cc of Iomerol Breath hold acquisitions were preferred. 3mm and couch motion of 5mm with administration. A spiral CT angiography of the chest CT.

RESULTS

Clinical data and frontal chest radiograph
Nine patients presented with life threatening massive hemoptysis of bright red blood (>500cc/24 hours) with diffuse alveolar opacification; 6 patients had unilateral lung white-out and 3 had bilateral lung white-out. Clinical data collected included: previous history of lung TB (n=3), sequelae from childhood lung infection (n=4), and history of cardiomyopathy with systemic hypertension (n=2). These patients immediately underwent bronchial angiography with embolization.

For the remaining 53 patients, clinical data at the time of evaluation included: previous history of TB (n=8), history of bronchiectasis (n=18), bronchogenic carcinoma (n=10), invasive aspergillosis (n=1), Wegener’s granulomatosis (n=1), previous thoracic aortic surgery (n=1), Osler-Rendu-Weber disease (n=2), and 12 patients without identifiable previous cardiopulmonary disease at the time of admission. Fifty-five patients presented with bright red blood hemoptysis while 7 patients had black blood hemoptysis at clinical examination.

Bronchial fiberoptic endoscopy
Complete BFE was possible in 38 of 53 patients. The examination was terminated at the patient’s request of could not be completed because of uncooperative patients in 15 cases. Endobronchial blood was identified in 38 cases. Lobar localization of bleeding was possible in 15 cases and was not possible because of diffuse blood in 9 cases and absence of bleeding at the time of BFE in 6 cases. An infiltrating endobronchial tumor was identified in 12 cases.

Computed-Tomography of the chest
CT was possible in all 53 patients without immediate life threatening condition. CT angiography could not be acquired in two patients with history of laryngeal edema from previous intravenous iodinated contrast administration and one patient with recent diagnosis of renal failure who was not on dialysis. Motion artifacts were present at lung window settings in 18 patients but images could still be evaluated. Mediastinal window images could be analyzed in all cases.

Chest CT showed no abnormality in 4 cases. In 49 cases, hemoptysis was identified by the presence of ground glass opacities in one lung (n=40) or both lungs (n=9). Focal parenchymal consolidations were present in 19 cases. A focal increase in density of the ground glass opacities was identified in 28 cases, consistent with the site of bleeding (as per protocol specifications). Underlying pathologies identified included: bronchiectases (n=22) (fig. 1), sequelae from TB (n=8), mediastinal/hilar masses (n=12) (fig. 2), pulmonary arteriovenous fistula (n=2), multifocal nodular opacities with air crescent sign in immunosuppressed patients suggesting invasive aspergillosis infection (n=2), bilateral lower lung zone masses with cavitation consistent with Wegener’s granulomatosis (n=1) (fig. 3) and one case of suspected aortobronchial fistula in a patient with thoracic aortic prosthesis with a mediastinal collection of fluid and gas. A patient with black blood hemoptysis underwent repeat CT at 24 hours that showed a subcentimeter arteriovenous fistula that was retrospectively detectable on the initial CT within an area of parenchymal consolidation (fig. 4).
In 4 cases, CT showed no etiology for the hemoptysis. In 8 cases, CT showed an etiology that was unsuspected after clinical and plain radiographic examination.

**PATIENT MANAGEMENT**

Forty patients underwent bronchial angiography with selective embolization of the vascular territory suspected of supplying the site of bleeding: 22 cases of bronchiectasis, 8 cases of sequelae from TB, 1 case of aspergillus, 1 case of Wegener’s granulomatosis, and 8 tumors. In one case of tumor, selective embolization could not be performed because the catheter could not be secured into the bronchial artery. Two patients with bright red blood hemoptysis and negative BFE and CT underwent bronchial angiography. Bronchial angiography was negative in both cases and embolization was not performed. Five patients underwent pulmonary angiography with embolization: 1 tumor, 3 AVF, and 1 false aneurysm. One of these patients had invasive aspergillosis that was refractory to medical therapy instituted 1 month previously. Comparison with the CT obtained one month

**Correlation between BFE and CT findings (Table I)**

A significant difference between BFE and CT existed only for bleeding localization (p<0.005) and the percentage of detected underlying etiology (p<0.0001). The identified site of bleeding was similar for BFE and CT for all 15 patients where localization was possible at both CT and BFE (k=1). Two patients had an endobronchial tumor seen at BFE that were undiagnosed at CT.

**Table I:**

CT findings and bronchial fiberoptic findings in the 53 patients included in the protocol for evaluation of severe hemoptysis.

<table>
<thead>
<tr>
<th></th>
<th>BFE</th>
<th>CT</th>
<th>P (chi-square or Fisher’s exact test)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of exams</td>
<td>38</td>
<td>53</td>
<td></td>
</tr>
<tr>
<td>Presence of bleeding</td>
<td>38 (100%)</td>
<td>49 (92%)</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Localization of bleeding</td>
<td>15 (39%)</td>
<td>38 (72%)</td>
<td>&lt;0.005</td>
</tr>
<tr>
<td>Etiology detected</td>
<td>12 (32%)</td>
<td>49 (92%)</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

**Fig. 1:** Thoracic CT shows bronchiectasis and ground glass opacities with an area of increased density in the middle lobe. Because bronchiolo-alveolar lavage was not performed prior to CT, the bleeding is localized in the middle lobe.

**Fig. 1 :** La TDM thoracique montre des opacités en verre dépoli avec accentuation focalisée dans le lobe moyen chez un patient présentant des bronchiectasies. En l’absence de lavage bronchiolo-alvéolaire lobaire moyen préalable, le saignement est localisé au lobe moyen.

**Fig. 2:** Thoracic CT performed in a patient with bronchogenic carcinoma presenting with severe hemoptysis. The CT image, using mediastinal window settings, shows the tumor involving the left main pulmonary artery (a). Pulmonary angiography performed before embolization demonstrates the stenotic and irregular lumen of the left pulmonary artery (b). After embolization with coils, the artery distal to the coils is no longer enhanced (c).

**Fig. 2 :** TDM thoracique réalisée chez un patient porteur d’un carcinome bronchique et présentant une hémoptysie sévère. La coupe en fenêtre médiastinale objective l’envahissement tumoral de l’artère pulmonaire gauche (a). L’angiographie pulmonaire réalisée avant embolisation montre la réduction et l’irrégularité de la lumière artérielle pulmonaire gauche (b) et après mise en place de coils métalliques au sein de l’artère érodée l’absence d’opacification de l’artère (c).
DISCUSSION

Severe hemoptysis requires emergent diagnosis and treatment: the mainstay of treatment is to preserve airway patency and prevent drowning of the alveoli with blood leading to asphyxia and death (1). This clinical challenge mandates optimal patient work-up to ensure prompt optimal symptomatic patient management. Pre-treatment work-up may thus be limited to clinical and plain radiographic evaluation if required by the status of the patient. This was the case for 9 of our patients with massive hemoptysis who immediately underwent bronchial angiography with embolization. For patients in no immediate life-threatening condition, additional work-up must be organized based on examination time and efficacy (4).

Ideally, clinical evaluation and knowledge of the patient’s prior cardiopulmonary history should allow some degree of orientation with bright red blood hemoptysis suggesting a systemic source and black blood hemoptysis suggesting a pulmonary arterial origin. However, such data may not be available in an emergency situation. Some diseases may cause bronchial or pulmonary arterial bleeding including tumors (5), tuberculosis (6), and invasive aspergillosis (7) that may cause arterial wall erosion with false aneurysm formation as seen in one of our patients (8). The detection at pulmonary CTA of a possible pulmonary arterial origin for the bleeding may have an impact on the type of angiography performed and the immediate management of the patient. Chest CT may sometimes be the only technique allowing detection of pulmonary AVF when evaluation of the lung parenchyma on plain radiographs is complicated by hemoptysis or when the lesion is small. Chest CT enables pre-treatment evaluation of the angioarchitecture of the lesion (9). In our study, the distribution of underlying etiologies for the hemoptysis was typical (1, 4), but CT modified patient management in 8 cases. Precise localization of the site of systemic or pulmonary arterial bleeding is essential since it has an impact on the selection of the site for therapeutic embolization. The subselective nature of the embolization site is important since complications may occur with bronchial (cord ischemia) (10, 11) and pulmonary (12) embolization. Pre-treatment work-up also is important because it allows global management of the symptom and underlying cause. This is especially relevant for patients with underlying malignancy where invasive treatment may be withheld, as in two of our patients. In patients with aortobronchial fistula (13) or invasive aspergillosis refractory to medical treatment (7, 14), surgery is usually performed, with or without presurgical embolization. A multidisciplinary approach for diagnosis and treatment is necessary for optimal management.
BFE often is performed on an emergency basis, but the contribution of this technique to diagnosis and management is limited. BFE allows in situ treatment with vasoconstrictors, selective intubation or balloon occlusion of the draining bronchus. These techniques temporarily improve local control of the bleeding (15). The first limitation of BFE is the fact that it is not well accepted and tolerated by patients. The second limitation is related to the poor results of BFE to localize the site of bleeding when performed after the hemorrhage has stopped or when active severe bleeding is present causing multifocal bronchial opacification precluding identification of the site of bleeding. The last limitation is related to the exclusive proximal endobronchial evaluation. Data from the literature are concordant since BFE was contributory in less than 11% of patients with hemoptysis in the study by Hsiao (3). The superior value of CT compared to BFE in patients with hemoptysis, irrespective of the severity, has already been demonstrated (2, 16), even in patients with malignancy (16, 17). These authors suggest that BFE should only be performed after CT when CT is non-contributory. The main advantage of CT is that it provides evaluation of the tissues surrounding the proximal and distal bronchi (18).

The main advantage of BFE is for the detection of endobronchial tumors. Some tumors, including carcinoid tumors, may be responsible for hemoptysis (19). CT is limited for the detection...
of endobronchial tumors, especially in patients with hemoptysis where blood clots may simulate endobronchial tumors (20). As such, we believe that BFE is necessary when CT fails to show the underlying cause for hemoptysis. Cryptogenic hemoptysis is an exclusion diagnosis made in patients with negative CT and BFE. This diagnosis was made in 6% of our patients, and 7.1% of patients in the series from Hsiao (3). The accuracy of CT for localizing the site of bleeding is seldom reported in the literature. Our results show excellent correlation with the results from BFE. Based on our experience, CT is more frequently feasible than BFE in this patient population. Alveolar filling of variable density is a known cause of ground-glass opacities and consolidation at CT (21). In patients with hemoptysis, these opacities are assumed to correspond to hemorrhage and are useful for localizing the site of bleeding. CT is superior to standard radiographs for low density or retrocardiac lesions. Therefore, CT is recommended in patients with hemoptysis even if plain chest radiographs are normal (22). Interpretation of the CT findings must take into consideration possible redistribution of hemorrhage to dependent portions of the lung, especially when performed at some distance from the bleeding episode. It is for this reason that the predominance of opacities in the dependent portions of the lungs at CT was not considered of value for localization of the bleeding site. The presence of ground-glass opacities and parenchymal consolidation is not specific but quite suggestive in a clinical setting of hemoptysis. Diffuse pulmonary hemorrhage syndrome is difficult to differentiate from alveolar filling from hemorrhage at CT but rarely results in severe hemoptysis (23). The clinical context and detection of hemosiderin laden macrophages (siderophages) are helpful for delayed diagnosis of this condition. The value of CTA for detection of bronchial arteries, especially with anomalous origin, has been reported (24, 25). These arteries are more conspicuous when enlarged, which often is the case in patients with chronic bronchial inflammatory diseases such as bronchiectases or sequelae from TB, and thus are more easily detectable. CT angiography is mandatory for the diagnosis of vascular erosions, aorto-bronchial fistula, false aneurysm of the pulmonary artery, bronchial artery aneurysms that are sometimes partly thrombosed (26, 27) and thus contribute to the pre-embolization treatment planning.

In conclusion, when allowed by the clinical status of the patient, chest CT angiography is our first choice for pre-treatment complementary work-up of patients with severe hemoptysis for localizing the site of bleeding and diagnosing the underlying etiologies. Bronchial fiberoptic endoscopy is mandatory in patients with negative CT to exclude endobronchial tumor.

Références
12. Rémy-Jardin M, Watthine L, Rémy J. Transcatheter occlusion of pulmonary artery, bronchial artery aneurysms and anomalous origin, has been reported (24, 25). These arteries are more conspicuous when enlarged, which often is the case in patients with chronic bronchial inflammatory diseases such as bronchiectases or sequelae from TB, and thus are more easily detectable. CT angiography is mandatory for the diagnosis of vascular erosions, aorto-bronchial fistula, false aneurysm of the pulmonary artery, bronchial artery aneurysms that are sometimes partly thrombosed (26, 27) and thus contribute to the pre-embolization treatment planning.

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