A 45-Year-Old Man With a Lung Mass and History of Charcoal Aspiration

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A 45-year-old man was seen in consultation for evaluation of a spiculated right-lower-lobe mass that enlarged over 1 year. The patient had suffered accidental instillation of activated charcoal into the right lung via nasogastric tube 2 years prior to this consultation, with resultant respiratory failure, pneumonia, and pneumothorax. Biopsy of the mass showed anthracosis and granulomatous inflammation. A positron emission tomogram was strongly positive at the lesion, and right-lower-lobectomy with partial diaphragmatic resection was performed. On gross examination of the mass, a charcoal concretion was evident. Histologic examination showed intrinsic and surrounding granulomatous inflammation, but without tumor. The patient recovered uneventfully, and after 1 year had not experienced further complications. *Key words: lung mass, charcoal, aspiration, anthracosis.*
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Introduction

Accidental or purposeful ingestion of toxins occurs annually in several million Americans, with about 1,000 deaths reported.[1] Oral or nasogastric administration of activated charcoal is a preferred treatment for adsorbable toxins, especially if administered within one hour of toxin ingestion.[2] In the United States in 2003, 134,619 patients were treated with single doses of charcoal, and 5,793 with multiple doses.[1] The treatment is generally safe, efficacious, and well tolerated, with rare complications, including aspiration of the charcoal, bowel obstruction, and electrolyte abnormalities.[3]

We present a case of both acute and chronic lung disease caused by accidental instillation of activated charcoal into the airways. While the acute complications of charcoal aspiration are well known, the chronic complications are poorly described. Large-volume charcoal instillation as the cause of a metabolically active lung mass has not been reported, and clinicians should be aware of this unusual complication of a routine treatment for toxic ingestion.

Case Report

A 45-year-old man with history of alcoholism, tobacco abuse, and charcoal aspiration was admitted with upper gastrointestinal bleeding, and was found to have a 7 cm right-lower-lobe mass. The patient had been admitted to a different hospital 2 years prior, at which time he was thought to have barbiturate overdose. A nasogastric tube was erroneously placed into the airway, and activated charcoal was administered into the right lung. He rapidly developed respiratory failure and was transferred to another hospital, where bronchoscopy was performed. During the procedure, a large quantity of black material was suctioned from the distal right-lower-lobe airways. He was treated for pneumonia, pneumothorax, and persistent bronchopleural fistula. A series of 3 chest tubes were placed, draining a sterile, charcoal-containing pleural fluid. After 6 weeks of hospitalization he recovered and was discharged. As an out-patient he continued to use large quantities of alcohol and smoked 2 packs of cigarettes daily.

One year prior to the admission discussed below, he was admitted to our medical center with pleuritic right-sided chest pain, fever, chills, sweating, greenish sputum production, and a 14-pound weight loss over 2–3 months. Antibiotics were administered, and chest computed tomography revealed a 5-cm spiculated mass in the right lower

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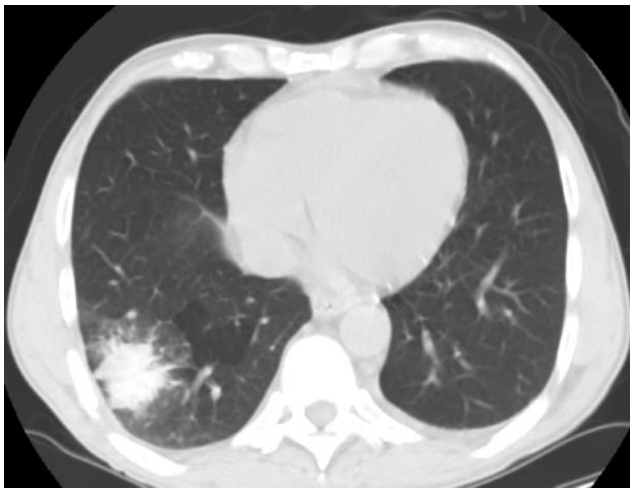

Fig. 1. Chest computed tomogram showing a spiculated right-lower-lobe mass, contiguous with the diaphragm, which on this image measures 3.1 cm × 3.6 cm.

Fig. 2. This positron emission tomogram is strongly positive at the right-lower-lobe mass, with a measured standardized uptake value of 13, and no distant disease.

Fig. 3. Right-lower-lobe gross specimen. There is a 7 cm × 7 cm × 4.5 cm, hard, darkly pigmented mass with satellite lesions.

lobe. Transbronchial biopsies showed moderate anthracosis and no tumor. Bacterial culture found *Klebsiella pneumoniae*, but cultures for acid-fast bacillus and fungi were negative. He had clinical improvement with treatment for pneumonia, and was lost to follow-up after transfer to an in-patient alcohol detoxification center.

The patient was admitted again 2 years after his initial charcoal aspiration, with hematemesis. Upper gastrointestinal endoscopy showed diffuse hemorrhagic gastritis, presumed secondary to ethanol abuse. The spiculated right-lower-lobe mass had increased to 7 cm (Fig. 1). Repeat bronchoscopy with transbronchial biopsies revealed only anthracotic material, and transthoracic needle biopsy was performed. The radiologist remarked on the hardness of the mass. Core biopsy again showed anthracotic material, with surrounding granulomatous inflammation.

The patient's spirometry was normal: forced expiratory volume in the first second was 91% of predicted. A chest positron emission tomogram (PET) was strongly positive at the right lower lobe (Fig. 2). The "standardized uptake value" was 13, and the study showed no distant disease. After extensive discussion, right-lower-lobectomy was performed. In surgery, dense, fibrous adhesions between the lung and chest wall were lysed, and a portion of the diaphragm that adhered to the mass was resected. Gross section showed a 7 cm × 7 cm × 4.5 cm hard black mass with small satellite nodules (Fig. 3). Histologic evaluation revealed infiltration of carbonaceous material, with surrounding granulomatous inflammation (Figs. 4 and 5). Regional lymph nodes also contained carbonaceous material. There was no evidence of malignancy. The patient tolerated surgery well and was discharged, without subsequent respiratory limitations. Ten months after lung resection he continued to struggle with alcoholism and tobacco addiction but had no radiographic evidence of tumor or chronic lung disease.

Discussion

This patient suffered severe complications from accidental instillation of charcoal into the lung. The case highlights the importance of verifying proper nasogastric tube placement, which can be performed via pH testing, visual inspection of aspirates, radiographic evaluation, or capnography.[4] A limiting toxicity of activated charcoal is the potential for aspiration, especially in somnolent or obtunded patients, with an overall incidence of about 0.6%,[3] although subclinical aspiration may be much more common.[5]

Acutely, our patient suffered respiratory failure, in agreement with published case reports that describe acute pneumonitis, acute respiratory distress syndrome, pneumothorax, bronchiolitis obliterans, asphyxiation, and death as some sequelae of charcoal aspiration.[6–9] In this case, pneu-

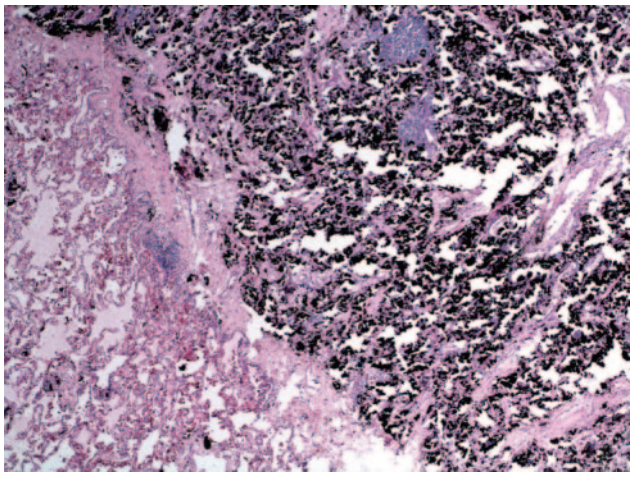

Fig. 4. Right-lower-lobe histology low-power photomicrograph. There is abundant black foreign material and granulomatous inflammation.

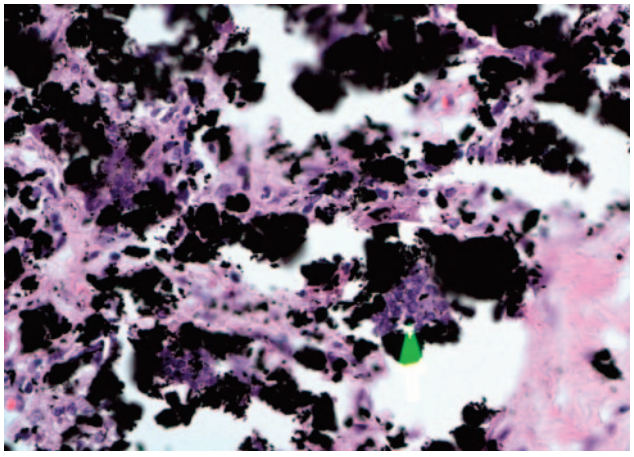

Fig. 5. Right-lower-lobe histology high-power photomicrograph. There is a multinucleated giant cell (green arrow) with adjoining pigmented material.

mothorax and persistent bronchopleural fistula were probably secondary to the large volume of charcoal solution instilled into the distal airways, with subsequent positive-pressure mechanical ventilation, similar to patients in other case reports.[6,7,10-12] Initial treatment was supportive and included bronchoscopy to clear the airways of charcoal. Charcoal was also recovered from the pleural space and drained through a thoracostomy tube.

Chronic lung disease has been occasionally described after charcoal aspiration. A young girl developed chronic, symptomatic granulomatous inflammation, diagnosed via open lung biopsy, 4 years after activated charcoal was instilled into her airways. After the episode, she suffered from chronic dry cough and dyspnea with exertion, and had one episode of pneumonia. The computed tomogram showed a radiographic "tree-in-bud" pattern. Biopsy showed bronchiolar obliteration, persistent anthracosis, and a giant cell reaction within the airways.[10]

Another report[11] described a young woman who died 14 weeks after tricyclic antidepressant overdose and massive activated charcoal aspiration. The autopsy found fibrous obliteration and stenosis of the small airways, and copious black material with a surrounding foreign-body giant cell reaction.

Activated charcoal is an inert substance, insoluble and nonabsorbable, but in the lungs it is clearly immunogenic. Instillation of activated charcoal into the lungs of rats causes an immediate increase in lung microvascular permeability, and most of the charcoal seems to lodge in small, distal airways, sparing the alveolar spaces. This may cause overdistention of unaffected alveoli and activation of resident alveolar macrophages.[13,14]

In our patient the quantity of charcoal instilled and perhaps its administration under pressure led to a concretion. The inorganic particulate matter caused local granulomatous inflammation, and the resultant inflammatory mass developed the radiographic and metabolic characteristics of bronchogenic carcinoma.

Metabolically active tumors and inflammatory conditions frequently cause intense fluorodeoxyglucose uptake, and a standardized uptake value $>$ 2.5 times the background uptake is approximately 78% specific for malignancy in a patient at risk.[15] Granulomatous inflammation is a glucose-avid process, and is often cited as a cause of "false-positive" PET scans. Granulomatous inflammation, which is not thought to be oncogenic, is often found within and around tumors in the lung, and is likely to contribute to their higher standardized uptake values.[16] PET-positive granuloma, with a standardized uptake value greater than the frequently used cutoff value of 2.5, has been described in granulomatous disorders such as tuberculosis, sarcoidosis, histoplasmosis, amyloidosis, Wegener's granulomatosis, and foreign-body reaction to inert substances.[17] After several negative biopsies, this possibility was strongly suspected in our patient's case. Nonetheless, the specter of carcinoma and the patient's desire for closure influenced the decision to proceed with resection, and he had good results, with no complications associated with the surgery.

REFERENCES

1. Watson WA, Litovitz TL, Klein-Schwartz W, Rodgers GC Jr, Youniss J, Reid N, et al. 2003 Annual report of the American Association of Poison Control Centers Toxic Exposure Surveillance System. Am J Emerg Med 2004;22(5):335–404.
2. Chyka PA, Seger D. Position statement: single-dose activated charcoal. American Academy of Clinical Toxicology; European Association of Poisons Centres and Clinical Toxicologists. J Toxicol Clin Toxicol 1997;35(7):721–741.

3. Dorrington CL, Johnson DW, Brant R; Multiple Dose Activated Charcoal Complication Study Group. The frequency of complications associated with the use of multiple-dose activated charcoal. Ann Emerg Med 2003;41:(3)370–377.
4. Araujo-Preza CE, Melhado ME, Gutierrez FJ, Maniatis T, Castellano MA. Use of capnography to verify feeding tube placement. Crit Care Med 2002;30(10):2255–2259.
5. Moll J, Kerns W 2nd, Tomaszewski C, Rose R. Incidence of aspiration pneumonia in intubated patients receiving activated charcoal. J Emerg Med 1999;17(2):279–283.
6. Harris CR, Filandrinos D. Accidental administration of activated charcoal into the lung: aspiration by proxy. Ann Emerg Med 1993; 22(9):1470–1473.
7. Sabga E, Dick A, Lertzman M, Tenenbein M. Direct administration of charcoal into the lung and pleural cavity. Ann Emerg Med 1997; 30(5):695–697.
8. Menzies DG, Busuttil A, Prescott LF. Fatal pulmonary aspiration of oral activated charcoal. BMJ 1988;297(6646):459–460.
9. Mauro LS, Nawarskas JJ, Mauro VF. Misadventures with activated charcoal and recommendations for safe use. Ann Pharmacother 1994; 28(7-8):915–924.
10. Graff GR, Stark J, Berkenbosch JW, Holcomb GW 3rd, Garola RE. Chronic lung disease after activated charcoal aspiration. Pediatrics 2002;109(5):959–961.
11. Elliott CG, Colby TV, Kelly TM, Hicks HG. Charcoal lung: bronchiolitis obliterans after aspiration of activated charcoal. Chest 1989; 96(3):672–674.
12. Thomas B, Cummin D, Falcone RE. Accidental pneumothorax from a nasogastric tube (letter). N Engl J Med 1996;375:1325.
13. Arnold TC, Willis BH, Xiao F, Conrad SA, Carden DL. Aspiration of activated charcoal elicits an increase in lung microvascular permeability. J Toxicol Clin Toxicol 1999;37(1):9–16.
14. Takemura T, Rom WN, Ferrans VJ, Crystal RG. Morphologic characterization of alveolar macrophages from subjects with occupational exposure to inorganic particles. Am Rev Respir Dis 1989; 140(6):1674–1685.
15. Gould MK, Maclean CC, Kuschner WG, Rydzak CE, Owens DK. Accuracy of positron emission tomography for diagnosis of pulmonary nodules and mass lesions: a meta-analysis. JAMA 2001;285(7): 914–924.
16. Kubota R, Yamada S, Kubota K, Ishiwata K, Tamahashi N, Ido T. Intratumoral distribution of fluorine-18-fluorodeoxyglucose in vivo: high accumulation of intratumoral macrophages, granulation tissues, and cancer cells studied by microautoradiography. J Nucl Med 1992; 33(11):1972–1980.
17. Goo JM, Im JG, Do KH, Yeo JS, Seo JB, Kim HY, Chung JK. Pulmonary tuberculoma evaluated by means of FDG PET: findings in 10 cases. Radiology 2000;216(1):117–121.