Bronchogenic Cyst: Imaging Features with Clinical and Histopathologic Correlation

PURPOSE: To characterize the imaging features of bronchogenic cysts.

MATERIALS AND METHODS: The computed tomographic (CT) and/or magnetic resonance (MR) images in 68 histopathologically proved cases of bronchogenic cyst in 38 male and 30 female patients, aged newborn to 72 years (mean, 22 years), were retrospectively reviewed.

RESULTS: There were 58 mediastinal and 10 extramediastinal cysts. At CT (n = 62), 60 cysts were sharply marginated with smooth (n = 35) or lobulated (n = 25) borders. Twenty-five cysts were of water attenuation, 25 were of soft-tissue attenuation, two were air filled, two had an air-fluid level, and two had dependent milk of calcium. On T1-weighted MR images (n = 23), 18 cysts were hyperintense and five were isointense to cerebrospinal fluid. On T2-weighted MR images (n = 18), 17 cysts were isointense or hyperintense to cerebrospinal fluid. Of the 25 soft-tissue–attenuation lesions at CT, 11 appeared cystic because of internal homogeneity, lack of internal enhancement, mural enhancement, and characteristic location. Fourteen appeared solid based on morphology and attenuation. MR imaging of nine of the latter showed marked hyperintensity on T2-weighted images.

CONCLUSION: CT of bronchogenic cysts typically shows sharply marginated mediastinal masses of soft-tissue or water attenuation. Most appear cystic. A minority appear solid and can be confused with other lesions; MR imaging can be useful for elucidating the cystic nature of these lesions.

Bronchogenic cysts are congenital lesions thought to result from abnormal budding of the embryonic foregut. At computed tomography (CT), bronchogenic cysts typically manifest as spherical masses of either water or soft-tissue attenuation. When bronchogenic cysts manifest as water-attenuation masses on CT scans, differentiation from other mediastinal processes such as lymphadenopathy or neoplasia is not difficult. However, when bronchogenic cysts manifest as soft-tissue–attenuation masses on CT scans, differentiation from solid lesions can be more problematic. We reviewed a large series of bronchogenic cysts to fully define the spectrum of CT, magnetic resonance (MR) imaging, and ultrasonographic (US) features of bronchogenic cyst.

MATERIALS AND METHODS

All cases with a histopathologic diagnosis of bronchogenic cyst and cross-sectional imaging (CT, MR imaging, or US) that were referred to the Department of Radiologic Pathology, the Armed Forces Institute of Pathology between 1978 to 1997 were included. By definition, all cysts fulfilled strict histopathologic criteria for diagnosing bronchogenic cyst: a lining of respiratory epithelium associated with a wall containing glands, cartilage, and smooth-muscle elements (Fig 1) (1). We studied 68 cysts in 68 patients (38 male and 30 female patients; age range, newborn to 72 years; mean age, 22 years).

Clinical records were available in 66 cases and were reviewed, with notation made of presenting complaints. Surgical reports were reviewed for cyst location and presence of a stalk and point or points of attachment to adjacent mediastinal structures such as the
esophagus or tracheobronchial tree. Pathology reports were reviewed for gross description of the maximal diameter of the lesion and the cyst contents.

Forty-two cysts were imaged with only CT, 20 cysts were imaged with both CT and MR imaging, four cysts were imaged with only MR imaging, and two cysts were imaged with only prenatal US. Because of the retrospective and multiinstitutional nature of the study, CT and MR techniques were inconsistent. Of the 62 CT scans obtained, 33 scans were only contrast material enhanced, 14 were only nonenhanced, and 15 were obtained with and without contrast material enhancement. Of the 24 MR examinations, 23 studies used a short repetition time/short echo time sequence (T1-weighted), and 18 used a long repetition time/long echo time sequence (T2-weighted). Gadolinium-based contrast material was administered in three cases. All imaging studies were reviewed by at least two thoracic radiologists (H.P.M., M.E.R., W.M.K., S.M.) simultaneously, and findings were recorded per consensus.

CT scans were evaluated for cyst shape and margin characteristics, visualization of a cyst wall, presence of mass effect on adjacent structures, cyst location, attenuation, homogeneity, calcification, and patterns of enhancement following intravenous administration of iodinated contrast material. Lesions were classified as anterior mediastinal if they were located anterior to the heart or great vessels (prevascular space), posterior mediastinal if located in either paraspinal regions, and middle mediastinal if located in the paratracheal or subcarinal regions or along the course of the esophagus. On CT scans, the mediastinal cysts were classified as either water or soft-tissue attenuation in one of two ways. If region-of-interest measurements within the cyst were available, the lesions were classified as water attenuation if their attenuation was less than 20 HU and as soft-tissue attenuation if their attenuation was greater than 20 HU. If region-of-interest measurements were not available, the cysts were classified as water attenuation if their attenuation was similar to fluid in the gallbladder or spinal canal and as soft-tissue attenuation if their attenuation was greater than fluid in the gallbladder or spinal canal.

The soft-tissue-attenuation lesions on CT scans were subcategorized as cystic appearing, solid appearing, or indeterminate according to the following criteria: (a) If the attenuation of the lesion was less than that of surrounding soft tissue, if the lesion was internally homogeneous, if there was no internal enhancement, and if there was a well-defined thin wall, the lesion was categorized as cystic appearing. (b) If the attenuation was similar to that of the surrounding soft tissues, if the lesion was internally heterogeneous, and if it did not have a well-defined thin wall, it was categorized as solid appearing. (c) Lesions were categorized as indeterminate if they did not meet all stated criteria for classification as either cystic appearing or solid appearing.

MR images were evaluated for signal intensity on T1- and T2-weighted images, homogeneity, and enhancement following intravenous administration of gadolinium-based contrast material. Signal intensity on T1-weighted images was classified as isointense to cerebrospinal fluid (CSF), isointense to skeletal muscle, or hyperintense to skeletal muscle. Signal intensity on T2-weighted images was classified as hypointense to CSF, isointense to CSF, or hyperintense to CSF.

US images were specifically evaluated for cyst location, visualization of a cyst wall, internal echos or septations, and presence or absence of acoustic enhancement.

RESULTS

Clinical Presentation

Fifty-seven (84%) of 68 affected patients presented in the first 4 decades of life (Table 1). Of the 66 patients for whom a clinical history was available, 38 patients (58%) were symptomatic with pain (n = 15), dyspnea (n = 8), respiratory infection (n = 7), wheezing (n = 5), cough (n = 5), dysphagia (n = 1), pneumothorax (n = 1), and superior vena cava syndrome (n = 1). Several patients had more than one symptom. Twenty-eight patients (42%) were asymptomatic, and the bronchogenic cyst was incidentally discovered because of an abnormality de-

<table>
<thead>
<tr>
<th>Age (y)</th>
<th>No. of Cases (n = 68)</th>
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<td>0–9</td>
<td>23</td>
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<tr>
<td>10–19</td>
<td>6</td>
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<td>20–29</td>
<td>16</td>
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<td>60–69</td>
<td>3</td>
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<td>70–79</td>
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Table 1. Distribution of Bronchogenic Cysts by Patients’ Age

Figure 1. Bronchogenic cyst in a 3-year-old asymptomatic boy. High-power photomicrograph shows characteristic features of a bronchogenic cyst. Note cyst lining of pseudostratified columnar respiratory epithelium (arrowhead), cartilage plate (C), smooth muscle (S), and bronchial glands (arrow) in the cyst wall. (Hematoxylin-eosin stain; original magnification, ×150.)

Figure 2. Bronchogenic cyst in a 19-year-old asymptomatic man. Intraoperative photomicrograph shows a bronchogenic cyst (C) with attachment to the distal esophagus (e) by a stalk (arrowheads).

Figure 3. Bronchogenic cyst in a 1-year-old asymptomatic boy. Photograph of a specimen shows a pearly white translucent cyst. Note blood vessels in the cyst wall.
Surgical Findings

Sixty-seven patients underwent complete surgical resection of their bronchogenic cyst. In one patient, biopsy and marsupialization were performed of the cyst wall, but it was not completely resected. At surgery, a stalk connecting the cyst to an adjacent structure was identified in 31 cases (Fig 2). The attachment point of the stalk varied widely. In eight cases, the stalk was attached to the trachea or carina. A pleural attachment was noted in four cases and an esophageal attachment in four. Other points of attachment included the diaphragm (n = 3), hilum (n = 1), aorticopulmonary window (n = 1), and sympathetic trunk (n = 1). In the remaining nine cases in which a stalk was surgically identified, the point of attachment was not documented.

Gross Features

Descriptions of gross specimens were available in all 68 cases, and measurements of the cyst size were available in 67. Maximal cyst diameter ranged from 1.3 to 11.0 cm, with a mean of 4.8 cm (Fig 3). The cyst content varied but was of a liquid nature in all cases. Descriptions of the cyst contents were available in 53 cases. The fluid was most frequently described as milky and gelatinous (n = 16). Other descriptions of the fluid included green and mucoid (n = 12), brown or hemorrhagic (n = 8), yellow and gelatinous (n = 6), white and translucent (n = 5), yellow and puslike (n = 3), and thin and serous (n = 1). Two cysts were completely air filled. The chemical composition of the fluid was not analyzed in any case.

Location

There were 58 mediastinal (85%) and 10 extramediastinal (15%) bronchogenic cysts. Of the mediastinal cysts, 46 cysts (79%) were located in the middle mediastinum, 10 (17%) were located in the posterior mediastinum, and two (3%) were located in the anterior mediastinum. The extramediastinal cysts were located in the lung parenchyma in seven cases (Fig 4), the diaphragm in two, and the pleura in one. The lung parenchymal cysts did not show a predilection for a particular lobe and were located in the right upper (n = 2), right lower (n = 3), and left upper (n = 2) lobes.

CT Findings

On CT scans (n = 62), 60 cysts were sharply margined masses with either smooth (n = 35) or lobulated (n = 25) borders. Indeterminate borders were seen in two cases, likely due to obscuration of the margins by associated atelectasis. Fifty-eight lesions were in the mediastinum, and four were in the lung parenchyma. The CT attenuation characteristics of the lesions are summarized in Table 2. Of the 58 mediastinal cysts, 25 were classified as water attenuation (Fig 5) and 25 were classified as soft-tissue attenuation (Fig 6). Forty-eight of these 50 cysts were of homogeneous attenuation and two were of heterogeneous attenuation. Of the remaining eight mediastinal lesions imaged with CT, six could not be classified because streak artifact obscured much of the cyst wall.

<p>| TABLE 2 |</p>
<table>
<thead>
<tr>
<th>CT Attenuation Characteristics of Bronchogenic Cysts</th>
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<tbody>
<tr>
<td>Attenuation Characteristics</td>
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<tr>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>Mediastinum (n = 58)</td>
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<tr>
<td>Water attenuation</td>
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<tr>
<td>Soft-tissue attenuation</td>
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<tr>
<td>Cystic appearing</td>
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<tr>
<td>Solid appearing</td>
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<tr>
<td>Indeterminate</td>
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<tr>
<td>Milk-of-calcium</td>
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<tr>
<td>Streak artifact-obscured cyst</td>
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<tr>
<td>Lung (n = 4)</td>
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<tr>
<td>Completely air filled</td>
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<td>Air-fluid level</td>
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Figure 4. Prenatal diagnosis of bronchogenic cyst. (a) Transverse sonogram of the thorax obtained at 26 weeks gestation shows a unilocular cyst (C) in the right hemithorax. Note posterior acoustic enhancement (arrows). (b) Supine frontal and (c) cross-table lateral chest radiographs obtained 3 days after birth show a thin-walled (arrows in b), air-filled cyst in the right lung, with a dependent air-fluid level (arrowheads in c).

Figure 5. Bronchogenic cyst in a 21-year-old asymptomatic woman. Transverse contrast-enhanced chest CT scan (mediastinal window settings) shows a well-circumscribed water-attenuation cyst in the middle mediastinum. Note the thin, enhancing wall medially (black arrows) and peripheral punctate calcification (white arrow).
the cyst and two had dependent high-
attenuating material consistent with milk of calcium (Fig 7). On the basis of previously stated criteria, the 25 soft-tissue-attenuation lesions at CT were sub-
categorized as cystic appearing \( (n = 11) \), solid appearing \( (n = 7) \), or indeterminate \( (n = 7) \). Of the four lung parenchymal cysts imaged with CT, two were completely air filled and two had an air-fluid level (Fig 4).

Calcification was seen in six (10%) of 62 cysts imaged with CT. In four cases, calcification was located peripherally in the cyst wall and was punctate and discontinuous in nature (Fig 5). In two cases, milk of calcium was present in the cyst fluid (Fig 7). Contrast-enhanced CT \( (n = 48) \) did not show enhancement of cyst contents in any case. Mural enhancement, however, was observed in 16 cysts and was helpful in the delineation of a thin wall (Fig 5).

Mass effect on surrounding structures such as bronchi, esophagus, or mediastinal vessels was observed in 25 cases. Atelectasis and/or parenchymal consolidation was seen in eight cases. Three patients had an ipsilateral extralobar sequestration, one patient had a small pericardial effusion, and one patient had an ipsilateral congenital diaphragmatic hernia.

### MR Imaging Findings

On T1-weighted MR images \( (n = 23) \), 12 cysts were slightly hyperintense to skeletal muscle (Fig 6), six cysts were isointense to skeletal muscle, and five cysts were isointense to CSF (Fig 8). On T2-weighted MR images \( (n = 18) \), 11 cysts were isointense to CSF (Figs 6, 8), six cysts were hyperintense to CSF, and one was hypointense to CSF. On gadolinium-enhanced MR images \( (n = 3) \), the cyst contents did not enhance, but enhancement of the cyst wall was seen, aiding delineation of a thin wall (Fig 8).

Twenty cysts were imaged with both MR imaging and CT. Of these, nine were categorized at CT as either solid-appearing or indeterminate lesions (Fig 6). At MR imaging, all nine cysts were of increased signal intensity compared to CSF on T1-weighted images and of markedly increased signal intensity (similar to that of CSF) on T2-weighted images, the latter finding being consistent with the cystic nature of these lesions.

### Prenatal US

Prenatal US in one case showed a unilocular anechoic cyst in the right lung with posterior acoustic enhancement and mass effect on the right atrium (Fig 4). Prenatal US in a second case showed a multilocular cyst with dependent echogenic material in the right lung. Both cysts developed air-fluid levels on chest radiographs in the postnatal period.

### DISCUSSION

Bronchogenic cysts are congenital lesions thought to result from abnormal budding of the ventral foregut that occurs between the 26th and 40th days of gestation (2). This abnormal bud subsequently differentiates into a fluid-filled, blind-ending pouch. Most cysts are located in the mediastinum, near the tracheal carina. In our series, 58 (85%) of 68 cysts were mediastinal in location, and 46 (79%) of 58 mediastinal cysts were in the middle mediastinum. Less commonly, cysts may occur within the lung parenchyma, pleura, or diaphragm (10 [15%] of 68 cysts). A stalk or pedicle attaching the cyst to an adjacent mediastinal struc-

ture is common and was found in 31 (46%) of our 68 cases. Bronchogenic cysts
Bronchogenic cysts from our series. have excluded some true extramediastinal components than do mediastinal cysts, we may cation. Because intrapulmonary cysts of the 86 cysts were extramediastinal in lo- fied as bronchogenic cysts had cartilage in their wall, and approximately 25% of f the fluid contained within bronchogenic cysts is usually a mixture of water and proteinaceous mucus. The contents of the cysts in our series were not chemically analyzed. However, descriptions of the fluid ranged from a thin, watery liquid to hemorrhagic fluid to a very viscous, mucoid material. This variability in cyst content is likely responsible for the variability of attenuation seen on CT scans and signal intensity characteristics seen on MR images (10,11). It has been suggested, based on analysis of cyst fluid, that calcium is a major factor contributing to high attenuation on CT scans (12,13). However, most of the cysts that we classified as having soft-tissue attenuation on CT scans (based on region-of-interest measurements) were hyperintense to CSF on T2-weighted MR images and isointense to skeletal muscle on T1-weighted MR images. This finding suggests that mucus and proteinaceous debris, not calcium, within the cyst is the most likely explanation for the increased attenuation seen on CT scans (14). We did, however, observe two cysts with clear evidence of calcium-containing fluid within the cyst manifesting as dependent milk of calcium on CT scans.

Twenty-five (43%) of 58 mediastinal bronchogenic cysts in our series were classified as having soft-tissue attenuation on CT scans based on measurements of internal attenuation. However, 11 of these lesions had features that were otherwise characteristic of fluid-filled cysts (including homogeneous internal attenuation, no central enhancement, and a thin, often enhancing wall), and most occurred in a characteristic location such as the subcarinal or paratracheal region. Given that another 25 lesions were clearly fluid filled on CT scans (according to measurement of internal attenuation) and that two other lesions contained calcium-fluid levels, we believe that a confident diagnosis of bronchogenic cyst could be rendered with CT in almost two-thirds of our cases (38 [66%] of 58 cases). However, we believe that the remaining 20 lesions could not be confidently diagnosed as cysts with CT, either because of internal heterogeneity, high attenuation numbers, streak artifact, lack of mural enhancement, or atypical location. In such difficult cases, we believe that MR imaging, by demonstrating markedly increased signal intensity within the lesions on T2-weighted images, can be useful for suggesting the true cystic nature of the lesion.

Thus, based on our experience, we believe that the following imaging features may be helpful for differentiating nonwater-attenuation bronchogenic cysts from solid masses. First, the presence of a well-defined, thin, smooth wall suggests that the lesion is a cyst. Delineation of the wall is facilitated by intravenous administration of iodinated or gadolinium-based contrast material. A thick or irregular wall is not a typical feature of bronchogenic cyst and suggests necrotic neoplasm or lymphadenopathy. Second, bronchogenic cysts with high CT attenuation numbers are usually of homogeneous attenuation and have cyst contents that do not enhance following administration of contrast material. In fact, because the cyst contents do not enhance, attenuation differences between mediastinal soft tissues and the cyst and its contents are often accentuated following administration of contrast material, which...
facilitates recognition. Conversely, if the lesion is heterogeneous or enhances centrally, neoplasia must be excluded. Third, MR imaging can be very useful for differentiating high-attenuating cysts on CT scans from soft-tissue masses. Such cysts are typically isointense or hyperintense to CSF with all pulse sequences. A lesion that is hypointense to CSF on T2-weighted images should be viewed with caution.

We acknowledge several limitations of our study. Because of its retrospective and multiinstitutional nature, the CT and MR imaging techniques were inconsistent. In particular, region-of-interest measurements were not available in all cases; attenuation characteristics in these cases were based on visual criteria. It is possible that if region-of-interest measurements were available in all cases, fewer lesions would have been classified as being of soft-tissue attenuation on CT scans. It is also unfortunate that so few cases were imaged with contrast-enhanced MR imaging. It is thus difficult to reach firm conclusions regarding the utility of this technique for imaging bronchogenic cysts. Lack of enhancement of cyst contents on contrast-enhanced MR images, however, may prove to be a reliable indicator of the cystic nature of problematic bronchogenic cysts.

Appropriate treatment of patients with bronchogenic cysts depends on the patient's age and symptoms at presentation. Symptomatic cysts should be resected (either at thoracotomy or by means of video-assisted thoracoscopy) regardless of patient age, unless surgical risks are unacceptably high (15). It is generally recommended that asymptomatic cysts in young patients be removed (16), because of the low surgical risk and the potential risk of late complications (albeit rare) such as infection, hemorrhage, or neoplasia within the cyst. Conservative (watch-and-wait) treatment has been advocated in asymptomatic adults or other high-risk patients (17). Percutaneous catheter drainage (18) or sterile alcohol ablation (19) has been performed in selected cases. In such patients, radiologic diagnosis is of great importance, as tissue confirmation will not be obtained.

In summary, bronchogenic cysts typically manifest as sharply marginated, middle mediastinal masses of soft-tissue or water attenuation on CT scans. Most bronchogenic cysts can be confidently diagnosed by using nonenhanced CT; however, administration of contrast material at CT or the addition of MR imaging can be useful for differentiating problematic soft-tissue-attenuation cysts from mediastinal neoplasia.

References