High Resolution CT Anatomy of the Pulmonary Fissures

Aamer Aziz, MD, MSc, PhD, Kazuto Ashizawa, MD, Kenji Nagaoki, MD, and Kuniaki Hayashi, MD

Rationale and Objectives: Pulmonary interlobar fissures are important landmarks for proper identification of normal pulmonary anatomy and evaluation of disease. The purpose of this study was to define the radiologic anatomy of the pulmonary fissures using high resolution computed tomography (HRCT) in a large population.

Methods: HRCT of the lungs from aortic arch to diaphragm was performed in 622 patients, with a slice thickness of 1 mm and slice interval of 10 mm. Major, minor, and accessory fissures were studied for their orientation and completeness.

Results: Both major fissures were mostly facing laterally in their upper parts (100% and 89% right and left, respectively). The left major fissure faced medially (69%) while the right major fissure faced lateral (60%) in their lower parts. The right major fissure was more often incomplete (48% as compared with 43% on the left, $P < 0.05$). Minor fissures were convex superiorly with the apex in the anterolateral part of the base of the upper lobe, and were incomplete in 63% of cases. Azygos, inferior accessory, superior accessory, and left minor fissures were also seen in 1.2%, 8.6%, 4.6%, and 6.1% of the cases, respectively.

Conclusion: The pulmonary fissures are highly variable and the right major fissure differs considerably from the left. The fissures are often incomplete.

Key Words: pulmonary fissures, high resolution computed tomography, radiological anatomy

(*J Thorac Imaging* 2004;19:186–191)

The lungs are divided into various lobes by a double layer of infolded reflections of visceral pleura called the fissures.[1] On posteroanterior or lateral chest radiographs the fissures are not adequately visualized as they are undulating in form and only the part that is tangential to the x-ray beam is seen.[2]

The major fissures have been studied on conventional CT[3] and appear as curvilinear avascular bands, or sometimes as lines or dense bands, or as "ground glass" band.[3,4] On HRCT the major fissures are more often seen as thin fine lines and could be studied in greater details, especially their completeness. Various studies have described the major fissures to be incomplete in 18% to 73% of cases.[5] Some authors have described the normal and variant orientations of the major fissures on CT and HRCT.[6]

The minor fissures have also been studied on CT and HRCT. They manifest as triangular, round, or oval[4] upwardly convex avascular zones or high-attenuation lines forming a quarter or half circle[7] extending from the major fissure to the lateral chest wall and were incomplete in 52% to 88% of the patients.[7–10] One study has examined the morphology of minor fissures extensively on HRCT.[10]

The accessory fissures are not uncommon when studied by HRCT and may be seen in 22%[11] and 32%[12] of patients. The accessory fissures that have been consistently identified are the azygos,[13] inferior accessory,[14] superior accessory,[11] and the left minor fissures.[15]

There have been few studies that have described the morphology of most fissures sampled at small intervals on HRCT in a large population. This has been mainly due to the technical limitation of the older CT machines to image large volumes in a short time. The pulmonary fissures are too thin to be adequately imaged with a large slice thickness and important information about their orientation may be lost if not imaged with high resolution. The aim of this study was to evaluate a large number of patients and to describe the morphology and completeness of the major, minor, and accessory fissures on HRCT along with their frequencies and variations.

MATERIALS AND METHODS

A total of 881 patients were studied by HRCT between August 1999 and July 2000. Of these, 259 patients were excluded as they had advanced pulmonary disease that distorted the fissures from their normal orientation. The remaining 622 patients (301 males and 321 females) included in this study were either disease free, or had pulmonary disease not significant enough to alter the orientation of the fissures. Their ages ranged between 15 and 92 years with an average age of 64 years. All the patients were scanned on the same CT machine (HiSpeed; General Electric Medical Systems; Milwaukee, WI). The patients were scanned in supine position. The distance covered for the scans was from the top of the aortic arch to the diaphragm. Twenty incremental scans with slice thickness of 1 mm and slice interval of 10 mm were acquired in 2

From the Department of Radiology, Nagasaki University School of Medicine, Sakamoto 1-7-1, Nagasaki 852-8501, Japan.

Reprints: Aamer Aziz, MD, MSc (Nuc Med), PhD (Radiology), Department of Radiology, Nagasaki University School of Medicine, Sakamoto 1-7-1, Nagasaki 852-8501, Japan. (e-mail: aziz@i2r.a-star.edu.sg).

breath holds. The scans were reconstructed using high-resolution protocol and the images were displayed with the window width of 1600 and window level of −600 (lung window).

Each slice was carefully examined for the orientation, completeness, and morphology of the major, minor, and accessory fissures on both sides. The fissures were classified as facing anterior or posterior and lateral or medial based upon the direction of the convex portion of the fissure. When the fissures faced in more than one direction in a slice, the predominant direction was noted. For simplicity of data evaluation, 5 consecutive slices were considered together, grouping them in 4 zones: superior, suprahilar, infrahilar, and inferior. The orientation of the fissures was consistent among the 5 slices in each zone.

RESULTS

A total of 24,880 HRCT images (12,440 on each side) in 622 patients were analyzed in 4 zones of the lungs. On the left side, the major fissures extended more superiorly than on the right. The fissures were convex medial in 66% (58% posteromedial and 8% anteromedial) of superior zones and lateral in 64% (61% anterolateral and 3% posterolateral) of suprahilar zones. They were facing medially in 54% (52% anteromedial and 2% posteromedial) of infrahilar zones and 68% (all anteromedial) of inferior zones (Table 1) (Figs. 1, 2).

On the right side, the major fissures were facing medially in 85% (all posteromedial) of superior zones, and faced laterally in 63% (62% anterolateral and 1% posterolateral) of suprahilar, 55% (53% anterolateral and 2% posterolateral) of infrahilar, and 62% (60% anterolateral and 2% posterolateral) of inferior zones (Table 2) (Figs. 1, 2). In addition to these most common orientations, other orientations of the major fissures were also seen with lesser frequencies (Tables 1, 2 and Fig. 2).

The degree of incompleteness of major fissures varied, with right major fissures more often and more extensively incomplete than the left (Fig. 3). Forty-three percent of the left and 48% of the right major fissures were incomplete in at least 1 level ($P < 0.05$). The fissures were mostly incomplete in the infrahilar zone in their medial one-fourth, which comprised 60% of the total number of incomplete fissures (Fig. 3).

The minor fissures were identified in 78% of subjects and were classified in 4 types based on the position of their most superior parts relative to the base of the upper lobe: anterolateral, anteromedial, posterolateral, and posteromedial. Anterolateral configuration was seen in 37%, followed by posteromedial in 34%, posterolateral in 16%, and anteromedial in 13%. The minor fissures were incomplete in 63% cases.

Inferior accessory fissures were seen in 53 cases (8.6%), of which 80% were in the right lower lobe. These fissures were attached to the major fissure near its medial one-third and lateral two-thirds, extending posteriorly and curving slightly medially. Twenty-seven superior accessory fissures (4.6%) were visualized, 62% being on the left side. These were oriented in the horizontal plane and at times were difficult to identify. Thirty-eight left minor fissures (6.1%) were visualized separating the lingula from the rest of the left upper lobe. They were similar to the right-sided minor fissures, and were present slightly higher than them. Eight azygos fissures (1.2%) were visualized in the medial parts of the right upper lobes, convex facing laterally in orientation (Fig. 4).

DISCUSSION

Pulmonary fissures are important landmarks that divide the lungs in various lobes. It is important to know the normal configuration and orientation of the fissures before any comment can be made about a change in their position due to disease.

Some of the previous studies have tried to explain the normal morphology of the pulmonary fissures based on chest radiographs.[2,8,14] As the fissures have undulating course and are oriented only for a short segment in the plane of the x-ray beam, it is difficult to see the entire length or orientation of the fissures on posteroanterior or lateral chest radiographs.

Other studies have been done on conventional CT.[3,4] Normal fissures are thin and are out of the resolution of the conventional 10 mm thick slices. They appear mostly as avascular bands due to partial volume averaging of thicker slices

TABLE 1. Percentages of Visualization of Various Orientations of Left Major Fissure (the Facing Direction of the Convexity of the Fissure)

	Medial		Lateral	
Lung Zones	Facing Anteromedial	Facing Posteromedial	Facing Anterolateral	Facing Posterolateral
Superior	8	58	31	3
Suprahilar	16	20	61	3
Infrahilar	52	2	44	2
Inferior	68	0	31	1

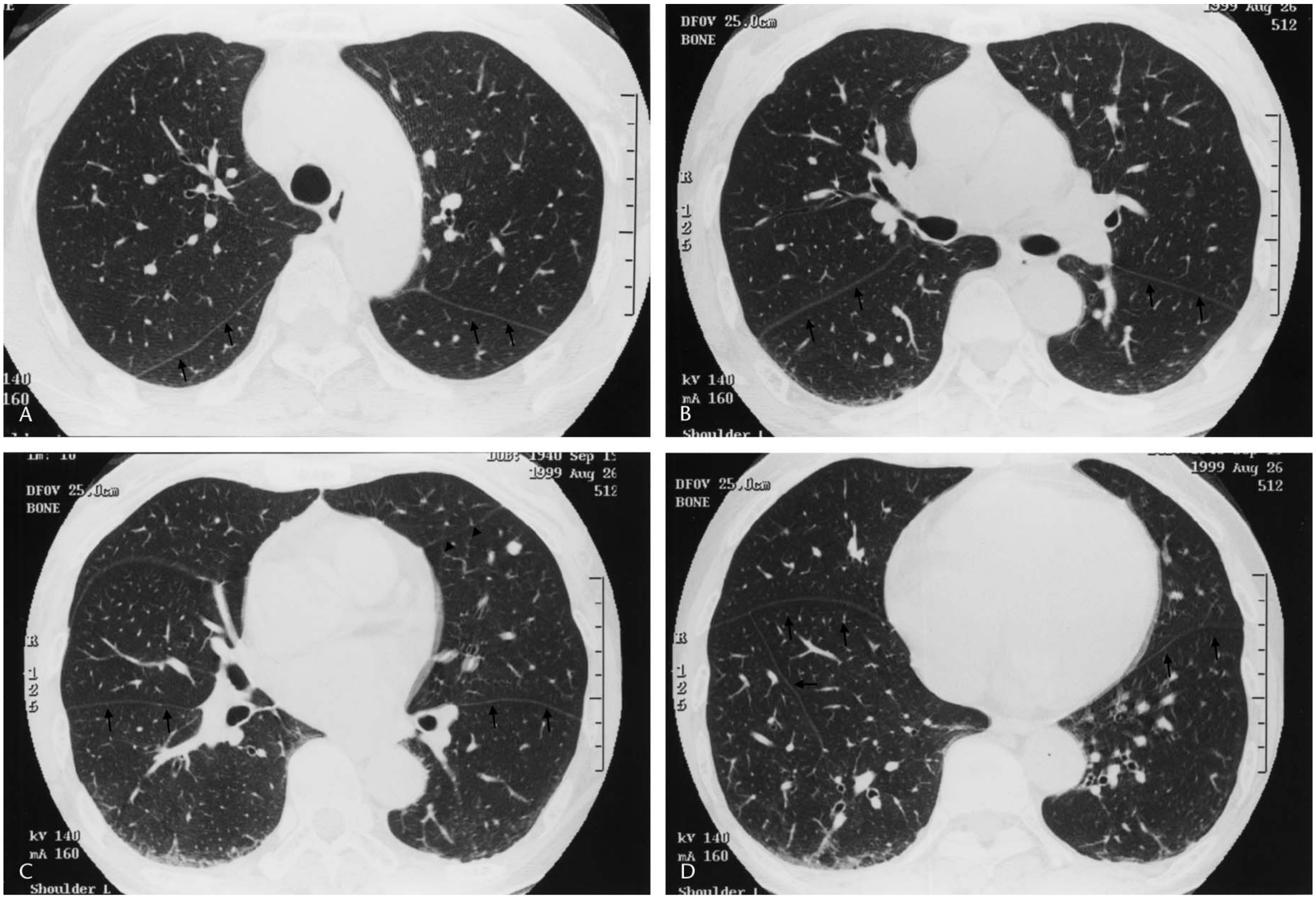

FIGURE 1. The orientations of major fissures seen in (A) superior, (B) suprahilar, (C) infrahilar and (D) inferior zones of the lungs (arrows). Left minor fissure (arrowheads) and inferior accessory fissure (long arrow) are also seen.

and their orientations are difficult to visualize; however, thin sections considerably improve their visibility.

The left major fissure in our study appears to be facing medially in 66% of cases in superior zone and faces laterally in 64% of cases in suprahilar portions. In infrahilar and inferior zones it faces medially in 54% and 68% of cases, respectively. Thus, the convexity of the fissure faces posteromedially in the superior zone, the convexity becomes facing anterolaterally, and then lateral margin of the major fissure sweeps anteriorly to make the fissure facing anteromedially in its lower parts. This orientation is consistent with already published data,[1,4] and has been likened to the shape of a propeller blade. On the other hand, the right major fissure in our study was oriented facing medially in superior zone in 85% of cases and continues downwards facing laterally in 63%, 55%, and 62% of cases in the suprahilar, infrahilar, and inferior zones, with 38% of fissures oriented in medially facing direction as well in the lower zones. The majority of fissures had their convexities facing posteromedially in the superior zones and become facing anterolaterally in its lower parts, the lateral margin of the fissure thus remaining posterior to its medical margin. Thus, a substantial number of right major fissures differed from their left counterparts (Figs. 1, 2). This seems to be a major difference in our study from a previous study that has described both the major fissures as having a shape likened to a propeller blade.[4] However, the orientation of the right major fissure as seen in our study supports another study in which a similar orientation of the right major fissure has been reported based on pathologic examination of the fixed inflated lung specimen,[8] though there are some differences in the percentage of incompleteness of fissures bilaterally and in the orientation of the minor fissure. We feel that our study with thin section HRCT images scanned at a smaller slice interval is closer to the study based on actual anatomic details rather than to the other studies based on HRCT with less sampling frequencies.

The right major fissures were found to be more often incomplete than the left in our study. This is in agreement with various previous studies,[5,8,16] which have shown the right major fissure to be more often incomplete than the left. Our study shows that only a small portion of the major fissures is incom-

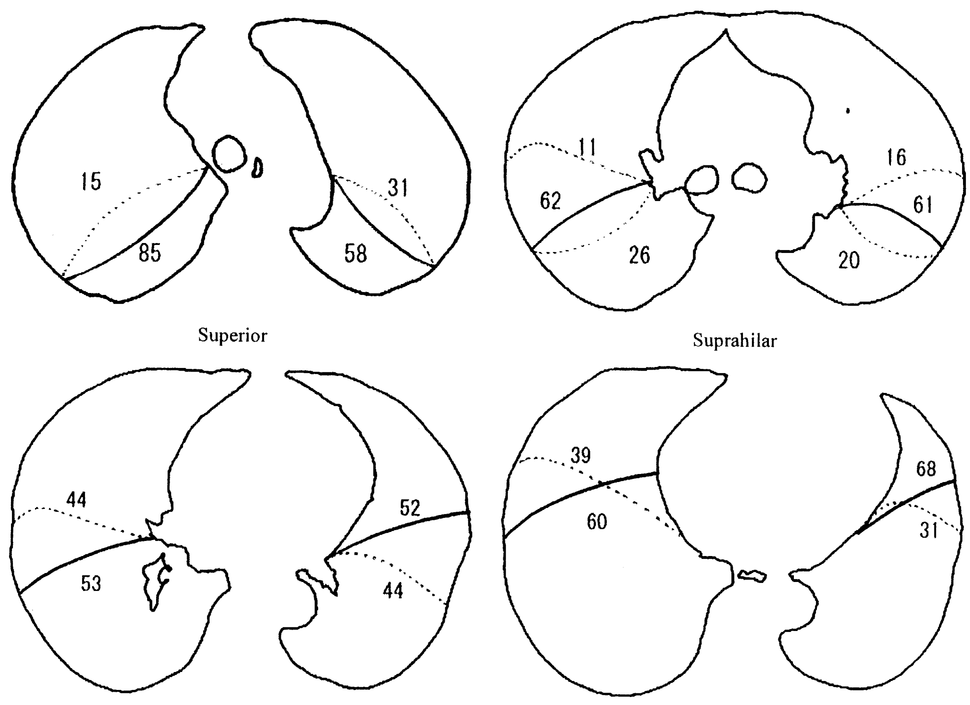

FIGURE 2. The orientations of the major fissures in 4 zones of the lungs. The most common orientations are shown as solid lines, while other orientations are shown as dotted lines. The numbers are the percentages at which these orientations were seen. (Orientations that occur with small percentages are not shown).

plete, mostly at the hilum. This is supported by the data shown in the study of dissected specimens of fixed inflated lungs, in which the extent of incompleteness of the major fissures was generally small.[16]

The minor fissures were seen with a great variability. All of the minor fissures were convex facing superiorly with the apex of the convexity bulging into the base of the upper lobe. This is in agreement with the previously published data; however, in our study the anterolateral and posteromedial orientations appear with almost the same frequencies (37% and 34%, respectively), whereas the previous data shows the orientation to be more in the posteromedial parts.[7,10] The incidence of incompleteness of the minor fissure in our study (63%) is less than one study that reports it to be 78%,[7] while it is higher than reported in another study (54%).[10] However, in those studies, the slice thickness was between 1.5 and 4 to 5 mm and the entire extent of the minor fissure was not imaged in all of the patients. Our data illustrates that thin slices at close intervals illustrate the fissure more completely than either thick sections or those taken at larger intervals.

TABLE 2. Percentages of Visualization of Various Orientations of Right Major Fissure (the Facing Direction of the Convexity of the Fissure)

	Medial		Lateral	
Lung Zones	Facing Anteromedial	Facing Posteromedial	Facing Anterolateral	Facing Posterolateral
Superior	0	85	15	0
Suprahilar	11	26	62	1
Infrahilar	44	1	53	2
Inferior	38	0	60	2

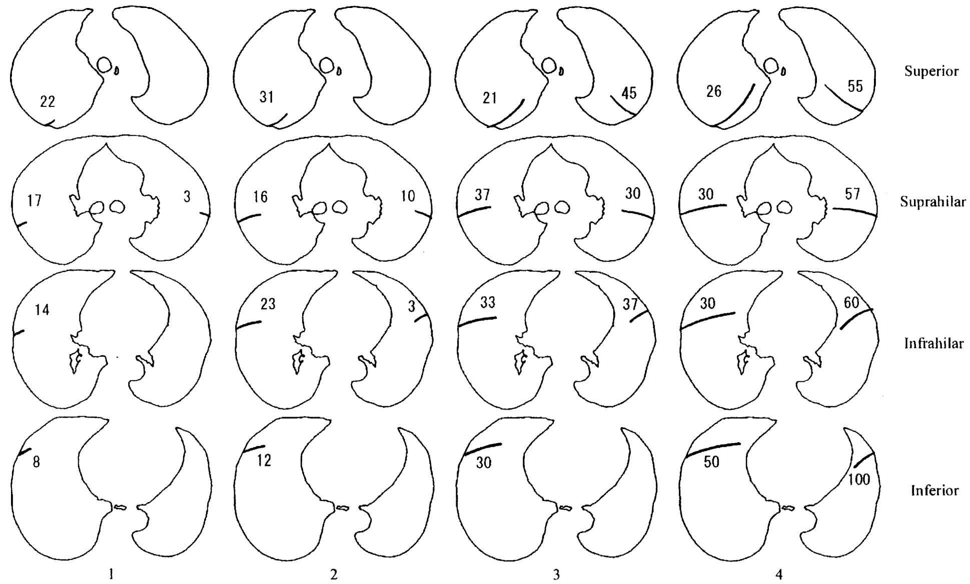

FIGURE 3. The percentages of completeness of major fissures in 4 zones of the lungs. 1 = Fissures visualized for less than one-fourth the distance between lateral chest wall and mediastinum. 2 = Visualized up to one-half the distance. 3 = Visualized up to three-fourths of the distance. 4 = Visualized for more than three-fourths of the distance but not reaching up to the mediastinum. The numbers represent the percentages of various forms.

The accessory fissures are not uncommon. We visualized the azygos fissures with less frequency (1.2% of total cases) than other studies based on radiologic data.[1] The reason may be that we sampled the lungs starting at the aortic arch and azygos fissures may not extend so low; had the apices been included in our study, we might have had different frequencies. The inferior accessory fissures were visualized with greatest frequency (8.6%). This may be due to the fact that this fissure is oriented in sagittal plane and is well visualized on axial HRCT, while the other accessory fissures are mostly oriented in a more horizontal plane, thus precluding their proper visualization and tend to be missed in the interslice gap, thus falsely reducing the frequency of their visualization.

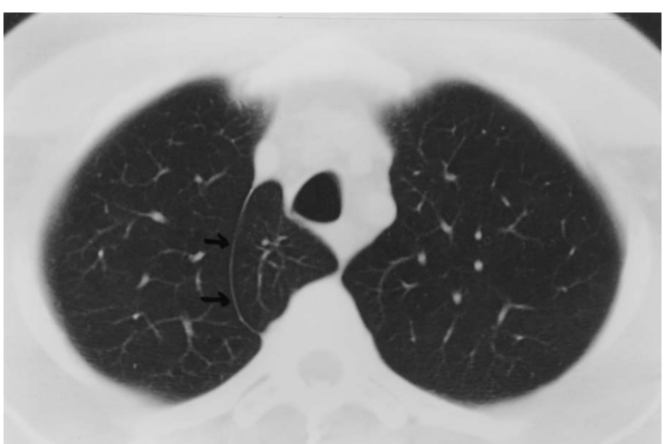

FIGURE 4. Azygos fissure (arrows). The fissure is seen as a convex-laterally thick line curving in the upper part of the right lung.

One limitation of our study is that the description is based on the HRCT images alone and there was no pathologic correlation. Axial sections even at an interval of 10 mm are not close enough to image the fissures oriented in horizontal planes (normal right minor, superior accessory, and left minor fissures) parallel to the scan direction. These fissures may be lost in the interslice gap or may only be visualized partially. To overcome this problem, a multiplanar visualization would be more desirable. Our study population consisted of Japanese adults mostly of advanced age. To study the normal fissural anatomy, an ethnically mixed population including younger healthy volunteers would be optimal.

To conclude, we have presented the normal orientations of the major, minor, and accessory fissures as studied with incremental HRCT at 10 mm intervals. Our data generally support the previous study based on anatomic-pathologic data.[8] The fissures are variable in their orientations and completeness and knowledge of their normal orientation is essential for proper interpretation of chest CT.

REFERENCES

1. Wilson AG. Pleura and pleural disorders. In: Armstrong P, Wilson AG, Dee P, et al, eds. *Imaging of Diseases of the Chest*. 2nd ed. St. Louis MO: Mosby; 1995:641–716.
2. Aziz A, Ashizawa K, Nagaoki K, et al. Study of normal fissures seen on

posteroanterior and left lateral chest radiographs. *Acta Med Nagasaki*. 2001;46:67–71.
3. Marks BW, Kuhns LR. Identification of the pleural fissures with computed tomography. *Radiology*. 1982;143:139–141.
4. Proto AV, Ball JB. Computed tomography of the major and minor fissures. *AJR*. 1983;140:439–448.
5. Glazer HS, Anderson DJ, DiCroce JJ, et al. Anatomy of the major fissure: evaluation with standard and thin section CT. *Radiology*. 1991;180:839–844.
6. Hayashi K, Aziz A, Ashizawa K, et al. Radiographic and CT appearances of the major fissure in normal and various abnormal conditions. *Radiographics*. 2001;21:861–874.
7. Berkmen YM, Auh YH, Davis SD, et al. Anatomy of the minor fissure: evaluation with thin-section CT. *Radiology*. 1989;170:647–651.
8. Raasch BN, Carsky EW, Lane EJ, et al. Radiographic anatomy of the interlobar fissures: a study of 100 specimens. *AJR*. 1982;138:1043–1049.
9. Frija J, Schmit P, Katz M, et al. Computed tomography of the pulmonary fissures: normal anatomy. *J Comput Assist Tomogr*. 1982;6:1069–1074.
10. Ariyurek OM, Karabulut N, Yelgec NS, et al. Anatomy of the minor fissure: assessment with high-resolution CT and classification. *Eur Radiol*. 2002;12:175–180.
11. Godwin JD, Tarver RD. Accessory fissures of the lung. *AJR*. 1985;144:39–47.
12. Ariyurek OM, Gulsun M, Demirkazik FB. Accessory fissures of the lung: evaluation by high-resolution computed tomography. *Eur Radiol*. 2001;11:2449–2453.
13. Speckman JM, Gamsu G, Webb WR, et al. Alterations in CT mediastinal anatomy produced by an azygos lobe. *AJR*. 1981;137:47–50.
14. Felson B. *Chest Roentgenology*. Philadelphia, PA: WB Saunders; 1973.
15. Austin JHM. The left minor fissure. *Radiology*. 1986;161:433–436.
16. Yamashita H. *Roentgenologic Anatomy of the Lung*. Tokyo: Igaku-Shoin; 1978:49–53.

