The Fissural Complex of the Lung: Anatomy and Variations on Thin-Section CT Scans

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Purpose: To evaluate further the right minor and major fissure on thin-section narrow-interval CT scans with particular emphases on orientation, degree of completeness.

Materials and Methods: Thin section CT scans from 10 mm distal to carina to the proximal basal segmental bronchus were obtained at 5 mm intervals in 50 consecutive subjects. Orientation, degree of completeness, and the relationship of the minor and major fissure on thin-section CT scans were analyzed.

Results: Four principal types of the minor fissure could be identified according to the highest point of the upper surface of the middle lobe. At bronchus intermedius level, the major fissure appeared with its medial end anterior to lateral end in 45 subjects. The minor fissure was complete in only 10 subjects (20%). Completely absent minor fissure was noted in four subjects (8%). The major fissure was incomplete in 17 subjects (34%) at bronchus intermedius level. The minor and major fissure intersected each other in only 27 subjects (54%). The highest point of intersection was variable.

Conclusion: There are much more variations in the fissural complex in our study than in previous reports and these variations can be visualized well on thin-section CT scans.

Index Words: Pleura, CT
Lung, Anatomy
Lung, CT

INTRODUCTION

The fissural complex is a term that can be used to describe the relationship of the minor and major fissures on the right side of the lung. These relations are diverse because of variations in the orientation of the fissures, in the degree of incompleteness of the fissures, and in lobar size(1).

The fissures are easily depicted on thin-section CT scans as hyperattenuation lines or bands. There have been several reports on the appearances of the right minor and major fissures on thin-section CT scans(2-5). But to our knowledge, there have been no reports on the detailed anatomy of the fissural complex evaluated with thin-section CT scans.

In this study, we evaluated further the right minor and major fissures on thin-section narrow-interval CT scans with particular emphases on orientation, degree of completeness, relationship, and the uncommon appearance of the fissures.

MATERIALS and METHODS

Thin-section CT scans were obtained in 50 consecutive subjects to evaluate detailed anatomy and patterns of the fissural complex. The ages of these 37 male and 13 female subjects ranged from 13 to 84 years (average, 44 years). Fifteen normal volunteers and 35 patients with lesions that did not distort or obliterate the fissural structure were included in this study. Informed consent was obtained from all subjects.

In all subjects, CT scans were performed with CT-W 700 scanner (Hitachi Medical, Tokyo). Thin-section CT scans were obtained with the subjects in the supine position at end inspiration. Consecutive sections with
1 mm collimation (46 subjects) or 2 mm collimation (four subjects) and at 5 mm intervals were obtained from 10 mm distal to the carina to the proximal basal segmental bronchus. The entire length of the bronchus intermedius was included in the CT sections.

Imaging parameters were as follows: 120 kVp, 400 mA, and 1.9-sec scan time. An algorithm with a high-convolutional filter was used for image reconstruction without targeting. A wide window (width, 1500: level, -700) was used for image display. Contrast medium was not administered intravenously in any patient.

CT scans were retrospectively analyzed by two radiologists with a consensus. Particular attention was given to orientation, degree of completeness, and the relationship of the minor and major fissures.

The orientation of the minor fissure was categorized according to the highest point of the upper surface of the middle lobe on consecutive CT scans. The orientation of the major fissure was analyzed at bronchus intermedius level with emphases on anterior and posterior relation between its medial and lateral ends.

Incomplete fissures were defined as those that appeared without complete lobar separation. The degree of completeness of both the fissures were classified into complete, mildly incomplete (more than one half of complete fissure), moderately incomplete (less than one half of complete fissure), and absent.

The relationship between the fissures was defined by describing the highest point of intersection between the fissures if they met each other.

**RESULTS**

The minor fissure appeared as a line in 42 subjects and as a band in four subjects on thin-section CT scans. It was absent in four subjects. In four subjects who had the fissure as a band, 2 mm collimation of CT scans was used. The major fissure appeared as a line in 48 subjects and a band in two subjects on CT scans. The major fissure appeared as a band in two of four subjects in which CT scans were obtained with 2 mm collimation. Double fissure sign (fissures are seen as two parallel lines due to cardiac motion on thin-section CT scan (6)) of the major fissure was seen in six subjects (12%) at level of bronchus intermedius. Double fissure sign of the minor fissure was also seen in two subjects.

**Orientation of the fissures**

We could identify four principal types of the minor fissure according to the highest point of the upper surface.
of the middle lobe. Type I included the fissure with which the middle lobe is posteromedially high. On thin-section CT scans, the fissure on the middle lobe side was concave medially and the curvature of the fissure expanded anterolaterally on caudal scans. It was bordered medially by the middle lobe and laterally by the anterior and/or posterior segment of the upper lobe (Fig. 1). Type II included the fissure with which the middle lobe was laterally high. On thin-section CT scans, the fissure on the middle lobe side was concave laterally and the curvature of the fissure expanded anteromedially on caudal scans. It was bordered medially by the anterior and/or posterior segment of the upper lobe and laterally by the middle lobe (Fig. 2).

Type III included the fissure with which the middle lobe was domed centrally. On thin-section CT scans, the fissure appeared as a circle and the curvature of the fissure expanded peripherally on caudal scans. With this fissure, the right middle lobe was surrounded anteriorly by the anterior segment and posteriorly by the posterior segment of the right upper lobe (Fig. 3).

Type IV included the fissure with which the middle lobe was posterocentrally high. On thin-section CT scans, the fissure on the middle lobe side was concave posteriorly and it met the major fissure. The curvature of the fissure expanded anteriorly on caudal scans (Fig. 4). The fissure was bordered anteriorly, medially, and laterally by the upper lobe and posteriorly by the middle lobe and the major fissure. Type I minor fissure was observed in 15 subjects. Variation of type I minor fissure was seen in two of 15 subjects. In these, the top of the middle lobe appeared at two different portions on the same CT scan along the mediastinal side and the posteromedially high middle lobe followed on subsequent caudal CT scans. We observed type II minor fissure in 18 subjects. The minor fissure initially had contact with lateral chest wall but no contact with the major fissure [as Type II in the study of Berkmen et al. (4)] in 13 subjects (Fig. 2) whereas it had initial contact with the major fissure in five subjects [as type IIA in the study of Berkmen et al. (4)] (Fig. 5). Type III and type IV minor fissure was seen in six and three subjects respectively. In two subjects, both the minor and major fissure are incomplete and they joined together (Fig. 6).

Extensive fusion between the middle and lower lobe was formed in this type. We observed sagittal orientation of the anterior minor fissure as described by Gross et al. (7) in only one subject. The middle lobe was anteromedially high in one subject. On CT scans, the minor fissure on the middle lobe side was concave anteromedially and the fissure was bordered anteriorly by the middle lobe and posteriorly by the upper lobe.

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Fig. 2. Type II minor fissure.

a. Schematic drawings of laterally high right middle lobe as viewed from lateral side (left) and corresponding fissural surfaces as viewed from front (right).
b. CT scan at subcarinal level shows minor fissure, with which middle lobe is laterally high. Major fissure is oriented with its medial end anterior to lateral end. Ground-glass opacity in right middle lobe and upper lobe is due to recent hemoptysis. Irregular tuberculous nodules are also seen in posterior segment of upper lobe.
c. CT scan obtained 15 mm caudal to B shows medially expanding curvature of incomplete minor fissure. Posterior minor fissure has an intersection with major fissure posterocentrally (arrow). Tuberculous endobronchial mass (arrowheads) is seen in bronchus intermedius.
[Type IA in the study of Berkmen et al. (4)]. The minor fissure was absent in four subjects. Except two subjects who had the conjoined major fissure with the minor fissure, the orientation of the major fissure could be evaluated in 48 subjects. In forty-five of 48 subjects, the major fissure was oriented with its medial end anteriorly or horizontal to its lateral end (Fig. 1-5). The medial end was posterior to its lateral end in only three subjects.

Table 1. Orientation and Degree of Completeness of the Minor Fissure (n=50)

<table>
<thead>
<tr>
<th>Orientation</th>
<th>Complete</th>
<th>Mildly Incomplete</th>
<th>Moderately Incomplete</th>
<th>Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type I</td>
<td>2</td>
<td>13</td>
<td>15(30%)</td>
<td></td>
</tr>
<tr>
<td>Type II</td>
<td>2</td>
<td>13</td>
<td>3</td>
<td>18(36%)</td>
</tr>
<tr>
<td>Type III</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>6(12%)</td>
</tr>
<tr>
<td>Type IV</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>3(6%)</td>
</tr>
<tr>
<td>Indeterminate</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>4(8%)</td>
</tr>
<tr>
<td>Absent</td>
<td></td>
<td></td>
<td></td>
<td>4(8%)</td>
</tr>
<tr>
<td>Total</td>
<td>10(20%)</td>
<td>32(64%)</td>
<td>4(8%)</td>
<td>50(100%)</td>
</tr>
</tbody>
</table>

+ Indeterminate group included two subjects with conjoined minor and major fissure, one subject with sagittal orientation of anterior minor fissure, and one subject with the fissure in anteromedially high middle lobe.

The degree of completeness of the fissures

The degree of completeness of the minor fissure was described in Table 1 in relation to each type of the orientation of the fissure. The right minor fissure was completely traced in 10 subjects (20%). It was mildly incomplete (Fig. 1, 2, 5) in 32 subjects (64%) and moderately incomplete in four subjects (8%). The minor fissure was absent in four subjects (8%). Mildly incomplete minor fissure caused mild degree of fusion between the upper and middle lobe (Fig. 1, 2, 5). In eight subjects with moderately incomplete or absent minor fissure, extensive fusion between the upper and middle lobe was shown.

The right major fissure was complete in 33 subjects (66%) at bronchus intermedius level. They are mildly incomplete (Fig. 1) in 14 subjects (28%) and moderately in complete in three subjects (6%). Incomplete major fissure also caused a fusion between the adjacent lobes. With sufficiently high middle lobe and accordingly high minor fissure, incomplete major fissure at bronchus intermedius level caused a fusion between the middle and lower lobe (Fig. 1). But with low middle lobe and accordingly low minor fissure, it caused a fusion between the upper and lower lobe at this level. In two subjects with conjoined minor and major fissure, extensive fusion between the middle and lower lobe was seen (Fig. 6).

Fig. 3. Type III minor fissure.

a. Schematic drawings of domed right middle lobe as viewed from lateral side (left) and corresponding fissural surfaces as viewed from front (right).
b. CT scan at level of bronchus intermedius shows minor fissure, with which middle lobe is domed centrally. Middle lobe is surrounded by minor fissure.
c. CT scan obtained 5 mm caudal to B shows concentrically expanding curvature of minor fissure. Minor and major fissure do not meet each other.
Relationship between the fissures
Intersection between the minor and major fissure was shown in 27 (54%) of 50 subjects. The portion of the highest intersection between the fissures on thin-section CT scans was not always posteromedial (Fig. 1).

Posteroventrally (Fig. 2, 4, 5) and posterolaterally high.

Fig. 4. Type IV minor fissure.

a. Schematic drawings of posteroventrally high right middle lobe as viewed from lateral side (left) and corresponding fissural surfaces as viewed from front (right).
b. CT scan at level of bronchus intermedius shows minor fissure, with which middle lobe is posteroventrally high. Minor fissure meets major fissure posteriorly.
c. CT scan obtained 5 mm caudal to B shows anterolaterally expanding curvature of minor fissure.

Fig. 5. Variant type II minor fissure.

a. CT scan at subcarinal level shows laterally high middle lobe. Posterior minor fissure had initial intersection with major fissure.
b. CT scan obtained 10 mm caudal to A shows anteromedially expanding curvature of incomplete minor fissure.
DISCUSSION

Berkmen et al. (4) described the anatomy of the minor fissure by using thin-section CT scans and categorized the fissure into two major configuration; the location of the highest point of the upper surface of the middle lobe is medial(type I) and lateral(type II). This type I and type II minor fissure on thin-section CT scans roughly parallel type I and type II fissure in our study. With a sufficiently domed middle lobe, it is conceivable that some of vascularized right upper lobe may also be seen posterior to the minor fissure and anterior to the major fissure. With idea of this domed middle lobe, Frija et al.(3,5) added another type of minor fissure. This fissure appears as a linear circle surrounding the middle lobe on thin-section CT scan. This type III minor fissure was seen in six(12%) subjects in our study. Proto and Ball(8) also observed this domed middle lobe appearing as a round or oval lucent area on conventional CT scans in eight(8%) of 100 subjects. If the middle lobe is high posterocentrally, it could be expected that the vascularized lung anterior, medial, and lateral to the minor fissure should belong to the right upper lobe. The vascularized lung posterior to the minor fissure is usually the right middle lobe on thin-section CT scan. This is the type IV minor fissure in our study which was seen in three subjects(6%). Gross et al.(7) reported radiographic and CT findings of sagittal orientation of the anterior minor fissure. In their study, they suggested that the sagittal anterior minor fissure should extend inferiorly to the right hemidiaphragm and merge superiorly with the horizontal minor fissure. They found 12 cases of sagittal orientation of the anterior minor fissure during nine-month-study. We could find only one subject(2%) with this type of the minor fissure.

The frequency of each type of the minor fissure in our study is much different from that of previous study. In the study of Berkmen et al. (4), type II minor fissure was seen in only four(13%) of 32 subjects in their study. On the contrary, type I minor fissure prevailed (25 of 32 subjects; 78%). There was no mention on the minor fissure of type III and type IV in their study. In our study, the frequency of type II minor fissure (18 of 50 subjects; 36%) outnumbered that of type I minor fissure(15 of 50 subjects; 30%). This difference in frequency of each type of the minor fissure can not be explained simply. But in our study, we evaluated the fissural complex with narrow-interval CT scans. With this condition, more detailed anatomy of the fissural complex may have been shown.

The orientation of the minor fissure varies. In general, it has been regarded that the anterior aspect of the minor fissure is lower than the posterior aspect and the lateral part is lower than the medial part(1,4). Our study partly corroborated this suggestion, but in our study, laterally high minor fissure was shown in 18 subjects. So we think the minor fissure is not always high in its medial part.

The fissures are incomplete very frequently. Incomplete fissures may be defined as those that show absence of lobar separation. The frequency of the incomplete minor fissure is more than that of the incomplete major fissure. The frequency of incomplete minor fissure studied with anatomical specimens ranged from 62.3% to 88%(1, 9-11). The right minor fissure is also
incomplete in the studies with thin-section CT scans. The frequency of incompleteness of the right minor fissure on thin-section CT scans ranged from 12.5% to 47% (1, 10). On thin-section CT (with 2-mm collimation and at 2-cm intervals), Glazer et al. (2) noted incomplete right major fissure in 32 (64%) of 50 studied cases, at least one of three levels in carina, bronchus intermedius, and left atrium. And at bronchus intermedius level, they noted incomplete right major fissure in 17 (35%) of 49 identified major fissures. This frequency is also comparable with that of our study (34%).

We found conjoined incomplete right minor and major fissure in two subjects (4%) with extensive fusion between the right middle and lower lobe. This condition has not been mentioned in previous CT studies on the minor fissure.

Despite the diverse relation between the right major and minor fissures, the followings have been regarded as rules between the fissures: (a) Due to the lateral facing of the right major fissure (oriented with its medial end anterior to its lateral end), the intersection of the two fissures is anterior to the lateral edge of the major fissure. The highest point of intersection of the two fissures is posteromedial (1). In our study, lateral facing of the major fissure could be substantiated and was seen in 45 subjects. But there were noticeably many of the minor fissures of type II, III, and IV and so the highest point of intersection between the fissures was not always posteromedial. The highest point of intersection between the fissures was variable (Fig. 2, 4, 5, 7).

Familiarity with anatomy of the fissural complex may give a help in clarifying initially confusing plain radiographic findings. These include fluid collection in the incomplete fissures with various appearances, spread of disease processes through the incomplete fissures, and collateral air drift through lobar fusion (12, 13). Fissural fusion, especially in cases of conjoined fissure, may explain some interesting appearances of pleural fluid such as middle lobe step (horizontal plateau of fluid at the minor fissure and curvilinear lung-fluid interface below the minor fissure) (12). At times, both the anterior and posterior parts of an incomplete minor fissure may be seen on radiographs, especially when fluid is present. The posterior part projects superiorly, and therefore may be mistaken for the superior medial margin of the right major fissure, which is oriented in the same direction of the frontal view. In other cases, fluid in the anterior and posterior parts of the minor fissure can be clearly distinguished from fluid in the major fissure (13).

Acknowledgments
We sincerely thank Kyung Ae Paik for her line drawings.

REFERENCES

우측열구 복합체: 세절편 전산화단층촬영상의 해부학 및 변이
이경수 · 김표년 · 김일영 · 배원경 · 이병호
순천향대학교 의과대학 방사선과학교실

목 적: 세절편 전산화단층촬영을 이용하여 우측 대열구 및 소열구 등의 열구 복합체(fissural complex)의 해부학 및 변이를 알아보고자 하였다.

대상 및 방법: 50명의 성인에서 기관 용골부위부터 기저폐분절 기관지 근위부까지 5 mm 간격으로 1 mm 두께의 세절편 전산화단층촬영을 얻어 우측 대열구와 소열구의 정위, 완전성 및 두 열구의 관계를 알아보았다.

결 과: 우중엽의 높이에 따라 4종류의 소열구 형태를 볼 수 있었으며 대열구는 90%에서 중간 기관지부위에서 내측이 외측보다 전방에 위치하였다. 소열구는 20%에서 완전하였고 8%에서는 소열구를 볼 수 없었다. 중간 기관지부위에서 대열구는 34%에서 불완전하였다. 대·소열구는 54%에서서 서로 만남을 볼 수 있었고 만나는 위치는 변화가 심하였다.

결 론: 열구 복합체의 해부학적 모양이 과거에 보고된 양상보다 좀 더 복잡하고 다양함을 보여준다.