MAJOR ANATOMIC VARIATIONS OF PULMONARY FISSURES AND LOBES ON POSTMORTEM EXAMINATION*

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SUMMARY – This study was aimed at determining major accessory fissures (MAF) and absence or incompleteness of lobar or major fissures (MF) during routine forensic autopsies. Prior to starting this prospective study, forms were prepared to collect data on pulmonary lobes and fissures. In this study, 420 lungs of 210 autopsy cases were examined for incompleteness and absence of MF and complete accessory fissures. Horizontal fissures were incomplete in 18 right lungs. Incomplete oblique fissures were noted in three right and two left lungs. Unidentified abnormal fissures were determined in one left lung and five right lungs. The most common fissural abnormality was less than half complete horizontal fissure. Four right lungs had four lobes and two left lungs had three lobes because of complete accessory fissures. The number of lobes in the left and right lungs and the morphological features of both incomplete MF and MAF were determined in detail and the variations were photographed. It is concluded that, in addition to studies on computed tomography scans, autopsy series are useful for determining the variations of MF and MAF of the lungs in different populations.

Key words: *Lung – anatomy and histology; Lung – abnormalities; Autopsy*

Introduction

The lungs are divided into various lobes by a double layer of infolded reflections of visceral pleura called fissures[1-3]. There are two types of pulmonary fissures: lobar or major fissure (MF) and accessory fissure (AF)[3]. Normal MF (oblique and horizontal fissures) consists of double layers of infolded invaginations of the visceral pleura[4].

The left lung is divided into superior and inferior lobes by an oblique fissure that extends from the costal to the medial surfaces of the lung both above and below the hilum. Superficially, this fissure begins on the medial surface at the posterosuperior part of the hilum. It ascends obliquely backwards to cross the posterior border of the lung about 6 cm below the apex and then descends forwards across the costal surface to reach the lower border almost at its anterior end. The left horizontal fissure is a normal variant found in 10% of patients[1,2].

The right lung is divided into superior, middle and inferior lobes by oblique and horizontal fissures. The upper, oblique fissure separates the inferior from the middle and upper lobes, and corresponds closely to the left oblique fissure, although it is less vertical, and crosses the inferior border of the lung about 7.5 cm behind its anterior end. The short horizontal fissure separates the superior and middle lobes. It passes from

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the oblique fissure, near the midaxillary line, horizontally forwards to the anterior border of the lung, level with the sternal end of the fourth costal cartilage, and then passes backwards to the hilum on the mediastinal surface[2].

The MF may be complete when the lobes remain held together only at the hilum by the bronchi and pulmonary vessels, or they may be incomplete when there are areas of parenchymal fusion between the lobes[3]. An AF is a cleft of varying depth lined by two layers of visceral pleura. It can be complete or incomplete and extends inward towards the hilum at different depths[5]. Complete AF and absence or incompleteness of MF (horizontal and oblique) are important as they change the number of lobes in the lungs. In the presence of these major variations, the left lung may have three lobes and the right lung may have four or only two lobes.

To the best of our knowledge, there are only a few studies on major anatomic variations of AF and MF and lobes in autopsy series in the literature. This study was aimed at determining major accessory fissures (MAF) and absence or incompleteness of MF during routine forensic autopsies.

Materials and Methods

Prior to beginning this prospective study, forms were prepared to collect data on pulmonary lobes and fissures. Data were collected from 210 Anatolian medicolegal autopsies performed by forensic pathologists at The Konya Branch of Forensic Medicine Council (Turkey) and in the districts of Konya. During postmortem examination of the corpses, the thoraces were opened by cutting costal cartilages at 0.5 cm medially of the costochondral joint with a costotome.

A total of 420 lungs were examined for MAF and absence or incompleteness of MF. MAF were classified as: (a) complete or substantially complete (MAF-C); (b) half or slightly more than half complete (MAF-MH); and (c) less than half complete (MAF-LH). Absence or incompleteness of MF was classified as: (a) absence (MF-A); (b) half or slightly more than half complete (MF-MH); and (c) less than half complete (MF-LH).

Lobe numbers of the right and left lungs were determined according to fissure variations. The bronchial tree from the main bronchus to segmental bronchi of the lungs, which had lobe number changing fissure anomalies, was dissected. The prepared forms were

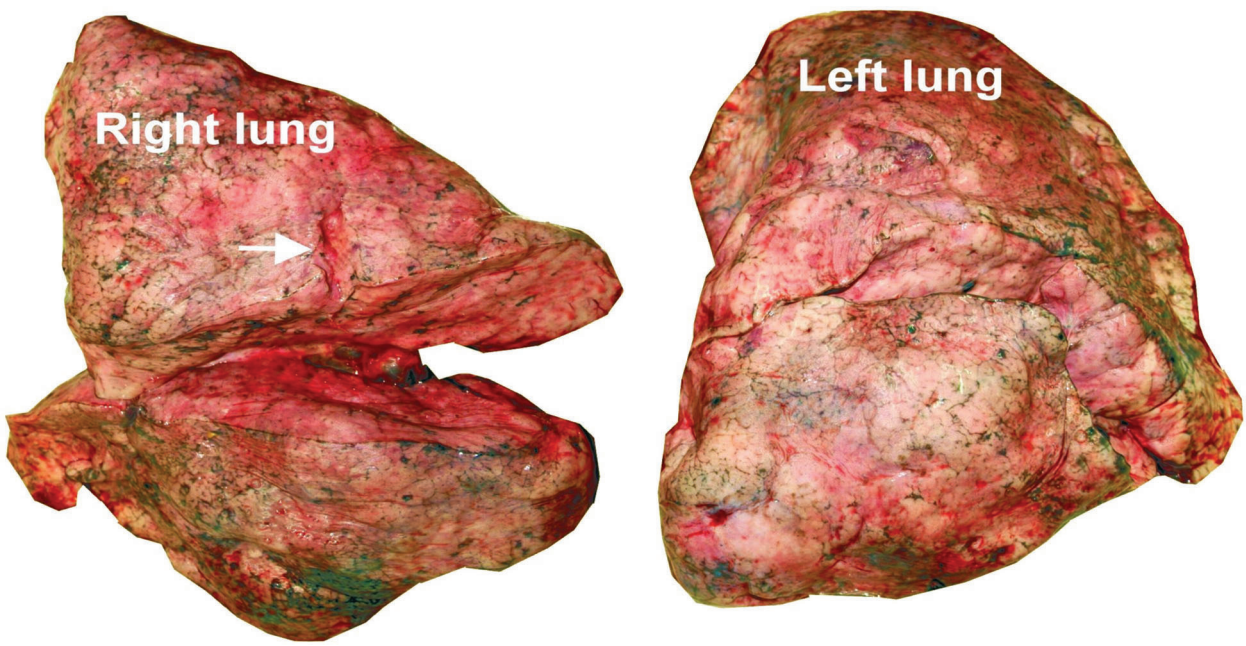

Fig. 1. A 53-year-old female: the oblique fissure is normal but the horizontal fissure is more than half incomplete in the right lung. Both right and left lungs have two lobes.

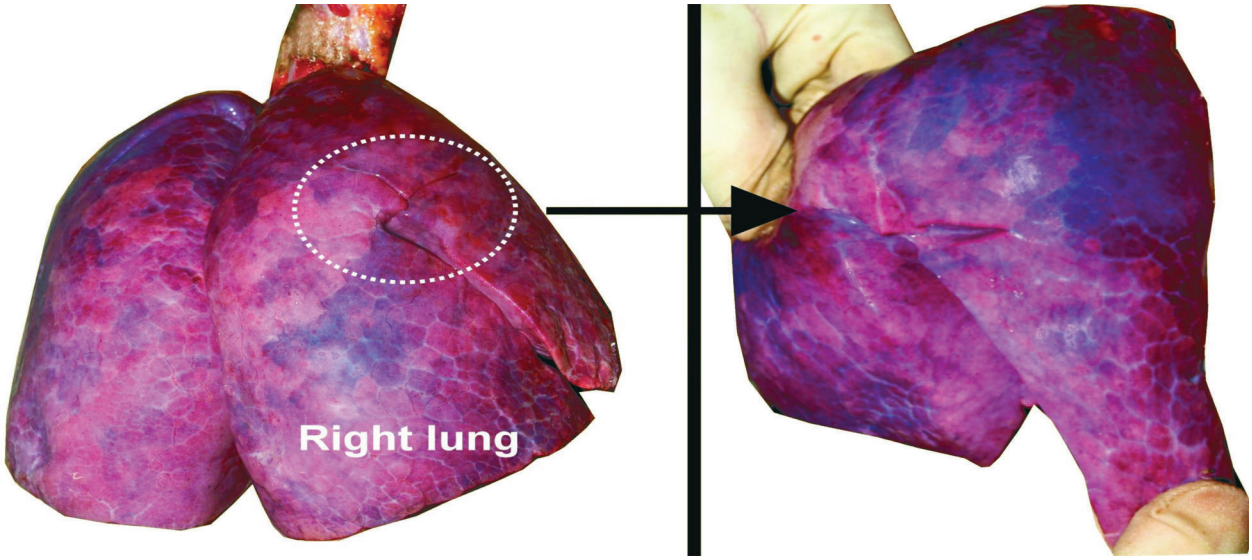

Fig. 2. A 6-year-old male: a slightly more than half complete oblique fissure and a very small horizontal fissure in the right lung, which has two lobes.

filled out for each of the cases and detailed photographs of the lungs were taken.

Results

The cases were aged between 1 and 93 years, mean age 35.5 years. A total of 420 lungs of 210 autopsy cases were examined in this study, with 142 (67.6%) of the cases male and 68 (32.4%) of them female. Horizontal fissures were incomplete in 18 right lungs (Fig.

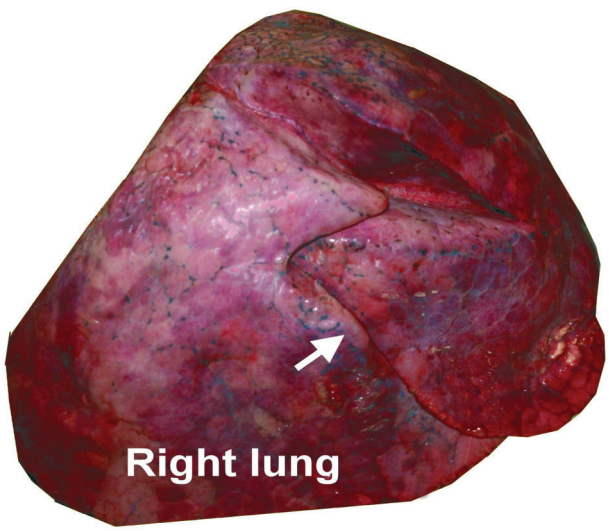

Fig. 3. A 31-year-old male: incomplete oblique and horizontal fissures in the right lung (unidentified abnormal fissure).

Fig. 4. A 25-year-old male: a slightly more than half complete oblique fissure in the left lung.

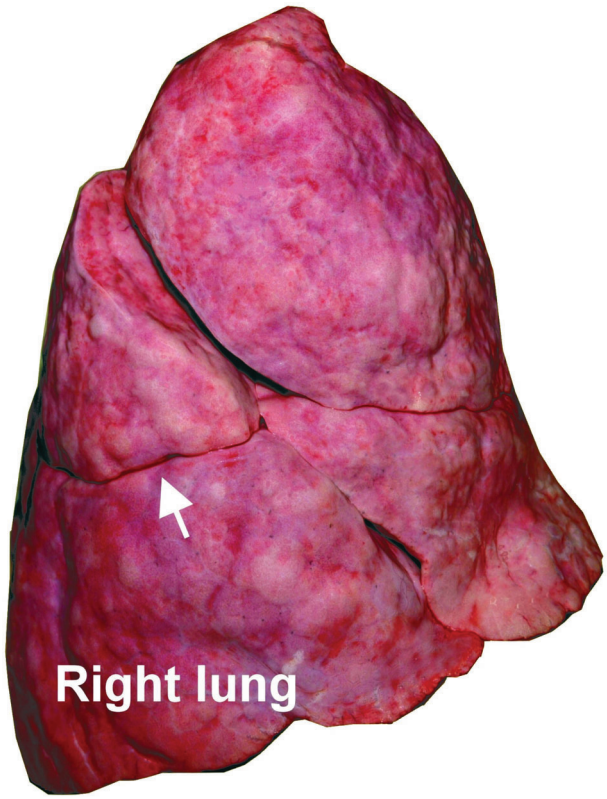

Fig. 5. A 4-year-old male: a complete accessory fissure in the right lung. The right lung has four lobes.

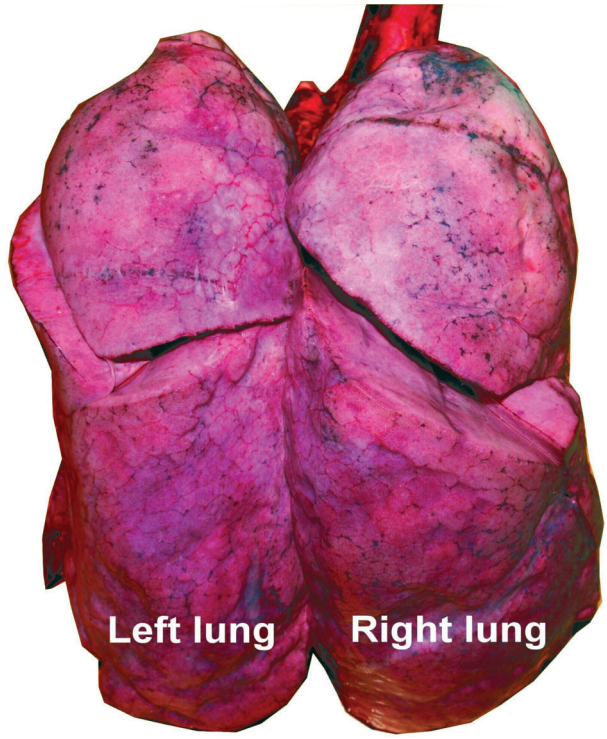

Fig. 6. A 35-year-old male: a complete accessory fissure in the left lung. Both left and right lungs have three lobes.

1), and incomplete oblique fissures were noted in three right (Figs. 2 and 3) and two left lungs (Fig. 4).

Detailed findings of MF and MAF are given in Table 1 and the number of lobes is shown in Table 2. The most common fissure abnormality was less than half complete horizontal fissure (6.2%). Unidentified abnormal fissures were determined in one left lung and five right lungs (Fig. 3).

Because of complete AF, four right lungs had four lobes (Fig. 5) and two left lungs had three lobes (Fig. 6). Four right lungs had two lobes because of absence of MF (Figs. 1 and 2).

When the bronchial tree from the main bronchus to segmental bronchi of the lungs, which had lobe number changing fissure anomalies, was dissected, it was observed that the numbers of lobar bronchi were compatible with the numbers of lung lobes, and the numbers of segmental bronchi did not change.

Table 1. Variations of interlobar fissures of the lungs in 210 autopsy cases

Fissure condition	Left lung		Right lung		
	Oblique fissure	Accessory fissure	Oblique fissure	Horizontal fissure	Accessory fissure
Complete or substantially complete	208	1	206	184	5
Half or slightly more than half complete	2	5	2	5	1
Less than half complete	–	5	1	13	2
Absent fissure	–	–	–	4	–
Unidentified abnormal fissure	–	1	1	4	–

Table 2. Number of lung lobes in 210 autopsy cases

	1 lobe	2 lobes	3 lobes	4 lobes
Left lung	2	206	2	–
Right lung	2	4	200	4

Discussion

Left and right differences in pulmonary lobulation are apparent in the early part of the sixth week of human development, and the architecture of the bronchopulmonary tree is essentially complete by the fourteenth week, by which time the pulmonary fissures are well formed. Computed tomography (CT) has enabled variations in the pattern of pulmonary fissures to be described in several series of adults, yielding the incidence of anomalous MF between 2% and 20%, a variation probably largely due to difficulties in the interpretation of incomplete fissures[6].

In a series of 1200 consecutive autopsies, the condition of lung fissures was determined as follows: (a) oblique fissure of left lung: complete 82.1%, over half complete 10.6%, less than half complete to no fissure 7.3%; (b) oblique fissure of the right lung: complete 69.6%, over half complete 25.6%, less than half complete to no fissure 4.8%; and (c) horizontal fissure of the right lung: complete 37.7%, over half complete 17.1%, less than half complete to no fissure 45.2%[7]. In a fetal postmortem study, a prevalence of 2.3% places anomalous pulmonary fissuring among the more common morphological abnormalities observed. The most common abnormality was absence of the horizontal fissure on the right, followed by an anomalous horizontal fissure on the left in the same study[6].

Glazer *et al.*[8] report that an incomplete MF was identified on thin-section images as a line or hyperattenuating band that did not extend to the mediastinum or hilum. In the same study, an incomplete MF was noted in the right lung in 64% and in the left lung in 52% of cases, and the upper and middle portions of the left MF were less frequently incomplete than were the comparable portions of the right MF[8]. A higher frequency of incomplete fissures has been reported in another study, which found some degree of fusion across the right MF in 71% and across the left MF in 73% of 270 fixed and inflated lungs (140 right and 130 left lungs)[9]. A plain radiographic-anatomic study of 100 specimens (50 right and 50 left lungs) demonstrated a 70% incidence of fusion across the upper right MF, 47% across the lower right MF, 40% across the upper left MF, and 46% across the lower left MF[10]. In our study, only major incomplete MF (MF-MH and MF-LH) were determined. According to our findings, horizontal fissures were the most common major incomplete fissure.

It has been reported in the literature that the true lobar pattern abnormalities occur in some conditions, notably situs inversus viscerum, polysplenia and asplenia, where it is believed to be an underlying defect in the normal process of determination of the left-right asymmetry. Polysplenia syndrome is characterized by bilateral bilobed lungs and asplenia by bilateral trilobed lungs; these syndromes are sometimes referred to as bilateral left- or right-sidedness, respectively[6,11]. In Bates' study[6], which was performed on fetuses with anomalous fissures, it is reported that other malformations were approximately three times more common than in fetuses with a normal fissural pattern, and four cases, one with situs inversus totalis and three with polysplenia syndrome, represented this type of abnormality. In our study, situs inversus totalis and asplenia were not detected in any of the cases, but both lobar pattern anomaly and polysplenia were detected in six cases.

The MF complicating identification of various diseases may be incomplete (MF-MH and MF-LH) or absent (MF-A). An incomplete MF may spread to adjacent lobes through the area of pulmonary fusion, and part of a collapsed lobe may demonstrate collateral air drift. Interlobar pleural effusion may have a characteristic appearance (incomplete fissure sign) when the MF is incomplete, although this sign may also be present in the case of complete fissure[4]. The identification of the completeness of the fissures is important prior to lobectomy because individuals with incomplete fissures are more prone to develop postoperative air leaks and may require further procedures such as stapling and pericardial sleeves[2,12]. The surgeon can avoid air leaks by properly clamping the fused pulmonary lobe segments[12]. In addition, it may be important to identify incomplete fissures, as it is believed that they may allow collateral ventilation between the lobes, which may compromise lobar exclusion[13].

Radiological studies were performed to classify and assess the frequency of AF of the lung by high-resolu-

tion CT scan[5,14]. In these studies, AF were detected in 32% and 30% of the patients and the inferior AF were most common (21% and 12%, respectively)[5,14]. On the contrary, in the study by Kilic *et al*.[15], the AF of the cadaver lungs were investigated and the right inferior AF (20%) was reported as the most common AF. In our study, MAF-C, MAF-MH and MAF-LH were investigated and MAF were most common in the inferior lobe of the left lung.

Accessory fissures are often unappreciated or misinterpreted on radiographs and CT scans[5], and these fissures, like all other fissures, serve not only as natural barriers against infection but also help in localizing any focal pulmonary parenchymal disease (e.g., a pulmonary nodule) and in differentiating pleural from parenchymal disease[16-18]. Therefore, identifying AF is important for a more precise localization of lesions and characterization of diseases[3,19].

Knowledge of the anatomy and normal variants of the MF and MAF may provide useful information for recognizing their variable imaging appearances, as well as the related abnormalities. Being aware of these variations before pulmonary lobectomy and segmentectomy may alter the preoperative plans.

Conclusion

Morphological and morphometric features and the incidence of MF and MAF in 420 Anatolian autopsy lungs were evaluated in this study. The most important limitation of this study was determination of only major anomalies in these lungs. It is concluded that, in addition to studies on CT scans, autopsy series are useful for determining the variations of MF and MAF of the lungs in different populations.

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Sažetak

VELIKE ANATOMSKE VARIJACIJE PLUĆNIH PUKOTINA I REŽNJEVA NA OBDUKCIJI

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Cilj ove studije bio je utvrditi glavne pomoćne pukotine te odsutne ili nepotpune lobarne ili glavne pukotine tijekom rutinske forenzične obdukcije. Prije početka ove prospektivne studije pripremljeni su obrasci za prikupljanje podataka o plućnim režnjevima i pukotinama. U ovoj studiji su odsutne ili nepotpune glavne pukotine te potpune pomoćne pukotine ispitane na 420 pluća u 210 obdukcijskih slučajeva. Horizontalne pukotine su bile nepotpune u 18 desnih pluća. Nepotpune kose pukotine utvrđene su u trima desnim i dvama lijevim plućima. Neidentificirane nenormalne pukotine utvrđene su u jednom lijevom plućnom krilu i pet desnih plućnih krila. Manje od pola potpune horizontalne pukotine bila je najčešća nenormalnost pukotina. Četiri desnih plućnih krila imalo je četiri režnja, a dvoja lijevih plućnih krila tri režnja zbog potpunih pomoćnih pukotina. Broj režnjeva u lijevim i desnim plućima te morfološka obilježja nepotpune glavne pukotine i glavne pomoćne pukotine točno je utrvđen, a varijacije su fotografirane. Zaključuje se da su uz kompjutorsku tomografiju obdukcijski slučajevi korisni za određivanje varijacija glavnih plućnih pukotina i pomoćnih glavnih pukotina u različitim populacijama.

Ključne riječi: *Pluća – anatomija i histologija; Pluća – anomalije; Obdukcija*