Rounded Atelectasis*
Clinical Experience with 74 Patients
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Rounded atelectasis is an atelectasis of a peripheral part of the lung due to pleural adhesions and fibrosis causing deformation of the lung and bending of some small bronchi. From 1970 to 1986, some 74 patients with rounded atelectasis have been seen at the Lung Department. Sixty-four of these patients had been exposed to asbestos. The lesion was secondary to a benign asbestos pleurisy in nine patients and resulted from a slowly increasing pleural fibrosis in 13 patients; in the remaining 39 patients with exposure to asbestos, rounded atelectasis was a sudden finding, with earlier roentgenograms showing only plaques or being normal. Three patients had bilateral lesions, and one had no fewer than three small rounded atelectases. All of the asbestos-exposed patients were men. Ten patients (four women and six men) had not been exposed to asbestos. Two of these cases occurred after trauma and four after a pleural exudate. One of the latter was the only one which disappeared spontaneously. The lingula was affected in 33 cases, the middle lobe in 16, the right lower lobe in 12, the left lower lobe in 11, the right upper lobe in six, and the left upper lobe (except the lingula) in one. Nine patients underwent surgery. Operation should be avoided; the typical roentgenologic and CT findings combined with negative results of bronchoscopy (and, in some cases, fine-needle biopsy) will suffice to exclude malignancy.

(Chest 1989; 95:936-41)

Pleural adhesions can cause atelectasis of part of the peripheral area of the lung, which on a plain chest roentgenogram has a rounded appearance. Although it was first described in association with pleural exudates and after therapeutic pneumothorax, exposure to asbestos is the principal cause today; however, any type of pleural inflammatory reaction can result in rounded atelectasis. There has been some controversy as to the importance of asbestos and regarding the pathogenetic mechanism. Two mechanisms have been suggested: the first is that the tumor occurs after a pleural exudate, and the other that it is the result of shrinking of extensive pleural fibrosis. In fact, both mechanisms occur. Material from the Lung Department in Uppsala, Sweden has been reviewed retrospectively to further elucidate this entity.

MATERIALS AND METHODS

Definition and Diagnosis

Rounded atelectasis is defined as atelectasis of a peripheral part of the lung due to pleural adhesions causing deformation of the lung and bending of some small bronchi. The lesion is usually suspected from the typical radiologic features: a tumor-like pleural-based lesion with fibrous strands or vessels (or both) and bronchi converging towards the lesion, often forming a typical "comet tail." In typical cases, rounding of the costophrenic angle is also present. Computed tomography is in most cases diagnostic, showing converging bronchi and vessels and thickened pleura. Pleural plaques are rarely mistaken for intraparenchymal lesions; in such cases, fluoroscopy with rotation of the patient quickly solves the problem.

Material and Investigations

All patients with rounded atelectasis who had been seen at the Lung Department from 1970 to 1986 were included. The findings in 12 of these patients have been reported previously. A thorough clinical history, including information on exposure to various agents, especially asbestos, was taken in all cases. Pulmonary function tests, including TLC and VC, were performed. All earlier available chest roentgenograms were sought. The investigations included CT scans in the later years; these were performed in 45 patients. Bronchoscopy has been done in 40 patients and fine-needle transthoracic biopsy in 31. Thoracotomy was performed in nine of the asbestos-exposed group and in two of the nonexposed patients, confirming in all cases the benign nature of the lesion. With increasing experience of rounded atelectasis, invasive methods are now rarely used.

RESULTS

In all, 74 patients were included in the study.

Incidence

From 1970 to 1979, some 23 patients from the County of Uppsala, Sweden, were diagnosed with rounded atelectasis, while during the period of 1980 to 1986, there were 51 patients. The Lung Clinic is the only available one in the county, and practically all occurring cases would be referred there. If calculated on all men 40 years of age or older in the county, there was a yearly incidence of 5/100,000 during the first time period (1970 to 1979) and 15/100,000 during the second (1980 to 1986).

Exposure to Asbestos

Of the 74 patients, 64 had been occupationally
exposed to asbestos, while ten denied such exposure.

Patients Exposed to Asbestos: All 64 patients were men. Their mean age was 62.6 years (1 SD = 11.3 years) at the discovery of the rounded atelectasis, the youngest being 34 years and the oldest 83 years. Only one patient, who had been an insulator, had had heavy daily exposure to asbestos. All of the others claimed moderate and intermittent exposure as builders or construction workers (31 patients), plumbers (five), electricians (four), car mechanics (four), and similar trades. The mean length of exposure was 24.6 years (1 SD = 12.6 years), and the mean latency time from first exposure was 36 years (1 SD = 10.4 years).

Patients Not Exposed to Asbestos: Of the ten patients who denied exposure to asbestos, four were women, and six were men. Their mean age was 59 years, with extremes of 35 to 75 years. Two of the cases occurred after trauma leading to rib fractures and hemorrhagic pleurisy. In four patients the lesions were seen after a pleural exudate of unknown cause. In one of those patients, the rounded atelectasis disappeared spontaneously. The final four cases were discovered en passant, and there was no history of previous pleurisy or chest trauma.

Smoking Habits

Among the 64 men who were exposed to asbestos, 30 were smokers at the time when the rounded atelectasis appeared, 24 were ex-smokers, and ten had never smoked. Of the ten nonexposed patients, one woman and five men were smokers, while the others had never smoked.

Site of Rounded Atelectases

Of the 64 patients who had occupational exposure to asbestos, 60 patients had only one rounded atelectasis each. Twenty-five were situated in the lingula, 11 in the right middle lobe, ten in the left lower lobe, nine in the right lower lobe, four in the right upper lobe, and one in the left upper lobe. Three patients had two rounded atelectases, two in both the middle lobe and the lingula, and one in the lingula and the right lower lobe. Finally, one patient had no fewer than three small rounded atelectases, one in each lower lobe and one in the right upper lobe. In the ten patients who were not exposed to asbestos, the lesions were situated in the lingula in five patients, in the right middle lobe in three, in the left lower lobe in one, and in the right upper lobe in one.

Thus, in all, there were 79 rounded atelectases: 33 (42 percent) in the lingula; 16 (20 percent) in the middle lobe; 12 (15 percent) in the right lower lobe; 11 (14 percent) in the left lower lobe; six (8 percent) in the right upper lobe; and one (1 percent) in the left upper lobe (Fig 1A). Thus, the left side was affected in 60 percent of the cases and the right in 40 percent, the difference being mainly due to the increased incidence in the lingula.

Roentgenograms before Occurrence of Rounded Atelectasis

Sixty-four patients had asbestos-related lesions. Of these 64, earlier chest roentgenograms were not available in nine cases. Six had had a normal roentgenogram two to five years previously, and 27 had pleural plaques only. The patients with pleural plaques had been followed regularly every two years with a chest roentgenogram. Thirteen patients had a progressive
pleuroparenchymal fibrosis, which involved the lung in such a fashion that a rounded atelectasis was formed (Fig 2). In nine patients, there was a pleural exudate of the type, benign asbestos pleurisy, which resulted in pleural fibrosis with rounded atelectasis.

Of the ten patients who denied exposure, earlier chest roentgenograms no older than five years earlier were available in eight. Seven of these were normal; one showed a pleuroparenchymal fibrosis bilaterally.

**Development after the Occurrence of Rounded Atelectases**

Of the 64 patients with asbestos-related lesions, follow-up has not been possible in three. In the others, observation time ranges from one to 16 years, with a mean of six years (Table 1). In 24 patients the rounded atelectasis has been stable, and there has been no other change occurring except for slight gradual increase of pleural plaques, if present. The observation time for this group is one to 12 years, with a mean of four years. In two patients with an observation time of seven years who had a normal chest roentgenogram before the rounded atelectasis, typical pleural plaques have, in addition, become visible.

In 12 patients, progressive pleuroparenchymal fibrosis has developed on the other side, from initially being normal or showing pleural plaques only. The observation time is two to 15 years (mean, nine years). Two of those patients had a pleural exudate on the side contralateral to the rounded atelectasis after one and four years, respectively. In 23 patients, bilateral progressive pleural fibrosis has either developed or continued to progress after the occurrence of the rounded atelectasis. These patients have been observed for one to 16 years, with a mean of seven years. Thus, in 35 patients (55 percent of all those exposed to asbestos), bilateral progressive pleuroparenchymal fibrosis either preceded the rounded atelectasis or developed after its appearance (Fig 2).

In all of the patients not exposed to asbestos, the rounded atelectasis has been stable, with the exception of the one mentioned case where it disappeared spontaneously, and the sequelae of the pleurisy have been nonprogressive. The ten patients have been followed for periods of three to ten years, with a mean of five years.

**Deaths**

Nine patients have died during the follow-up, all of them in the group exposed to asbestos. Two died from...
myocardial infarction four and eight years after the occurrence of the rounded atelectasis, and one died of cardiac insufficiency after one year. Three have died from asbestosis, two one year after the rounded atelectasis and one after four years; and two have died of pneumonia (according to the death certificate) at two and three years after the occurrence of this lesion.

_Pulmonary Function Tests_

These were performed in four of the nonexposed patients, who in the mean had a VC of 91 percent of the predicted value and a TLC of 111 percent. The same values in 42 patients who had been exposed to asbestos were 82 and 84 percent, respectively. Thus, most patients in the asbestos-exposed group showed a usually slight restriction, but a few had a severe affection with values of less than half of predicted, while those who were not exposed had pulmonary function within normal limits.

_DISCUSSION_

Rounded atelectasis has received increased interest in recent years, the probable main reason being that the majority of cases seen today are related to exposure to asbestos; however, any kind of pleuropulmonary reaction can result in this condition. A vast array of terms has been suggested for the entity, for example, contracted pleurisy,6 folded lung,8 pleuroma,10 Blesovsky's syndrome,11 shrinking pleuritis with atelectasis,6 and, if located at the lingula, twisted or folded lingula.12 The term "rounded atelectasis," was suggested by Hanke6 in 1971 and would seem suitable, as it is simple and short; in addition, this was the first article with a good description of the entity.

Although rounded atelectasis was originally described in association with pleural effusions1 and after therapeutic pneumothorax,8,4 there is no doubt that asbestos is the principal cause today. Of 33 cases described up to 1979,2,3,5,8,9,18,19 only six were said to be caused by asbestos; in the other cases, asbestos was not mentioned, and the causes of the effusion, when known, were stated to be tuberculosis, therapeutic pneumothorax, decompensation, infections other than tuberculosis, pulmonary infarction, or malignant tumor. Blesovsky9 pointed out the connection with exposure to asbestos in 1966, but it was not until 1980 that this was generally accepted. Since 1980, more than 200 new cases have been reported, excluding those in the present study.9,10,11,20-29 In 71 of these, mention of asbestos is made; 56 were exposed to it, and 15 were not.

One mechanism of rounded atelectasis is that described by Hanke;6 within a pleural effusion a part of the lung becomes atelectatic and adheres to another part of the lung. When the exudate is resorbed, the adhesions remain, and when the adjacent parts of the lung expand, some bronchi will be folded, and thus part of the lung cannot refill with air—it has become "trapped." Another mechanism is that there are diffuse fibrotic changes of the pleura involving the peripheral part of the lungs which progress or contract when "maturing," forcing part of the lung to become atelectatic. Bronchi under a fibrotic pleura will tend to bend like "trees to the wind."28 This is particularly true for diffuse pleural thickening due to asbestos, where the shape of the underlying bronchi has been likened to "flowing moustaches"26 or a broom.19 Pleural effusion, often without noticeable symptoms, is seen following exposure to asbestos, and so is extensive pleural thickening with fibrous strands reaching deep into the lung.31

Both of these mechanisms can result in rounded atelectasis in patients who have been exposed to asbestos. The patients with a normal chest roentgenogram or pleural plaques only and then a sudden appearance of rounded atelectasis have probably had a silent benign asbestos-related pleural effusion; it is well recognized that asbestos-related effusions can be asymptomatic. In 13 patients, there was a slowly progressive fibrosis of the pleura which gradually led to the rounded atelectasis, as illustrated in Figure 2. Unfortunately, in many published cases, no previous chest roentgenograms or recordings of the previous medical history are available, which means that the mechanism often cannot be ascertained. Since asbestos-related pleural effusion will often result in diffuse pleural thickening and can be seen during the course of a progressive diffuse pleural thickening, this discussion might well be academic.

As already mentioned, the diffuse asbestos-related pleural fibrosis has a tendency to progression.31 This can lead to a rounded atelectasis; when the progression continues after the appearance of this lesion, one can get the impression of a malignant tumor.48

In most persons not exposed to asbestos, rounded

### Table 1 — Subsequent Course after Appearance of Rounded Atelectasis in Patients with Exposure to Asbestos

<table>
<thead>
<tr>
<th>Course</th>
<th>Observation Time after Rounded Atelectasis, yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lost to follow-up</td>
<td>3 . . .</td>
</tr>
<tr>
<td>No change or slight increase in pleural plaques</td>
<td>24 1-12 (mean, 4)</td>
</tr>
<tr>
<td>Appearance of plaques</td>
<td>2 7 for both</td>
</tr>
<tr>
<td>Increase or appearance of pleuropulmonary fibrosis on opposite side</td>
<td>12 2-15 (mean, 9)</td>
</tr>
<tr>
<td>(thered with pleural effusion on opposite side)</td>
<td>(2) *</td>
</tr>
<tr>
<td>Increase of bilateral pleuropulmonary fibrosis</td>
<td>23 1-16 (mean, 7)</td>
</tr>
</tbody>
</table>

*Effusion appeared one and four years, respectively, after diagnosis of rounded atelectasis.
atelectasis seems to be secondary to a pleural effusion. This group contained the only case of spontaneous regression that was seen in the present study. Regression of rounded atelectasis as reported in the literature has also occurred mainly in the nonasbestos-exposed group, although it can also take place after a benign asbestos-related pleural effusion. The regression usually takes one or several months.

The majority of rounded atelectases in the present study were located in the two lower lobes and were situated medially, laterally, ventrally, or dorsally. Of the reviewed cases, the location was reported in exactly 100 cases.* Forty-seven of those were situated in the right lower lobe, 27 in the left lower lobe, 11 in the middle lobe, ten in the lingula, three in the left upper lobe except the lingula, and two in the right upper lobe (Fig 1B). These figures are similar to those in the present study, except for the lingula and the middle lobe. The lingula was affected in 42 percent (33/79) of the cases in the present study, but in only 11 percent of the reviewed cases; for the middle lobe, the corresponding figures are 20 percent (16/79) and 12 percent respectively. A possible reason is that the "twisted lingula" is a well-known phenomenon which is rarely reported. Bilateral rounded atelectases have previously been described in six patients.

The radiologic signs of rounded atelectasis have been well described. Bronchography and tomography (both CT and conventional) will reveal bronchi and vessels which bend and then converge towards the "tumor" (Fig 1). This convergence of bronchi and vessels towards the lesion is often also visible on a plain chest roentgenogram and has been termed the "comet tail." This otherwise typical sign is not always visible, however. Another finding in rounded atelectasis, usually best observed on the CT scan, consists of broad pleural adhesions above the acute angle between the pseudotumour and the pleura. In rare instances the folding will take place inwards into an interlobar fissure, and in this case, there will not be a broad pleural adhesion but always an obvious connection. Fibrous strands are often visible around and near the lesion and, especially in asbestos-related cases, at other sites in the same and often also in the opposite lung. At the part of the lesion nearest the hilus of the lung, an air bronchogram is often visible. Obliteration of the costophrenic angle on the same side as the rounded atelectasis is common and should alert the radiologist to the possibility of a pleural reaction.

Pleural extensions consisting of fibrotic strands or a partly atelectatic lung (or both) can also occur in malignant tumors. Since asbestos can cause malignant tumors as well as pleural fibrosis, coexistence of these diseases is fairly common. Care in the diagnosis is therefore necessary, and even experienced radiologists can make mistakes.

In a patient with a typical plain chest roentgenogram and CT scan suggesting rounded atelectasis and normal bronchoscopic findings, one needs only to follow the patient with chest roentgenograms, initially after one to two months and then with longer intervals. If still in doubt, bronchography may be of value; and if uncertainty remains, fine-needle biopsy can be performed. It could be argued that thoracotomy is a fairly safe procedure, but if operation can be avoided, this is preferable, at least from the patient's point of view, as freeing of the atelectatic part of the lung will usually only marginally benefit the patient.


REFERENCES

2. Caly P. Tumeurs bénignes et pseudotumores inflammatoires et pleurales. Acta Chir Belg 1955; (suppl) 52:5-27

*References 3, 5, 8, 9, 11, 12, 14, 16, 17, 19-21, 23, 24, 26, and 32.
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The 31st Annual Meeting of the ICA will be held at the Cavalieri Hilton Hotel, Rome, Italy, June 25-30. For information, contact Ms. Denise M. Rossignol, Executive Director, CME Programs, International College of Angiology, 1044 Northern Boulevard, Roslyn, New York 11576 (514:484-6880).