Recognition of Pleural Effusion on Supine Radiographs: How Much Fluid Is Required?

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A prospective analysis of supine radiographs in 40 patients with pleural effusions was undertaken to determine the radiographic manifestations of pleural effusion on supine radiographs and the quantity of fluid that may be detected in the supine position. The presence of pleural effusion was predicted from supine radiographs using the following signs: increased homogeneous density superimposed over the lung fields, obliteration of the silhouette of the diaphragm, meniscus sign, apical capping, and accentuation of the right minor fissure. The supine radiographic findings were correlated with findings on subsequent standing erect posteroanterior and lateral radiographs. This study indicates that effusion of sufficient quantity to produce blunting of the lateral costophrenic angle on an erect posteroanterior radiograph (175–525 ml) will produce a noticeable increase in the density of the lower lung zone on supine radiographs. As the quantity of effusion increases, the abnormality of the supine chest radiograph increases in a stepwise manner. The classical findings of increased density over the entire hemithorax and apical capping described in pleural effusion on supine radiographs are late findings seen typically in large effusions.

The radiographic manifestations of pleural effusion on erect posteroanterior (PA) and lateral chest radiographs are well known. Although minute quantities of pleural fluid require lateral decubitus radiographs for detection [1], as little as 25 ml of pleural effusion can produce noticeable elevation of the apparent level of the diaphragm and/or separation between lung and subdiaphragmatic gas on erect PA radiographs [2]. Collins et al. [2] showed that once 175 ml of fluid accumulates in the pleural space there will usually be noticeable blunting of the lateral costophrenic angle on erect PA chest radiographs. This finding is somewhat variable, and on occasion it may require up to 525 ml before blunting of the angle is apparent [2].

The radiographic features of pleural effusion on supine radiographs and the quantity of fluid required to produce these features are less well known. It is generally agreed that pleural effusion may produce an increased homogeneous density over the involved hemithorax [3–6] and fluid capping the ipsilateral lung apex [3]; however, the quantity of fluid required to produce these findings is unknown. Often, pleural effusion is entirely missed on supine radiographs until it is massive or until a subsequent erect radiograph shows a "new" pleural effusion. Also, the effusion may be misdiagnosed as pulmonary consolidation or collapse on the supine radiograph.

The purpose of this paper is to describe the radiographic features of pleural effusion on supine radiographs and to quantitate the amount of pleural fluid required to produce these findings. This is important since many critically ill patients who can have only supine chest radiographs may have clinically significant pleural effusions missed or misdiagnosed as other thoracic disorders on the basis of conventional concepts.

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TABLE 1: **Correlation of Radiographic Abnormalities on Supine Films with 64 Pleural Effusions in 40 Patients**

Effusion Size	No. (%) of Pleural Effusions					
	Totals	Detected on Supine Films	With Increased Opacity of Hemithorax	With Loss of Diaphragm	With CP Angle Meniscus	With Apical Cap
Very small (<175 ml) . . .	3	0	0	0	0	0
Small (175–525 ml)	11	10 (91)	10 (91)	5 (45)	0	0
Moderate (>525 ml)	28	28 (100)	28 (100)	20 (71)	7 (25)	0
Large	22	22 (100)	22 (100)	15 (68)	9 (41)	12 (54)

Note.—CP = costophrenic angle.

Subjects and Methods

Supine chest radiographs of variable focal-film distance (100–140 cm) were obtained in 40 patients with pleural effusions. These 40 patients had no known antecedent pleural adhesions or pulmonary parenchymal disease. Semierect and erect bedside radiographs were excluded from the study. Each supine chest radiograph was carefully evaluated for the following radiographic signs: (1) an increased homogeneous density superimposed over the lung fields in which the visibility of normal bronchovascular markings was maintained and in which there was no air bronchogram formation, loss of the silhouette of bronchovascuar markings, or shift of hilar or mediastinal structures or diaphragm to suggest pulmonary consolidation or collapse [3–6]; (2) loss of the normal silhouette of the diaphragm [7]; (3) blunting of the lateral costophrenic angle (meniscus sign) [4, 6–9]; (4) apical capping [3]; (5) elevation of the level of the apparent hemidiaphragm [4, 6–11]; (6) decreased visibility of the lower lobe vascularity below the level of the hemidiaphragm [6, 9, 10]; and (7) accentuation of the right minor fissure [7] compared with previous normal radiographs. Those cases in which an increased homogeneous density was evident over the lung field were subdivided into three groups based on whether the density extended over the lower lung zone, lower two lung zones, or entire hemithorax. These radiographic features were evaluated for each hemithorax and the presence or absence of pleural effusion was predicted from the supine radiographs.

Standing erect PA and lateral chest radiographs were subsequently obtained in each patient and lateral decubitus radiographs were obtained in a few. Computed tomography (CT) of the thorax was available in two cases. These confirmatory radiographic studies were obtained after the supine chest radiographs by an average of 34.6 hr (range, 3–72 hr).

On the basis of findings from the PA, lateral, and decubitus films, the pleural effusions were quantitated in the following manner. If no abnormality was detected on the erect PA radiograph, and pleural effusion could be recognized only on the lateral or decubitus radiographs, the quantity of effusion was classified as being very small. If minimal detectable blunting of the lateral costophrenic angle was evident on the PA radiograph, the volume of fluid was classified as small. Effusions were classified as moderate in size if the effusion occupied the lower part of the hemithorax but did not extend above the fourth rib anteriorly on the PA view [12, 13]. Large effusions extended above the level of the fourth anterior rib on the PA view [12, 13]. Thoracentesis was not performed in many instances, and, accordingly, was not used as a guide to the amount of fluid. The size of the effusion determined by the PA, lateral, and decubitus radiographs was correlated with the findings on the supine radiographs.

In all, there were 64 pleural effusions recognized on the PA, lateral, and decubitus radiographs. In 12 the right hemithorax alone was involved, in five there was an isolated left pleural effusion, and in 47 the effusion was bilateral (a total of 35 right-sided pleural effusions and 29 left-sided pleural effusions). The effusions were exudates in two patients (empyema and ruptured esophagus, one case each); transudates in 36 patients (congestive cardiac failure, renal failure, or plasma volume overload in 28 cases; intraabdominal pathology in five cases; and miscellaneous causes in three); and from intrapleural hemorrhage from multiple rib fractures in two patients.

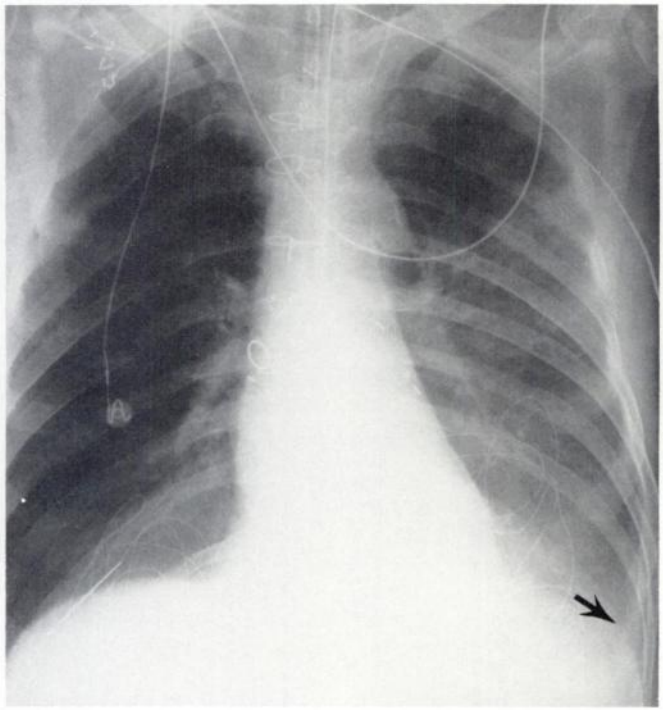
Results

On the basis of PA, lateral, and decubitus radiographs, the quantity of fluid was classified as being very small in three of the pleural effusions, small in 11, moderate in 28, and large in 22 (table 1).

None of the three very small effusions were detected by supine radiography (table 1). These very small effusions produced no abnormalities on either the supine or standing PA radiographs but did produce blunting of the posterior costophrenic angle on lateral films.

Of the 11 small pleural effusions, 10 were detected on supine radiographs (table 1). All 10 of these effusions showed increased homogeneous density of the lower lung zone on the supine radiographs (figs. 1 and 2). In addition, five demonstrated loss of the normal silhouette of the diaphragm. None of the 10 demonstrated either blunting of the lateral costophrenic angle or capping of the lung apex. The erect PA chest radiographs in these 10 effusions demonstrated noticeable blunting of the lateral costophrenic angles. One showed no detectable radiographic abnormality on the supine radiograph but did show blunting of the lateral costophrenic angle on the subsequent PA radiograph.

All 28 of the moderate-sized pleural effusions were detected on supine radiographs. The major finding was increased homogeneous density projected over the lower two lung fields (28 of 28); a few demonstrated increased density over the entire hemithorax. Twenty (71%) of 28 showed loss of the silhouette of the diaphragm and seven (25%) showed blunting of the lateral costophrenic angle; however, none demonstrated apical capping (table 1, figs. 1–3).



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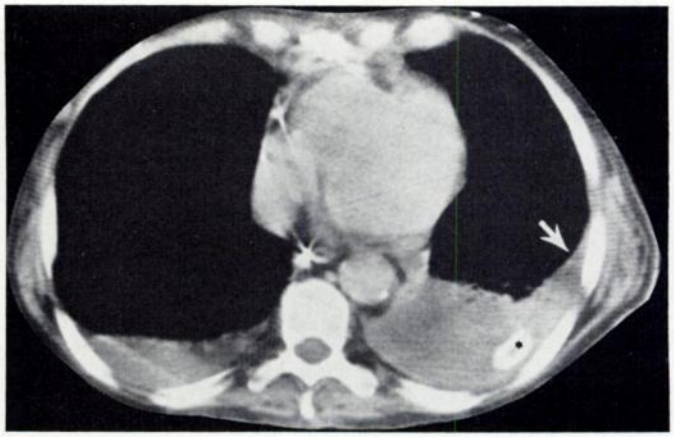

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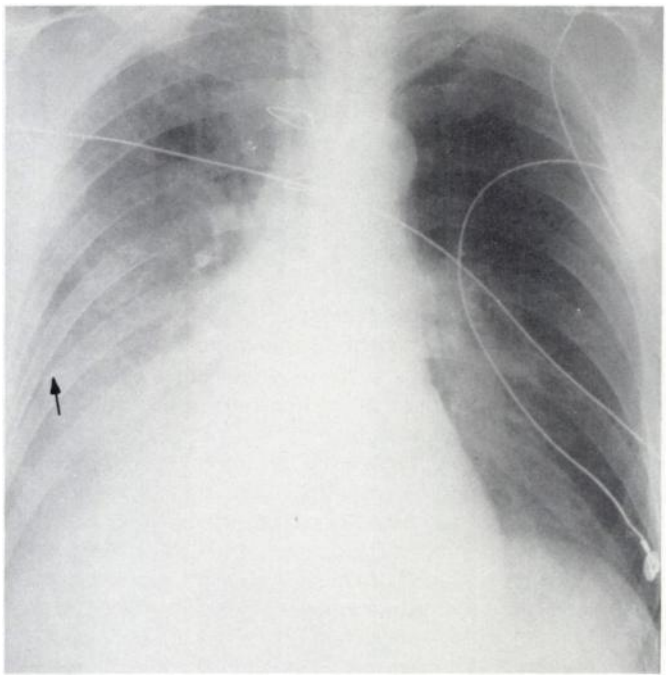
Fig. 1.—Small right and moderate-sized left pleural effusions. **A**, Supine radiograph. On right, increased density over lower lung zone. On left, increased density over lower two lung zones, obliteration of hemidiaphragm, and meniscus sign (*arrow*). **B**, CT scan of thorax at level of lung base 4 hr later. Small right pleural effusion and moderate-sized left effusion. On left, fluid is seen extending anteriorly into lateral costophrenic angle (*arrow*). *Asterisk* indicates thoracostomy tube inserted immediately before CT.



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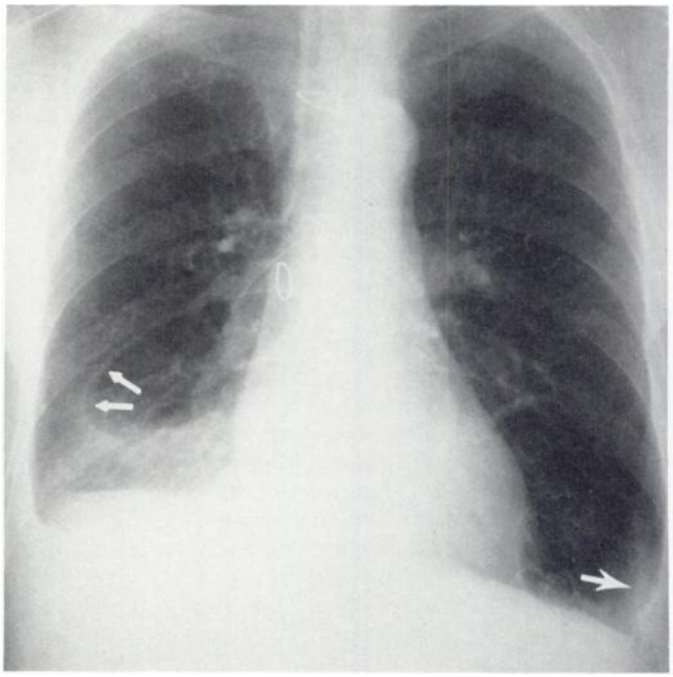
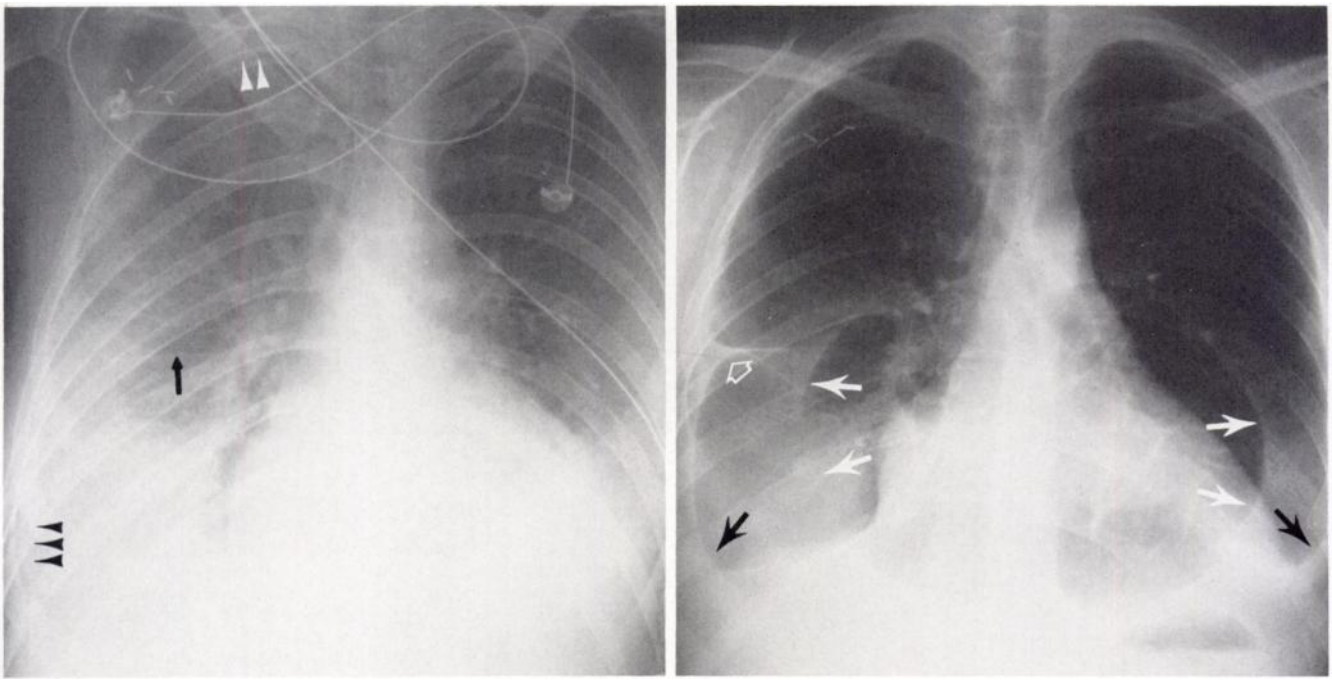


B

Fig. 2.—Moderate-sized right and small left pleural effusions. **A**, Supine radiograph. On right, increased density over lower two lung zones, obliteration of hemidiaphragm, and accentuation of right minor fissure (*arrow*). On left, increased density over lower lung zone. **B**, Erect chest radiograph 72 hr later. Subpulmonic fluid collection on right with meniscus of fluid in costophrenic angle and fluid extending into major fissure (*double arrows*). On left, meniscus sign and accentuation of vertical fissure line (*single arrow*).



A B

Fig. 3.—Large right and moderate-sized left pleural effusions. **A**, Supine radiograph. On right, increased density over entire hemithorax, obliteration of hemidiaphragm, accentuation of minor fissure (*arrow*), apical capping (*white arrowheads*) and meniscus sign (*black arrowheads*). On left, increased density over lower two lung zones and obliteration of hemidiaphragm. **B**, Erect chest radiograph 24 hr later confirms supine findings. Meniscus sign in both costophrenic angles (*black arrows*), incomplete fissure sign bilaterally (*white arrows*), and middle lobe step (*open arrow*). Fluid extends above level of fourth anterior rib on right but not on left.

All 22 large effusions were detected on the supine films, and all showed increased homogeneous density over the hemithorax, which frequently extended over the entire length of the hemithorax. Fifteen (68%) of 22 showed loss of the silhouette of the diaphragm, nine (41%) demonstrated blunting of the lateral costophrenic angle, and 12 (54%) showed capping of the lung apex (table 1, figs. 3 and 4).

Of the 35 right pleural effusions, accentuation of the right minor fissure compared with previous normal radiographs was present in 17 (48%). The effusion was quantitated as small in one, moderate in nine, and large in seven.

The radiographic findings of elevation of the apparent level of the hemidiaphragm and decreased visualization of the pulmonary vascularity below the level of the apparent dome of the hemidiaphragm were extremely difficult to evaluate. Problems in interpretation included poor penetration of upper abdominal structures on the supine films, bilaterality of effusion, and obliteration of the silhouette of the diaphragm by pleural effusion. Definite elevation of the apparent level of the hemidiaphragm occurred in four (6%) of the 64 effusions from subpulmonic extension of effusion in the supine position. This finding was present in one small, one moderate, and two large effusions. A definite decrease in visibility of the vessels below the dome of the apparent diaphragm compared with the opposite hemithorax occurred in three cases (5%).

Discussion

In the normal person, the AP diameter of the hemithorax is greatest at the lung base; accordingly, in the supine position, the transradiancy of the lung base is usually equal to or greater than that of the lung apex. Further, in the supine position, prominent pectoral or breast tissue will usually fall laterally away from the lung base. Therefore, in a well centered supine chest radiograph, if the density of the lower lung field is homogeneously increased to a level greater than that of the upper lung field, pleural effusion should be suspected. The increased homogeneous density is first projected over the lower lung zone; as the quantity of effusion increases, there is progressive increase in density upward until the entire hemithorax is increased in density (figs. 1–4).

Failure of pectoral or breast tissue to fall away from the lung fields, cardiomegaly and/or a prominent epicardial fat pad, and pulmonary collapse and/or consolidation may obscure pleural effusion on supine radiographs. A homogeneously increased density over one hemithorax may be mimicked by patient rotation or combined lateral and focus-grid distance decentering [14]. Prior mastectomy, absence of pectoral muscles, unilateral emphysema, pleural or chest wall mass, anterior pneumothorax, scoliosis, congenital or acquired occlusion of a pulmonary artery, previous lobectomy, or hypogenetic lung syndrome also leads to asymmetric thorax density [15]. Pulmonary consolidation and/or collapse should be suggested when normal bronchovascular markings are obliterated; when air brochograms are present; or in the presence of shift of hilar or mediastinal structures or normal fissures. However, consolidation without air bronchogram formation or early lower lobe collapse with minimal volume loss may be difficult to distinguish from pleural effusion on

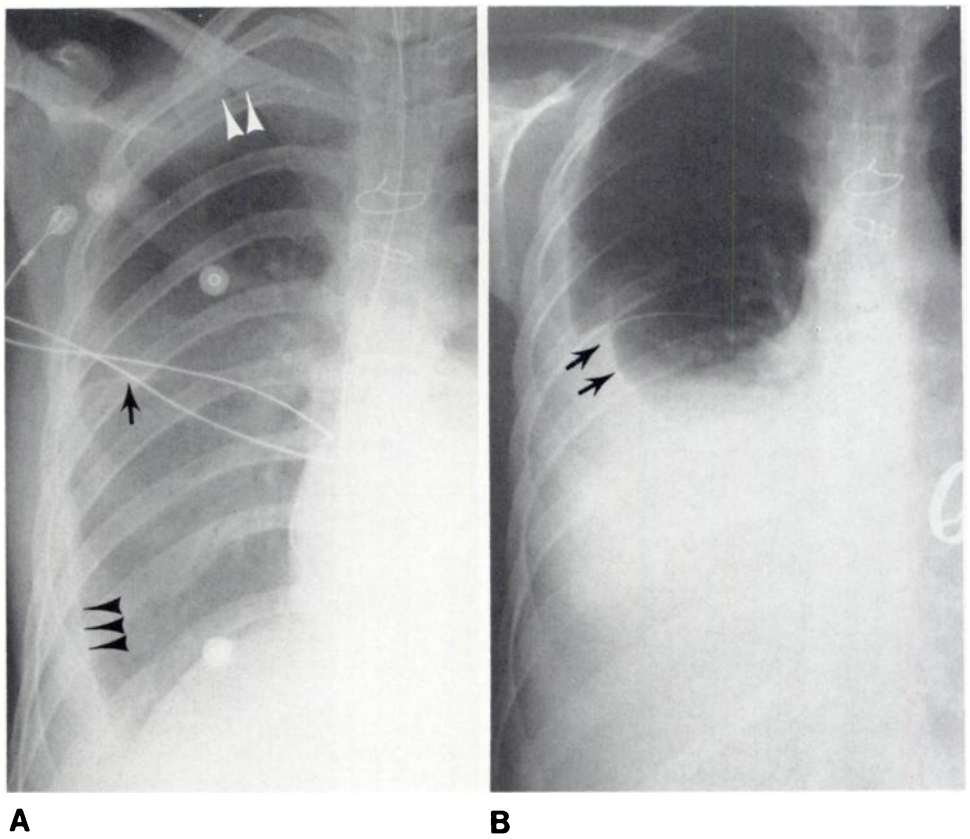


Fig. 4.—Large pleural effusion. **A**, Supine radiograph. Increased density over entire hemithorax, accentuation of right minor fissure (*arrow*), meniscus sign (*black arrowheads*), and apical cap (*white arrowheads*). **B**, Erect radiograph 48 hr later confirms large effusion extending above level of fourth anterior rib. Middle lobe step (*arrows*).

supine radiographs. Careful consideration of the radiographic findings should lead to the correct diagnosis, which may be confirmed by appropriate erect or decubitus radiographs.

On erect PA chest radiographs 175–525 ml of pleural fluid will cause noticeable blunting of the lateral costophrenic angles; effusions less than 175 ml will not [2]. In this study there were three very small effusions that produced no detectable abnormalities on the erect PA radiographs and were considered to be less than 175–525 ml in quantity. None of these effusions was detectable on the supine radiographs (table 1). Of 11 small pleural effusions that produced blunting of the lateral costophrenic angle on the erect PA radiograph and were considered to be 175–525 ml in volume, 10 (91%) were evident as increased densities over the lower lung zone on supine radiographs (figs. 1 and 2; table 1). Effusions of greater quantity were routinely detected on supine views as increased homogeneous densities over the involved hemithorax (table 1).

The degree of opacification of the hemithorax, limited to the lower lung zone in small effusions, did not usually involve the entire hemithorax until the effusion was large (figs. 3 and 4). Apical capping, seen in no small or moderate effusions, occurred in 54% of large effusions (table 1). Therefore, the findings classically described in pleural effusions on a supine chest radiograph [3–6] are typically seen only in large pleural effusions.

Blunting of the lateral costophrenic angles (meniscus sign) was present in no small, 25% of moderate, and 41% of large effusions. This finding, which is generally thought of as a finding of pleural effusion on erect radiographs, is produced in the supine position when the quantity of effusion is sufficient to fill the posterior hemithorax up to or near the level of the lateral costophrenic angle (fig. 1). Accentuation of the right minor fissure compared with previous normal radiographs (figs. 2–4) is a helpful adjunct to the diagnosis of moderate- and large-sized right pleural effusions but is uncommon in small right pleural effusions.

Decreased visibility of the vessels below the level of the diaphragm was very difficult to evaluate on the supine films because of underpenetration of upper abdominal structures [10], obliteration of the diaphragm, and bilaterality of effusion. In three cases, however, a definite decrease in the visibility of the pulmonary vascularity below the level of the apparent diaphragm was present compared with the opposite hemithorax. Elevation of the apparent level of the hemidiaphragm was also difficult to evaluate because of loss of the silhouette of the diaphragm and bilaterality of effusion. In only four cases was this finding definitely present. Because this finding is generally described in subpulmonic effusions in an erect position [4, 6–11], this suggests that, in some patients, fluid may collect in a subpulmonic location even when the patient is supine.

In summary, it is likely that pleural effusion will not be diagnosed on supine radiographs when less than 175 ml of pleural effusion is present. The radiographic findings described above should suggest the presence of pleural fluid in the range of 175–525 ml or greater. The major radiographic finding is an increased homogeneous density superimposed over the lung fields that does not obliterate normal bronchovascular markings, does not show air bronchogram formation,

and shows no evidence of hilar or mediastinal displacement until massive.

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