Acute left heart failure is most commonly caused by a hypertensive crisis. Radiographic signs on the plain chest radiograph obtained with the patient standing include:

- Redistribution of pulmonary perfusion
- Presence of interstitial patterns (Kerley lines, peribronchial cuffing)
- Alveolar densities with indistinct vascular structures (advanced stage)
- Pleural effusions

All of these signs are essentially attributable to increased fluid content in the abnormally heavy "wet" lung. The fluid accumulation follows gravity.

Redistribution

Changes in perfusion indicative of left heart weakness involve redistribution from the basal segments into the apical segments of the lungs. These changes can be diagnosed on the radiograph before the diagnosis of left heart failure can be made by auscultation. Lung perfusion in the erect patient is physiologically more pronounced in the basal segments than in the upper lobes (**Fig. 1.61**). The plain chest radiograph obtained with the patient standing shows that both the pulmonary arteries and the pulmonary veins in the basal segments lie closer together and exhibit greater diameter than those of similar size in the apical segments.

When you check laundry drying on a clothesline, you always feel the lower end. This is where the socks take longest to dry.

The capacity for diffusion is initially decreased in the flooded basal segments where the fluid accumulation begins. As a result, what is known as the Euler–Liljestrand mechanism reduces the normally greater basal perfusion in favor of the better-ventilated apical segments. This leads to greater prominence of the upper field vessels. As it is not easy to determine size on the plain chest radiograph, pragmatic compromises may be considered:

- Compare pulmonary vessels that are equidistant to a central point in the respective hilum.
- Compare the diameter of a random easily identifiable superior lobe artery (often the anterior segmental artery is most easily identifiable) with the diameter of the corresponding ipsilateral bronchus (**Fig. 1.62**).

As the pulmonary artery and corresponding ipsilateral bronchus are normally of precisely equal diameter, a larger arterial diameter is indicative of redistribution of perfusion (**Fig. 1.63**). The diagnostic criteria of caudal-to-cranial redistribution cannot be evaluated on radiographs obtained in the supine patient. This is another argument in favor of comparing the calibers of the pulmonary artery and the ipsilateral bronchus. The physiologic redistribution from posterior to anterior on the supine radiograph necessarily involves a caliber increase in the anterior segmental artery compared with the ipsilateral bronchus.

Expansion of the pulmonary artery in beginning pulmonary arterial hypertension (as in chronic obstructive pulmonary disease [COPD]) can simulate the redistribution of pulmonary perfusion. The decisive diagnostic criterion is such cases is the comparison with farther peripheral vessels that tend to be narrowed in pulmonary arterial hypertension (**Fig. 1.64**). Here, as always in such cases, the comparison should be made between arteries of the appropriate order in the vascular tree. For example, it would be a serious diagnostic error to compare a subsegmental artery with a segmental artery.

Redistribution can be absent in apical emphysema (**Fig. 1.65**).

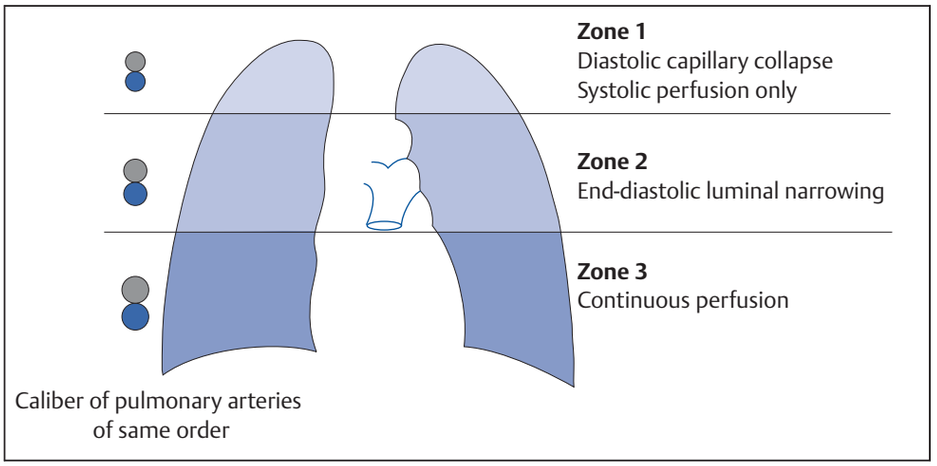

Fig. 1.61 Theory of pulmonary perfusion. Bjure and Laurell described the reduced vascular filling in the apical lung segments compared with the base of the lung as early as 1927. This increased basal perfusion is attributable to the hydrostatic pressure (approx. 12 mmHg), which is added to the blood pressure (systolic 25 mmHg, diastolic 8 mmHg).

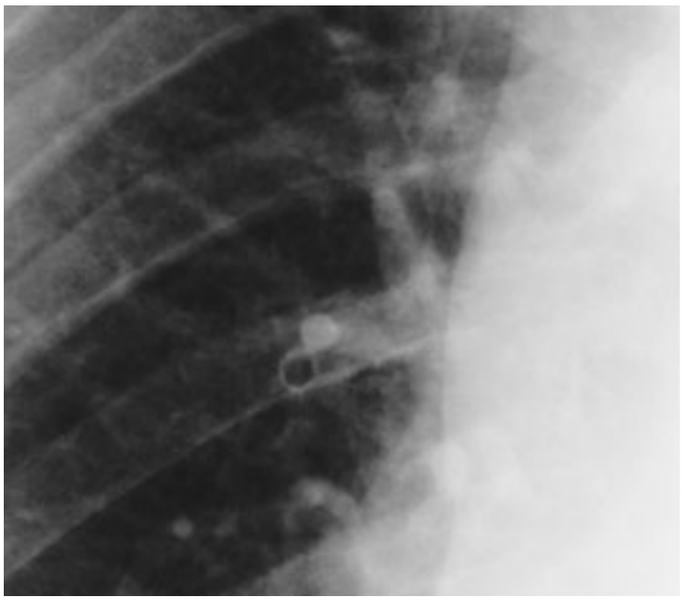

Fig. 1.62 Identical diameter of the anterior segmental artery and the accompanying bronchus (detail).

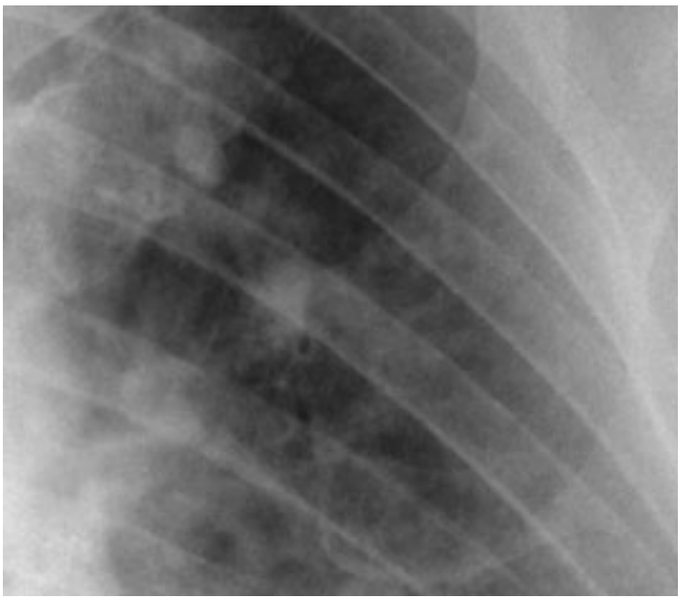

Fig. 1.63 Redistribution of pulmonary perfusion indicative of left heart failure. The detail shows a mismatch between the diameter of the slightly blurred segmental artery and the anterior upper lobar bronchus with wall thickening.

Fig. 1.64 Mismatch between the bronchial lumen and the accompanying artery in COPD. The relative increase in the size of the pulmonary artery compared with the bronchus results from the increased pulmonary arterial pressure and not from redistribution. Barrel chest in emphysema.

Fig. 1.65 Lack of redistribution in apical emphysema. Obstructive barrel chest in apical emphysema. Hypertensive configuration with definitive signs of congestion with Kerley lines (black arrow) and the onset of central blurring. Redistribution cannot develop due to emphysematous remodeling. ▶

Interstitial Edema

Increasing accumulation of intrapulmonary fluid leads to development of an interstitial edema (**Fig. 1.67**). The edematous fluid saturates the pulmonary interstitium, and the lymphatic system at this site is filled with hypocellular fluid and greatly dilated. Interstitial pulmonary edema can represent the onset of or a residual finding in edematous exudation of the lung.

Radiologic signs of interstitial pulmonary edema include:

- Thickened lymph vessels in the interlobular septa (**Kerley lines**)
- Peribronchial cuffing due to dilated lymph vessels coursing in the edematous wall of the bronchi

Kerley Lines (Fig. 1.66)

The most important sign of interstitial pulmonary edema is fine horizontal lines located primarily in the lower lung fields. Not always discernible on textbook images, these lines were first described by Kerley in conjunction with mitral stenosis and the resulting increased pressure in the pulmonary venous system. Named after him, these lines (**Fig. 1.66**) are initially visible as horizontal line shadows in the costophrenic angles of the lower lung fields (Kerley B lines). They measure up to 3 cm in length and 1–2 mm in width. Kerley B lines are distinguishable from discrete plate atelectasis by their typical stacked configuration (**Fig. 1.67**).

Kerley **B** lines occur primarily in the basal segments and course horizontally to the pleura, where they lead to pleural effusion. Remember: "Kerley **B** lines → **B**leura."

Kerley distinguished a second type of line from the B lines. These A lines course from the hilum to the periphery. These lines are attributable to edematous perivascular or peribronchial lymphatic channels (**Fig. 1.67**). C lines do not correspond to strictly linear changes but form a network of fine stripes (**Fig. 1.67**). Retrosternal Kerley lines coursing vertically are occasionally observed on the lateral radiograph. They are referred to as Kerley D lines but are essentially the same as Kerley B lines.

Peribronchial Cuffing

Edematous thickening of the bronchial wall due to lymphatic congestion is visualized on the posteroanterior radiograph as a well-defined ring structure, again usually in the vicinity of the anterior segmental artery (**Fig. 1.67**). In fact, a term like "donut" would be more informative than the ususal term peribronchial "cuffing". The thickening of the bronchial wall due to lymphatic congestion must be differentiated from bronchial wall thickening from other causes such as chronic bronchitis (mucosal edema, muscle hypertrophy). The presence of isolated peribronchial cuffing must not be interpreted as a sign of lymphatic congestion.

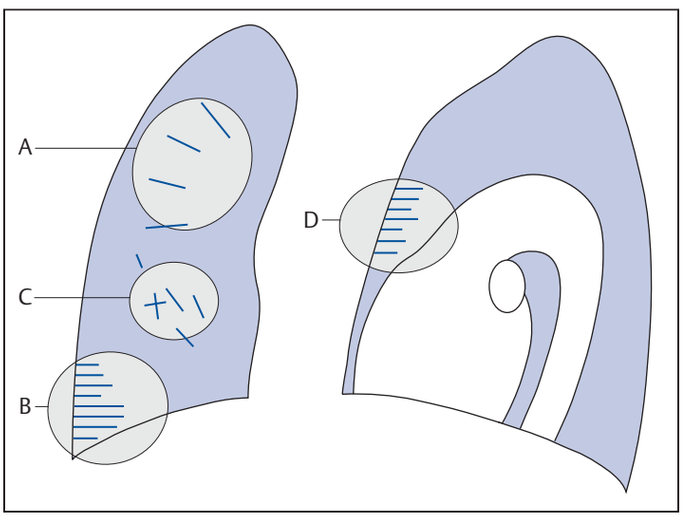

Fig. 1.66 Schematic diagram of the terminology of Kerley lines.

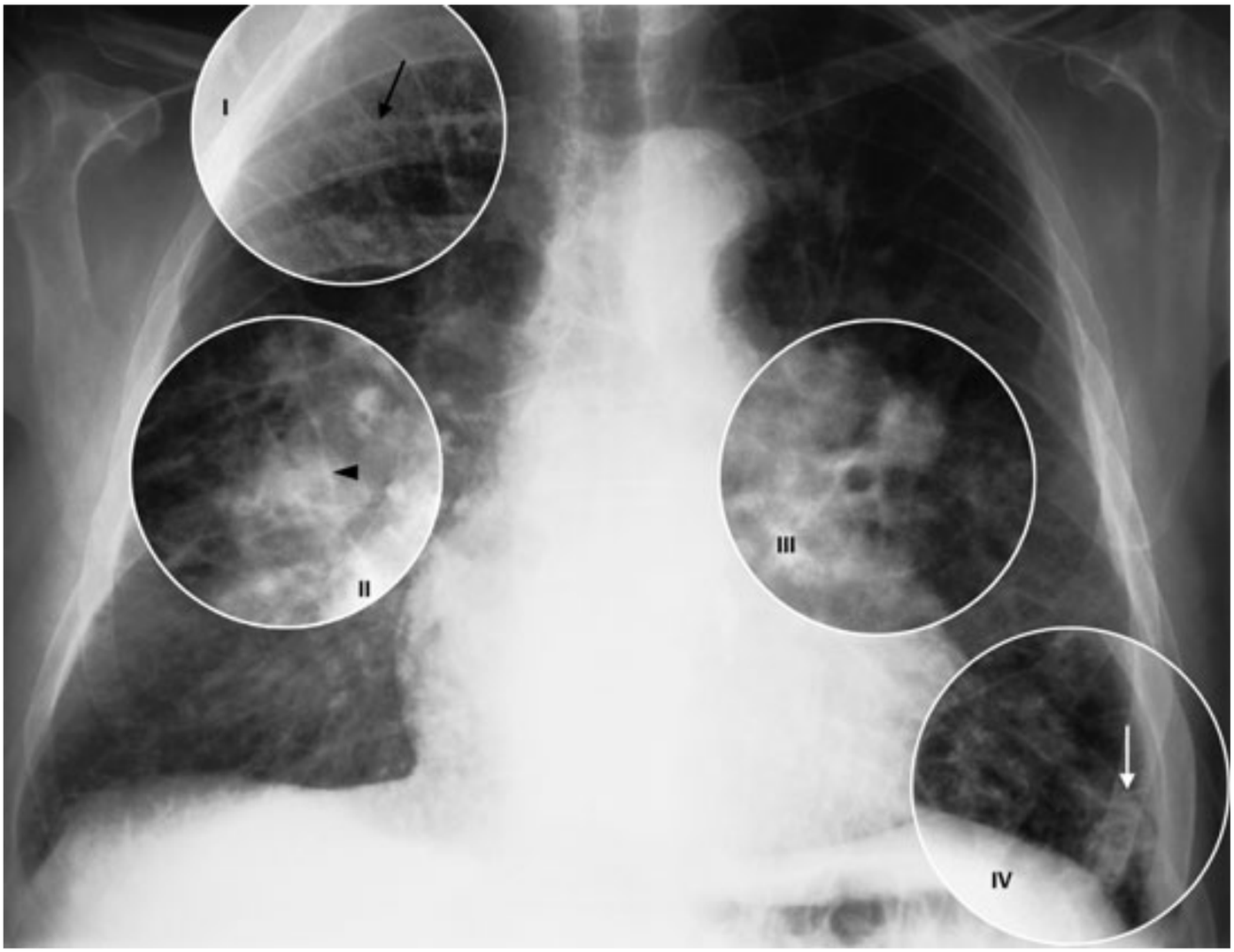

Fig. 1.67 Various examples of Kerley lines.
Pulmonary interstitial edema. Left heart enlargement is accompanied by findings of redistribution and significant septal thickening with Kerley lines. Bilateral effusions in the costophrenic angles. Initial blurring of vascular structures is seen in the right central region.

(I) Kerley A lines. The dilated lymph vessels coursing toward the hilum (black arrow) appear as radial streaky densities 1–2 cm long and less than 1 mm wide.

(II) Kerley C lines (detailed view of right middle lung field). Interstitial lines coursing neither radially nor horizontally to the pleura (black arrowhead).

(III) Peribronchial cuffing. Thickening of the bronchial wall appears as a ring when visualized end-on and resembles a tram line when visualized tangentially.

(IV) Kerley B lines. The fine, nearly horizontal line measuring 1 cm (white arrow) can be traced to the visceral pleura. The pleura is already slightly shifted away from the chest wall. An effusion is developing here in the costophrenic angle.