Chapter 9: Bronchography

To cite this article: (1964) Chapter 9: Bronchography, Acta Radiologica: Diagnosis, 2:sup224, 70-75

To link to this article: https://doi.org/10.1080/05678066409174247

Published online: 04 Jan 2010.

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CHAPTER 9

Bronchography

After inflation of the lungs, lesions of the bronchial tree were demonstrable at autopsy. As in the experiments of Macklin, they consisted of generalized dilatation of bronchi, bronchioles and alveoli. Moreover, in addition to interstitial and mediastinal emphysema, blood-mixed secretion was often visible in the bronchi. It could not be definitely ascertained whether this blood derived from the haemorrhages of the lung parenchyma, or was due to bronchial rupture.

In order to determine whether bronchial rupture or other bronchial lesions could be demonstrated in vivo, bronchography was performed before and after intermittent inflation of the lungs. The series comprised 10 dogs, weighing from 10—21 kg.

In the dog, four lobar bronchi are present on the right side. They are denoted here as the upper lobe, middle lobe and lower lobe bronchi, and the bronchus to the retrocardial lobe. On the left side, there is an upper lobe, a lingular and a lower lobe bronchus.

Selective bronchography was carried out as follows. The dog was intubated under anaesthesia, and roentgenograms were made in the dorsal position. A catheter for bronchography was introduced through the tracheal tube, and placed in the main bronchus on the side to be examined, 1—2 cm below the bifurcation. The dog was then turned so that this side was downwards. Contrast medium was injected through the catheter in portions of about 2 ml, under fluoroscopy, until the central bronchi were satisfactorily filled. Totally 1—1.5 ml/kg of body weight of propylidone (Dionosil®) was injected. Fluoroscopy or a frontal exposure was used to check that selective filling of the bronchi of the lower lung had been obtained. As a result of the dog's respiratory excursions, the contrast medium gradually spread in the peripheral direction, so that the finer bronchial branches were also filled. The films were exposed in the lateral projection, first during apnoea, and then at an intrabronchial pressure of 20 cm H₂O. In the latter case, the bronchial walls were covered by a thin layer of contrast medium, which allowed them to be studied in greater detail.

By keeping the dog in the lateral position throughout the examination, the contrast medium was prevented from spreading to the bronchi on the contralateral side. At the end of the examination, the contrast medium was aspirated from the bronchi as completely as possible under fluoroscopic control, and 300,000 IU of penicillin procaine were injected intramuscularly. About one week later, roentgenograms were made of the lungs to check that the contrast medium was no longer present. If this was the case, and the roentgenogram was without changes, the experiment was continued.

Intermittent inflation of the lungs was then done in the usual way, using the gas
Fig. 27. Bronchogram of the right lung before (a) and after (b) intermittent inflation to 60 cm H₂O. After inflation, round cavities have appeared in the medial part of the lower lobe and in the retrocardial lobe. The cavities have somewhat irregular walls. Autopsy: PIE. The cavities consist of dilated alveoli and groups of alveoli containing contrast medium.
Fig. 28. Bronchogram of the right lung before (a) and after (b) intermittent inflation to 70 cm H₂O. Uneven filling of the peripheral bronchi in b. Posterior mediastinal emphysema has appeared, with displacement of the trachea ventrally. *Autopsy:* PIE and posterior mediastinal emphysema.
injector, until roentgenologically visible pulmonary changes had appeared. Bronchography was carried out, with the same method and the same quantity of contrast medium as at the first examination. After this, the dog was killed by an overdose of anaesthetic, and autopsy performed at once. The lung specimens were fixed in formalin before microscopical examination.

The results of the roentgenologic examinations were judged by comparing the bronchograms before and after inflation of the lungs.

In four experiments, contrast-filled cavities in the lung in communication with the bronchial tree appeared after inflation.

Figure 27 shows the bronchi before and after intermittent inflation of the lungs in a dog weighing 13 kg. Conventional roentgenograms disclosed posterior mediastinal emphysema, and changes in the parenchyma as in interstitial emphysema. At bronchography of the right side after inflation of the lungs, round, sharply defined cavities were seen to have appeared in the medial part of the lower lobe, as well as in the lateral and dorsal part of the retrocardial lobe. The adjacent bronchial branches were slightly separated, and more poorly filled peripherally, as compared to before inflation. The same type of changes could be identified on examination of the left lung in another dog, but they were confined to the medial part of the lower lobe.

In two experiments, inflation of the lungs was followed only by an irregular distribution of the contrast medium in the bronchi. Figure 28 illustrates some additional changes observed after inflation. In Figure 28 a, the bronchial walls are smooth, and the contrast medium is evenly distributed throughout the bronchial tree. It is seen in Figure 28 b that some bronchi are only partly opacified. Between them, "alveolar" filling is seen.

In three experiments, the peripheral branches of the bronchi were also displaced in an arch beside the diaphragm. In the cases where posterior mediastinal emphysema had developed after inflation, the trachea and bronchial branches belonging to the apical lower-lobe segment were displaced in the ventral direction.

Autopsy was performed on 7 dogs, and interstitial emphysema could be demonstrated in all of them. Generalized dilatation of the bronchi and alveoli was visible in large parts of the lungs. The well-defined cavities in the retrocardial and lower lobes which were observed at bronchography could be verified. At macroscopical examination they corresponded to cavities of slightly smaller diameter, filled with contrast medium, with the same localization as those seen on the bronchograms. At microscopical examination, it was found that they consisted of greatly dilated alveoli or groups of alveoli. Small inflammatory infiltrates were present in every case in the bronchi and bronchioles of the lobes on the side examined by bronchography, whereas they were infrequent in the contralateral lung.

Control experiments

In a series of four controls, in which bronchography was done 6—26 days before inflation, and which were killed directly after it without renewed bronchography,
Fig. 29. Cineroentgenograms of the bronchi of the left lung during inflation from atmospheric pressure to 60 cm H₂O. a, during free respiration; b, under an intrabronchial pressure of 70 cm H₂O. After inflation, the diameter of the bronchi has increased, and they are elongated. The carina is displaced about 1 cm caudally. No bronchial ruptures are visible.

inflammatory changes were also present. They were chiefly situated in the lung earlier examined by bronchography. In addition, there were distended alveoli, perivascular air and haemorrhages in the lung parenchyma, but no cavities or any locally distended alveoli.

The following experiment was made for a closer study of the appearance of the bronchi during the course of inflation (Fig. 29). After bronchography of the left side, the lungs were inflated to an intrabronchial pressure of 60 cm H₂O for 4 periods of 30 seconds each. During this time, the bronchi were filmed in the lateral view, using the image amplifier and ciné-camera, the rate being 20 frames/second.

The roentgen tube, ciné-camera and experimental animal were fixed in the same position during the experiment. During inflation of the lungs, it was seen that the bifurcation was displaced in the caudal direction. At the same time, there was marked prolongation and dilatation of the bronchi in the sagittal plane, the lower-lobe bronchus being dilated to the greatest extent. No bronchial ruptures were directly visible. At autopsy, perivascular air was seen at microscopical examination. No ruptures of the bronchi could be demonstrated.

Discussion

The cavities in the lung parenchyma that were observed after inflation might have been caused by the injection of contrast medium, which was always made through a bronchial catheter. It was, however, carefully checked at each examination that no such artefacts were produced. Another possibility is that inflammatory changes induced obstruction of check-valvular type, with resulting secondary dilatation of the
alveoli peripheral to it. This is an unlikely explanation, since the inflammatory changes were distributed throughout the bronchi and bronchioles of the lung examined, whereas the cavities were present only in the lower lobe and the retrocardial lobe. It also appears improbable that the viscous contrast medium would have passed beyond such obstruction of check-valvular type to cavities lying peripherally. Consequently, the cavities had presumably arisen in connexion with inflation of the lungs.

The fact that the changes were localized to the lower lobe and the retrocardial lobe could be explained by the bronchi to these lobes being dilated most of all bronchi. They can therefore be envisaged as suffering the severest damage.

The reason why the cavities were demonstrable at autopsy only in the lung examined bronchographically may be that the contrast medium distended the air spaces, so that they did not collapse on preparation. Cavities of a somewhat similar appearance to those in my investigation have been described in “centrilobular emphysema” in man (65), but in my experiments no such emphysema was seen. The changes are therefore probably due to an acute alveolar distension in connexion with inflation.

The uneven contrast filling of the bronchi, observed in some cases after inflation, might be ascribed to deficiencies in the technique of examination. Such an uneven distribution of the contrast medium was not, however, seen on any of the 10 primary bronchograms, in which the same technique was used. Presumably, this source of error was not, therefore, of any decisive importance. A similar bronchographic picture has been described in diffuse, vesicular emphysema in man (105). It has been considered that the uneven distribution is due to the ventilation being uneven in different segments of the lung. The mechanism may possibly be the same in interstitial emphysema with its highly dilated alveoli after inflation.

The arched displacement of the bronchi basally, beside the diaphragm, was probably caused by locally distended alveoli. Displacement of the trachea and the dorsal bronchi in the ventral direction is, in all probability, to be ascribed to the mediastinal emphysema.

According to Macklin (73), in interstitial emphysema, the air passes from the bronchial tree to the interstitial tissue via ruptures in the alveoli. I was unable to demonstrate such ruptures or bronchial ruptures at bronchographic examination. This does not, however, rule out that they may well have been present.

Conclusions

In experimentally induced interstitial emphysema, bronchial changes can be demonstrated by bronchography. These changes consist of cavities (bullae) in the basal parts of the lungs, possibly representing dilated alveoli and bronchioles. Uneven opacification probably reflects an uneven ventilation of different segments of the lung. Arched displacement of bronchi in the periphery is presumably caused by locally distended alveoli.