GASEOUS INTERCHANGE BETWEEN ADJACENT LUNG LOBULES

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It is desired to make a preliminary report of certain experimental evidence that respiratory and other gases may enter one lobule from another in the lung without resort to known anatomical passageways. This was found *in vivo* and *in vitro* in work with dogs.

In vitro observations. A single lung lobe, freshly secured, was prepared by dissection at the hilus and isolation of the stem bronchus and origin of the first side branch, with care to avoid damage to the parenchyma. A cannula was tied into the lumen of the branch bronchus. The corresponding lung lobule was then inflated by blowing into the cannula, and immediately air was found to escape from the open stem bronchus. The stem bronchus was now ligated, the blowing continued, and the remainder of the lung became inflated. The pattern of dissemination of the air is depicted in Fig. 1. Here an atelectatic lung lobe was employed and serial röntgenographs were made during inflation. The relative density of the atelectatic tissues served to indicate the paths taken by the air.

The amount of pressure required to effect this passage of air from the cannulated lobule to the adjacent parts was estimated, as follows:

A specimen hitherto unused was placed in an air-tight chamber, and the stem bronchus and its first branch were separately connected to the outside with tubes. By gradually withdrawing air from the chamber the lung was expanded to a degree just sufficient to aerate all parts. Now, the tip of one bronchial tube was submerged in water, while a current of air with manometric control was run into the other tube. When the pressure had mounted to 1.0 cm. H_2O, there was bubbling from the submerged tube. Repeated trials gave the same minimum value and without regard for variations in the degree of lung expansion, except when complete collapse was allowed. Then, 6.0 cm. H_2O pressure was required to initiate air passage and 2.0 cm. H_2O pressure to maintain it.

These two types of experiment have been repeated many times and with the same results.

In vivo observations. A dog was anesthetized with ether, and tracheotomy was performed. A cannula with a dilatable tip was passed through the trachea and secured by air-tight fit in the lumen of the stem bronchus of the right lower lobe. The cannula, and the manner of its application are described elsewhere. Beside the first was placed a second cannula,—a simple, straight tube,—ending freely in the lumen of the primary bronchus. (Fig. 2). These cannulae were then attached by rubber tubing to two glass tubes, and these were connected by inserting them through rubber stoppers into

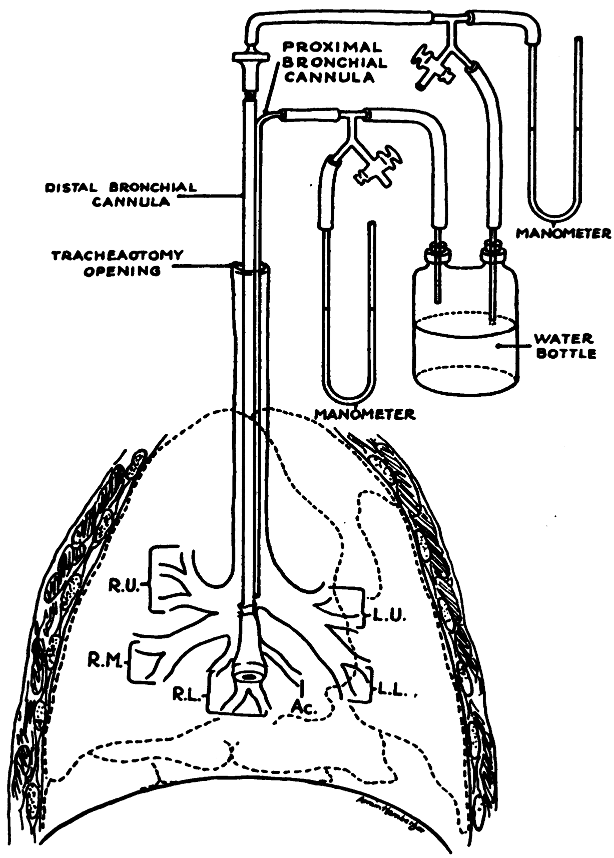
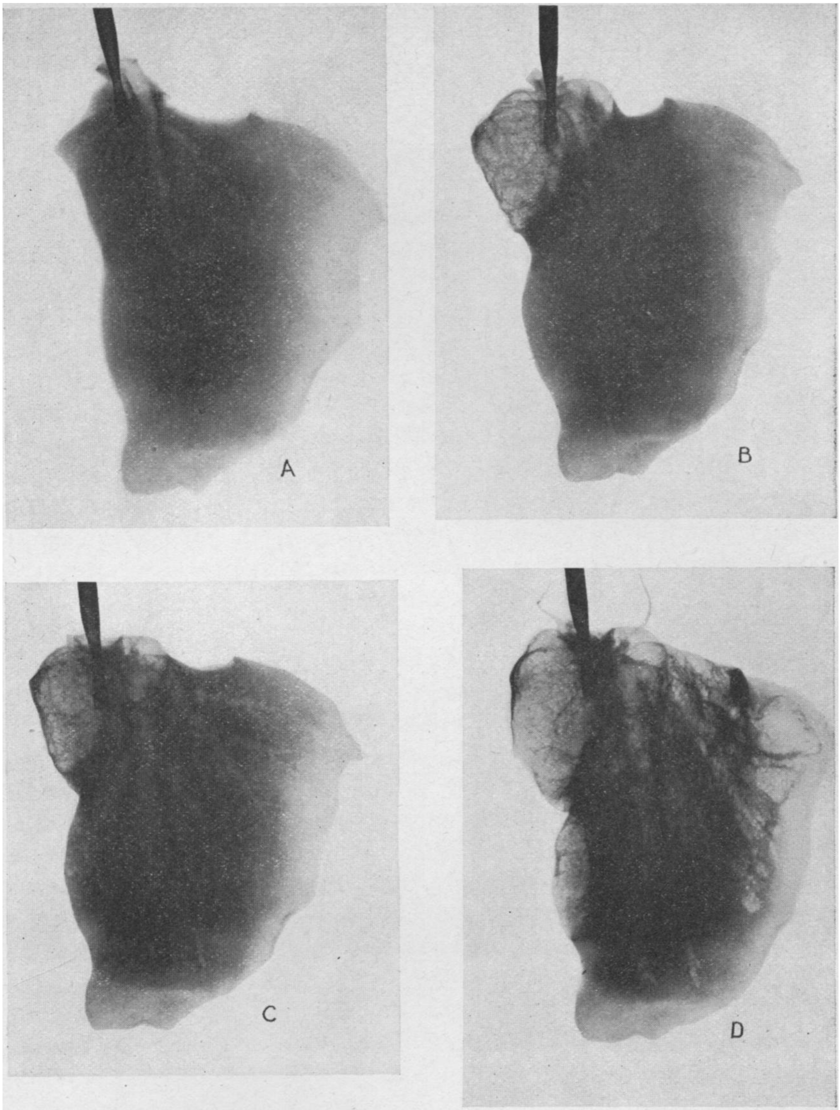


FIG. 2. Diagram representing positions of bronchial cannulae in the lung and connections with water bottle valve and manometers.



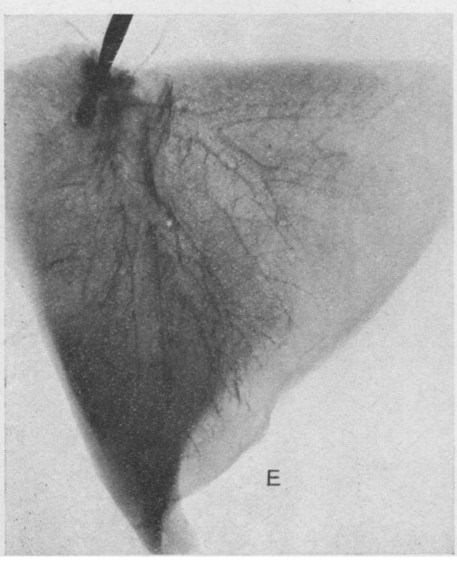


FIG. 1. Serial röntgenographs of atelectatic lung lobe during inflation, showing progress of air in passing from one lobule to the others. A, fully atelectatic lobe with cannula inserted in branch bronchus; B, one lobule inflated and air escaping from open stem bronchus; C, D and E, stem bronchus ligated and air inflating remainder of lobe.

a bottle. The bottle was half filled with water. The tube from the first (distal) bronchial cannula passed just beneath the surface of the water, while the other terminated in the atmosphere over it. Manometers were also connected with the bronchial cannulae. It was now found that bubbles escaped from the submerged tube with each expiration and continued to do so as long as observation was continued (30 min.). The attachments were then reversed, so that the first (distal) bronchial cannula was connected to the tube over the water, while the second communicated with the submerged tube. Again gas bubbled from under the water, freely and continuously, but this time only during inspiration. The entrance of air into the occluded part of the lung was observed in this manner for more than one hour. At sacrifice and autopsy, the first cannula was found to be firmly attached to the bronchial wall at the point indicated, and excessive suction and pressure applied to the junction failed to demonstrate leaks. This experiment with various modifications has been often repeated with the same results.

Certain other facts pertaining to the interlobular passage of air have been disclosed. Ligation of the blood supply to the obstructed lobe does not interfere with interlobular air passage; and under these circumstances, too, chloroform vapor will be transported with the respired air through this route. The rate of air passage from unit to unit in the lung in this manner may be as high as 1,800 cc. per hour, and as much as 4,000 cc. have passed in 3 hours. The minimum pressure required to effect the passage is no more than 1.0 cm. H_2O. No evidence can be obtained that such air transportation may occur between adjacent lobes of the lung.

Comment: It is evident that gases may pass from lobule to lobule in the lung lobe when the pressure in one has been elevated slightly over that in the other, and that this passage is reversible. It occurs with equal facility in the living lung and in the specimen removed from the animal. The low pressures involved and the pattern of dissemination suggest strongly that rupture and interstitial extravasation play no essential part. Transportation is from the airways of one part directly into those of the other, and whether this occurs by diffusion through membranes (alveolar walls) or by flow through anatomical passageways is not yet known. The lung lobules are commonly believed to be independent units and without anastomosis with each other.

Work is in progress to complete this investigation from certain aspects: *1*. Amplification of the data at hand; *2*. Existence and nature of the phenomenon in other species; *3*. Manner of the passage; *4*. Significance of the phenomenon to the pathogenesis of atelectasis; and, *5*. Significance to the action of forced breathing and cough in expelling obstructing material from the bronchial tree.