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Effects of Air Ions on Isolated Rabbit Trachea.* (23615)

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Evidence has recently accumulated indicating that negative air ions are beneficial in certain cases of hay fever and asthma(2). Positive ions, on the other hand, are reported to produce nasal obstruction, dryness of the mucous membranes, and headaches(6,8). In order to test whether these clinical observations could be correlated with any measurable changes in the pulmonary clearing mechanism (including ciliary rate, rate of mucus flow, and smooth muscle tone), the following *in vitro* experiments were undertaken.

Methods. Pieces of fresh rabbit† trachea 2-3 cm long were cut along the anterior wall, spread open, and pinned to small blocks of wood. These blocks were then placed in glass-and-plastic chambers (Fig. 1) containing air of 80-100% relative humidity. By means of a 10X dissecting microscope and a Strobotac-Strobolux combination it was possible to observe the surface of the tissue and determine the ciliary rate ± 50 beats/min. Rate of mucus flow was determined by timing the progress of air-bubbles or of added grains of talc (averaging .01 mm in diameter) in the mucous layer. Clearing efficiency was gaged by the ability of a tissue to remove talc grains applied evenly over its surface with a medical powder blower. The experiments were conducted at room temperature, which varied from 21-23°C. Air ions were generated by beta radiation derived from tritium which was contained in sealed foils; a reversible rectifying circuit made it possible to select positive or negative air ions at will(5). Measurements made with the Beckett probe and Beckman micro-microammeter(3) established that 1 x 10^9 air ions of either charge impinged on each cm^2 of exposed tissue/sec.

Results. 1. *Effect on Ciliary Rate.* Under conditions described above, the initial ciliary rate averaged between 1400 and 1500 beats/min. This level was maintained for a few hours, then slowly declined. In most experiments ciliary activity ceased within 6 hours, although in a few cases it continued for 24 hours. The manner in which rabbits were

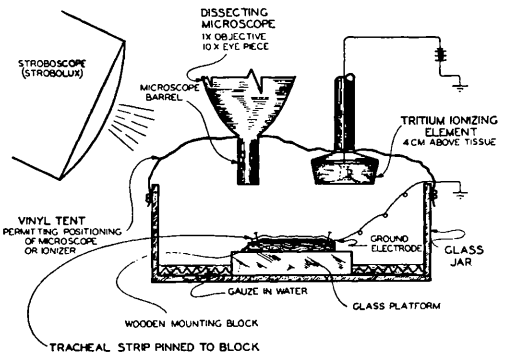

FIG. 1. Arrangement for observing effect of air ions on isolated rabbit trachea. Three such units were available.

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† We express our warm appreciation to Drs. Go Ing Gan and Agus Suhada of the University of Indonesia for meticulous work in a series of survey experiments with frogs, rats, guinea pigs, and cows in this laboratory during the spring of 1957. Their results demonstrated clearly that tracheas of these animals are not suited to *in vitro* technics we have employed and led to our selection of the rabbit as the experimental animal.

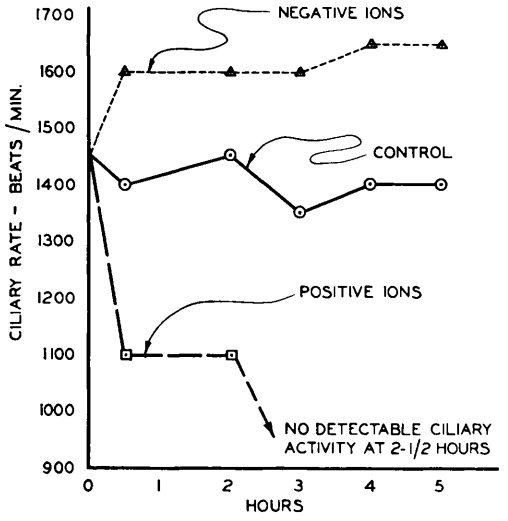

FIG. 2. Effect of air ions on ciliary activity of isolated rabbit trachea.

sacrificed had a considerable effect on vigor and durability of ciliary activity; intraperitoneal injection of a lethal dose of nembutal was found most satisfactory. Exposure of the tracheal strip to positive ions caused the ciliary rate to drop to 1100/min., and in some instances to cease altogether. Negative ions produced a rise in ciliary rate to 1600/min., or occasionally as high as 1700/min. (Fig. 2). If the ciliary rate of a tissue was lowered to 1100/min. by short exposure to positive ions,

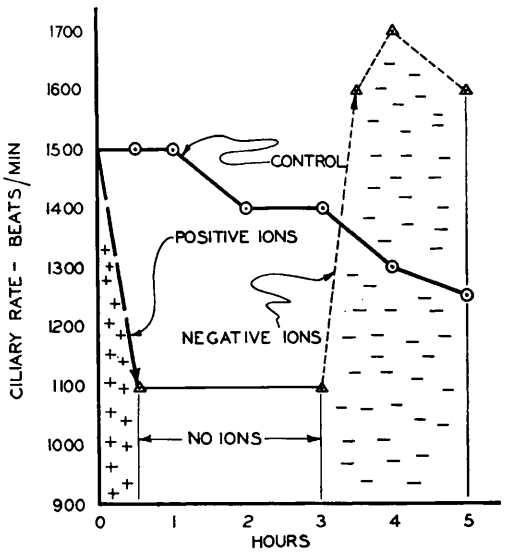

FIG. 3. Capacity of negative air ions to reverse inhibition of ciliary activity induced by positive air ions acting on isolated rabbit trachea.

and the tissue then placed in a control chamber, the cilia would continue to beat at this low rate until death of the tissue. If treatment with negative ions was instituted during this period of lowered ciliary activity, the rate was promptly restored to normal or above (Fig. 3).

2. *Effect on Mucus Flow.* As shown by Dalhamn and others(1), the ciliary rate and rate of mucus flow do not necessarily parallel each other. However, in most of our experiments exposure to positive ions caused the mucus flow and clearing ability either to decrease markedly or stop altogether. Negative ions, on the other hand, increased the mucus flow rate in about half of our experiments, had no effect on the mucus flow rate in the other half. (Fig. 4).

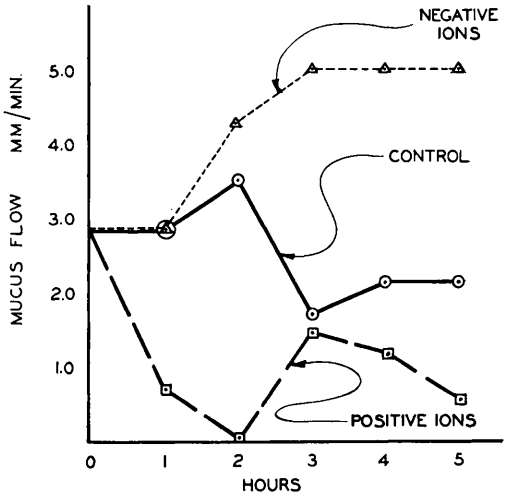

FIG. 4. Effect of air ions on rate of mucus flow on surface of isolated rabbit trachea. Rate measured by following movement of talc particles or air bubbles.

3. *Effect on Smooth Muscle.* It was routinely observed that positive ions caused the membranous posterior wall of the trachea to contract; in this condition it was impossible to elicit peristalsis by stretching the tissue laterally. Negative ions completely reversed this effect; the posterior wall relaxed and peristalsis could once more be elicited.

4. *Effect on the Mucous Layer.* Upon exposure to positive ions, the tracheal surface generally assumed a characteristic dry, nonglossy appearance. Negative ions either had

no effect on the surface or caused the appearance of a watery fluid, which could be drained off. Whether this fluid was a condensation of water molecules from the air or represented an actual secretion is not known. The mucous layer of control tissue had a glossy appearance, but was never watery.

5. *Effect on Ciliary Resistance to Mechanical Trauma.* It was noted that positive ions rendered the cilia peculiarly vulnerable to mechanical trauma. A single, very gentle stroke with a cotton-tipped swab dipped in Ringer's solution, which had no lasting effect on the control, completely stopped ciliary activity over all or most of the surface of the tissue receiving positive ions. This enhanced vulnerability completely disappeared when the tissue was exposed to negative ions. It also disappeared if the tissue was allowed to stand in the control chamber for an hour or more.

It is not at all obvious on *a priori* grounds that air ions should possess any capacity to influence biological systems. Nevertheless, evidence is collecting which establishes such activity in several areas. For example, positive ions reduce the succinoxidase content of the rat adrenal gland(4), and negative ions raise the CO_2 combining power of hamster blood plasma(7). During the past 2 years we studied the response of microorganisms suspended in very small drops of water when exposed to positive and negative air ions and have secured quantitatively reproducible alterations in survival curves(3).

While we have as yet developed no theory to account for the action of air ions on the rabbit trachea, it is possible that some of the changes we noted in the rate of water evaporation from droplets containing bacteria(3) may have significance here as well. A study of the inter-relationships and possible interdependence of the effects described in this series of experiments is currently in progress.

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Effect of Sodium Lactate Infusion on Urate Clearance in Man.* (23616)

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Gibson and Doisy(1) made the interesting observation, in normal human subjects, that ingestion of sodium lactate results in a striking if transitory decrease in the urinary excretion of uric acid, accompanied by a slight rise in plasma uric acid, suggesting "an elevated threshold in the kidney." Quick(2), Michael (3) and Nichols *et al.*(4) confirmed the decline in urinary uric acid excretion, a phenomenon which, in view of the physiological significance of lactic acid as a metabolic intermediate, may ultimately throw some light upon the still obscure nature of the renal tubular transport mechanisms for uric acid. The present study was designed to define this effect of lactate on renal excretion of uric acid more precisely by use of standard clearance technics.

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