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^{133}Xenon washout in the paranasal sinuses – a diagnostic tool for assessing ostial function

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SYMMARY

A ^{133}Xenon washout test is presented and interpreted. It was developed on the basis of studies into the accumulation of aerosols of different makes (lithium chloride in the form of ultrasonic, vibratory and pressurized aerosols) in the paranasal sinuses and sequential scintigraphy with radioactively labeled aerosols (99m Technetium colloidal sulfur) and is designed to shed light on the gas exchange in the paranasal sinuses and the patency of their orifices. The test constitutes a valuable addition to the battery of diagnostic tools for assessing paranasal sinus function and, at the same time, documents the true value of aerosol therapy.

Pressure changes and thus the condition of the orifices in terms of distension, stenosis or occlusion undoubtedly are instrumental in determining the accumulation of therapeutic aerosols in the paranasal sinuses, while aerosol qualities and the degree of congestion of the nasal mucosa equally play a role.

Following up Drabe's earlier investigations into the accumulation of radioactive phosphorus in the maxillary sinus (1952), we carried out similar studies to shed light on the deposition of lithium chloride aerosols in the maxillary sinus (1968), the lithium being determined in quantitative terms by flame photometry from the excised and ashed mucosa. A rough indication of the ostial condition was obtained in these studies by manometric measurements of resistance pressures using a modified version of Drettner's technique. The results obtained with different types of aerosols are shown in Figure 1.

Sequential scintigraphy using aerosols labeled with 99 m Tc colloidal sulfur showed the aerosols to accumulate preferentially in the nasal cavity; on applying vibration and, more specifically, pressure, aerosols were found to accumulate

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Aerosol	- vibr.	+ vibr.	- press.	+ press.	+ = %
jet	3.11	4.02	———	———→	24.0 %
ultrasonic	3.96	4.97	———	———→	20.0 %
+ = %	21.5 %	19.0 %			
vibr. ultrason. (22 subjects each)	——	——	4.26	5.50	22.6 %

Figure 1. Mean lithium concentration in maxillary sinus for different aerosol makes in chronic relapsing maxillary sinusitis.

at an accelerated rate at the roof and in the adjacent paranasal sinuses. This was confirmed by scintigraphic phantom studies using a folded hose through which an aerosol labeled with 99m Tc was made to pass at a rate of 16 liters/minute.

Extrapolating from these phantom studies to the interior of the nose, the niches and folds, i.e. the ostial areas, appear to be the preferential sites of aerosol accumulation.

Since the accumulation of an aerosol in the paranasal sinuses is apparently subject to ventilation and, consequently, to ostial patency, the airflow through the paranasal sinuses can be expected to yield information on the condition of the orifices.

While numerous methods were developed in the past few years for recording pressure changes, quantitative data on the gas exchange in the maxillary sinus were only reported by Drettner and Aust (1977), who found that the gas volume was exchanged within some 5 minutes depending, to a certain extent, on the size of the orifices.

With the help of the ^{133}Xenon washout test developed by Streckenbach et al. (1978) and currently tested by us it has now become possible to obtain quantitative data on the gas exchange in the frontal sinus of humans. For the purpose of this test a ^{133}Xenon-air mixture is injected into the frontal sinus by way of a cannula inserted through Beck's drill holes and Xenon clearance is determined as an indicator of gas exchange. With the time activity curves showing a mono-exponential function, the time required for the gas exchange is 1 to 10 minutes in normal individuals, i.e. during this time, a gas volume equivalent to the frontal sinus volume is exchanged on ventilation. The test was also employed in the maxillary sinus, the gas exchange times obtained at this site being comparable to the values reported by Drettner and Aust. Gas

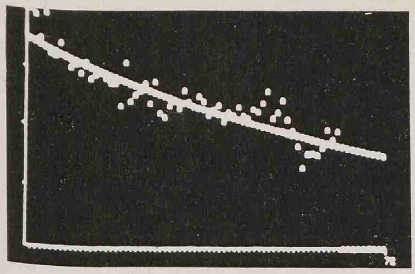


Fig. 2a. Time activity curve on ^{133}Xenon washout test in normally ventilated frontal sinus.

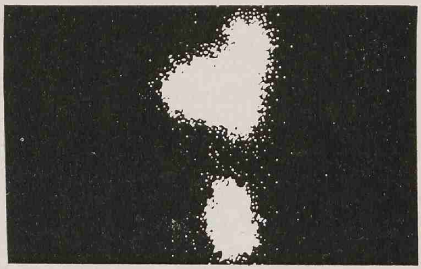


Fig. 2b. ^{133}Xenon scintigram of right frontal and maxillary sinuses.

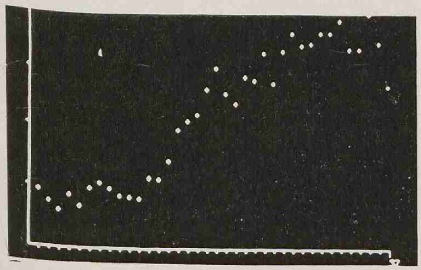


Fig. 2c. Time activity curve in nasal cavity on inhalation of 99m Tc colloidal sulfur. Note accelerated rate of activity rise on application of pressure with consequent enhanced aerosol accumulation.

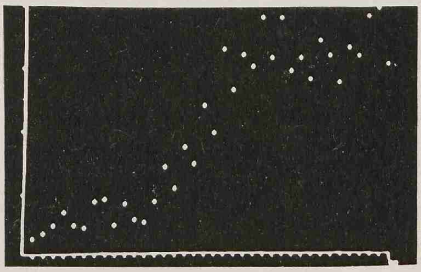
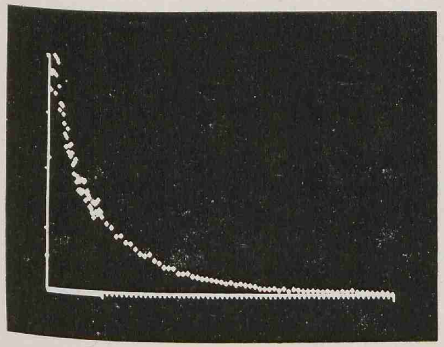


Fig. 2d. Conditions as under c., time activity curve in frontal sinus region.



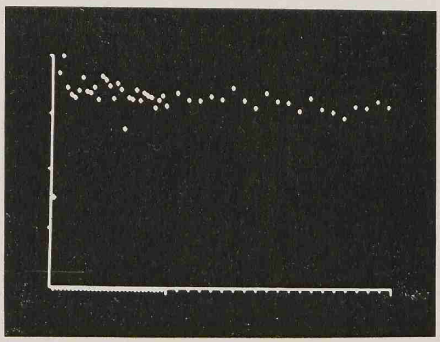


Figure 3. ^{133}Xenon time activity curve in frontal sinus.

Left: normal ventilation; exchange completed after approx. 1.25 minutes.
Right: Suspended ventilation; exchange time (halflife) more than 120 minutes.

exchange in the maxillary sinus was found to be sensitive to induced changes of nasal cavity pressure, while ostial stenosis or occlusion may reduce or altogether block ventilation, as can be seen from the following illustrations (Figures 2 and 3).

To conclude with, the Xenon washout test, once its clinical application has been extended and experience has accumulated in its interpretation, is likely to be a valuable addition to the battery of diagnostic tools designed to evaluate paranasal sinus function. It may well be expected to give information on the time factor involved in gas exchange and to serve as an indicator of ostial function. Particularly when combined with electro-manometric ventilation studies such as were developed by us, including resistometry, it appears to be a practicable method for evaluating the frontal sinus. The results obtained with it will constitute an aid both in deciding on the optimum therapy and in correctly assessing the merits of aerosol treatment.

ZUSAMMENFASSUNG

Ausgehend von Depositionsstudien an den Nasennebenhöhlen mit Aerosolen unterschiedlicher Erzeugungsart (Lithiumchlorid-Aerosol als Ultraschall-, Vibrations- und Druck-Aerosol) sowie sequenzszintigraphische Untersuchungen mit radioaktiven Aerosolen (99^{III}-Tc-Schwefelkolloid) wird zur Erfassung der Gasaustauschvorgänge in den Nebenhöhlen mit Rückschluss auf die Ostiumgängigkeit der sog. ^{133}-Xenon-Auswaschtest vorgestellt und interpretiert. Er stellt nicht nur eine Bereicherung in der Funktionsdiagmostik der Nebenhöhlen dar, sondern ordnet u.a. auch der Aerosoltherapie einen sinnvollen Stellenwert zu.

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