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Mercury content of the human lens

J. D. ABRAMS AND U. MAJZOUB

Institute of Ophthalmology and Moorfields Eye Hospital, London

In patients receiving prolonged miotic therapy, using drops containing phenylmercuric nitrate as preservative, the anterior lens capsule develops an appearance which is identical to that of mercurialentis (Abrams, 1963), a condition extremely common amongst those who work in an atmosphere of mercury. Only one analysis for mercury has been carried out hitherto on a lens showing mercurialentis (Atkinson and von Sallmann, 1946) and in this case the presence of mercury was reported without an exact figure for the amount detected.

Some doubt has, therefore, existed whether mercury is really present in the lens in such cases or whether the clinical appearance is due to some change in the capsule of the lens induced by mercury.

The fact that only one lens has been so analysed indicates the paucity of clinical material available and the technical difficulties in performing tests for very small quantities of mercury. Few lenses do in fact come to analysis because most patients with mercurialentis retain perfectly normal vision. Recently an opportunity has arisen to analyse the lens of a patient with the appearance of mercurialentis due to prolonged miotic therapy and the associated exposure to phenylmercuric nitrate; advantage has been taken of the method of activation analysis which is capable of detecting extremely small quantities of mercury.

Method

The method chosen was based on activation, by neutron irradiation, of the samples to induce the reaction Hg^{196} (n, γ) Hg^{197} followed by gamma-spectrometry to measure the 0·08 MeV gamma rays and comparison of their intensity with those from mercury standards of known weight given the same irradiation. In view of the low levels expected and the interference of high levels of sodium and chlorine activities usually found in irradiated biological samples, a simple chemical separation scheme was used rather than non-destructive analysis. This also gave the advantage of eliminating possible geometry errors when dealing with low energy gamma emitters.

The procedure used was to seal the samples after weighing them in silica ampoules, taking care to avoid overheating them and causing possible mercury losses. Standards were prepared using weighed amounts of mercuric nitrate solution made to 100 µg. Hg/ml., also sealed in silica. Samples and standards were irradiated in the BEPO reactor in a flux of 10^{12} neutrons/cm.^{2}/sec. for 24 hrs. After a short decay period the sample ampoules were cooled in liquid nitrogen, and then broken and rapidly transferred to a reflux distillation apparatus, where the samples were charred with sulphuric acid and wet-oxidized with nitric acid in the presence of 20 mg. inactive mercury carrier. Care was taken to prevent mercury losses at all stages, and after oxidation the solution was allowed to cool and then neutralized with sodium carbonate. The mercury was then precipitated by addition of NH_4S_x and the precipitate spun off and washed. The precipitate was then dissolved in H_2S-saturated caustic soda and reprecipitated by boiling with NH_4NO_3 solution. Standards were treated in exactly the same way, and after washing the final precipitates were slurried onto weighed counting trays with alcohol, reweighed to determine the chemical yields, and then counted on a gamma spectrometer using a 3″ × 3″ thallium-activated sodium iodide detector. Counting data

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Address for reprints: J. D. Abrams, Departmen of Physiological Optics, Institute of Ophthalmology, Judd Street, London, W.C.1

were collected over a period of several days in order to verify that the gamma peaks obtained decayed with a half-life of 65 hours and thus check radiochemical purity. Results were obtained by comparing peak areas for samples and standards at an arbitrary point on the decay curves obtained.

Results

The mercury content of three human lenses is reported in this paper. These lenses were all cataractous. One showed the appearance of mercurialentis and came from a patient who had been using miotics containing phenylmercuric nitrate 0·004 per cent. for several years for glaucoma. The other two lenses did not have the appearance of mercurialentis, and came from patients with senile cataract only. The lens from the glaucoma patient showed 1·08 parts per million of mercury, and the other two lenses showed 0·08 and 0·03 parts per million respectively.

The lenses were removed by identical techniques by one of us (U.M.) and care was taken to use no local medications containing phenylmercuric nitrate as a preservative. Alpha-chymotrypsin was used and the lens was delivered "head-first" in order to avoid any instrumentation to the central region of the anterior lens capsule.

Comment

The technique used for estimating mercury is probably accurate to within ± 5 to 10 per cent. and the limits of determination of mercury by activation analysis are between 10^{-7} and 10^{-10} g., a range which is very much below the quantities reported here. The mercury content of the suspected mercurialentis lens is therefore some twenty times higher than the content of the senile cataractous lens with most mercury in it.

Little is known about trace elements of the human lens, but in other parts of the body 0·05 parts per million of wet weight is about the highest mercury content which has been recorded. The figure of 1·08 parts per million must therefore be considered pathologically high for the lens showing the appearance of mercurialentis. This is particularly so in view of the fact that the mercury content relates to the lens as a whole and if, as now seems reasonable to conclude, the mercury is present in a small area of the anterior capsule, the concentration at that site must be considerably greater.

It is interesting to speculate on the precise cause of the beautiful appearance of mercurialentis on the slit lamp. Assuming that a human lens weighs about 200 mg., the amount of mercury present in the mercurialentis sample would be about 0·2 µg. The exact thickness of a film produced by this amount of mercury in an area of perhaps 3 sq. mm. will depend upon the form in which the mercury is present. As it is known that mercury can be deposited from solutions of phenylmercuric nitrate, the film itself may be composed of metallic mercury absorbed onto the capsule. Should this be so, the thickness of the film works out somewhere in the region of 0·01 µ, some fifty times smaller than the wave length of mid-spectral visible light. It is therefore hardly to be expected that this would present any significant obstruction to the transmission of light from aqueous humour through the lens.

According to Heavens (1968), a world authority on the optical properties of thin films, a layer of mercury of this thickness could be expected to have a slight granularity rather than to appear as a true film, and according to the particle size coloured effects might be obtained from oblique illumination. These features are well known clinically in all the metalloses which affect the lens. It appears to be impossible to identify the chemical nature of the film merely by inspection of its optical properties, because these depend on the characteristics of the particles rather than on the chemical composition.

Summary and conclusions

A cataractous lens was removed from a patient also suffering from chronic glaucoma. Miotic drops containing phenylmercuric nitrate 0·004 per cent. as a preservative had been used three times a day for 4 years and the lens showed the appearance of mercurialentis. It was found to have a significantly higher mercury content than that of two other cataractous lenses. Although it has not been possible to identify the precise site in the lens where this mercury is localized, these analyses suggest that the appearance of mercurialentis is due to the deposition of either metallic mercury or a compound containing this metal.

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