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COMMUNICATIONS

THE INFLUENCE OF CALCIUM CHLORIDE ON THE
PRODUCTION OF OCULAR FLUID AND ON OCULAR
PRESSURE

BY

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THE experiments of Chiari and Januschke⁽¹⁾ have already shown that injections of calcium chloride have the property of inhibiting or preventing the chemosis which appears after the instillation of a drop of mustard oil into the eye of a rabbit. This action may be attributed to a lesser permeability of the walls of the vessels. It would, therefore, not be surprising to find that the walls of the *intraocular* blood-vessels also become less permeable, and that, consequently, a limitation of the production of fluid in the anterior part of the eye takes place. A few investigations made in this direction strengthen this point of view.

Wessely⁽²⁾ found that the administration of calcium chloride lessens the secretion of albumen found, after the instillation of eserine, in the ocular fluid.

Rosenow⁽³⁾ introduced aseptic copper into the anterior chamber of an eye and found that an exudation forms in from 24 to 36 hours. If, however, calcium chloride has been previously administered parenterally only a little fibrin is formed.

Tristaino⁽⁴⁾ found *tonometrically* that after subcutaneous injection of calcium chloride in rabbits the ocular pressure fell to 6 mm. Hg.

Kleiber⁽⁵⁾ found that the introduction of calcium chloride into the anterior chamber or vitreous was followed by a subsequent lowering of the ocular pressure.

In order to obtain more reliable results we have found it necessary to observe the influence of calcium chloride *manometrically*. In the intact eye it is only possible to measure the tension which, however, may be dependent on different circumstances, so that it is impossible to make any accurate deductions from such measurements on the intraocular secretion.

It seemed preferable to measure the liquid-current which takes place when the eye is connected with a manometer in which there is a slight under-pressure, and then to ascertain whether the current changes under the influence of calcium chloride. It is also advisable to measure the blood pressure. The apparatus used (Fig. 1) is that described in Steyn's Dissertation⁽⁶⁾. It consists principally of a horizontal glass tube marked in millimetres in which the displacement of the liquid is indicated by a small air bubble. To the extreme ends of the horizontal tube are attached two vertical glass tubes with wide lumen by means of which the pressure can be kept constant in the manometer and the air bubble can be brought to any desired part of the horizontal tube during the experiment. The prevailing pressure in the eye can be measured at any moment by means of a mercury manometer attached to the horizontal tube. The apparatus is mainly a Leber's filtration manometer.

The amount of liquid that was displaced per minute from the eye of rabbits under urethane, narcosis was carefully noted for ten minutes with the pressure in the manometer from 5 to 10 mm. Hg. below the intraocular pressure at the beginning of the experiment. If the amount of liquid displaced per minute remained constant as also the blood pressure for the ten-minute period, 6 c.c. of the 5 per cent. solution of anhydrous calcium chloride was injected into the iliac vein. The displacement of the air bubble and the oscillations of the blood pressure were then noted carefully and continuously.

It was then observed as can be seen from the curve (Fig. 2) that during an average of twenty minutes after the injection of calcium chloride the production of ocular fluid was considerably increased. This period of increased production was followed by a period of distinct decrease of production of much longer duration. This decrease could be noted during one and a half to two hours, beyond which period it was not found practical to continue the experiment. This initial increase and subsequent decrease of fluid production takes place independently of the blood pressure, since the blood pressure falls directly after the injection, but soon regains its original height and remains at this level for the rest of the experiment.

FIG. 1.
Measuring Liquid Displacement

FIG. 2.

The same result follows when the experiment is performed in a slightly different way, namely by connecting the eye with a manometer in which there is a higher pressure than that in the eye, so that fluid is displaced into the eye. In these experiments the pressure in the manometer was 31 mm. Hg., an over-pressure of about 6 mm. Hg. We then observed that immediately after the calcium chloride injection a period followed during which the displacement of liquid into the eye ceased, and that the current was even reversed, so that fluid was displaced from the eye into the manometer, as is clearly shown in the following tables :

TABLE I

RABBIT 1.5 KG. URETHANE NARCOSIS.

Original eye pressure 25 mm. Hg. Over pressure in manometer 6 mm. Hg.

Displacement of liquid per min.			Displacement of liquid per min.			Displacement of liquid per min.		
3.01 p.m.	2 mm. ³ p. min.		3.37 p.m.	11 mm. ³ p. min.		4.12 p.m.	1 mm. ³ p. min.	
3.02 "	2 "		3.38 "	9 "		4.13 "	1.5 "	
3.03 "	1.5 "		3.39 "	10 "		4.14 "	1 "	
3.04 "	2 "		3.40 "	8 "		4.15 "	1 "	
3.05 "	2.5 "		3.41 "	7 "		4.16 "	1 "	
3.06 "	3 "		3.42 "	7 "		4.17 "	1 "	
3.07 "	2.5 "		3.43 "	6 "		4.18 "	1.5 "	
3.08 "	2.5 "		3.44 "	6 "		4.19 "	1.5 "	
3.09 "	2.5 "		3.45 "	3 "		4.20 "	1.5 "	
3.10 "	3 "		3.46 "	5 "		4.21 "	1.5 "	
3.11 "	4.5 "		3.47 "	4 "		4.22 "	1 "	
3.12 "	3.5 "		3.48 "	2 "		4.23 "	1.5 "	
3.13 "	2.5 "	6 cm. 5% CaCl ₂ injection in iliac vein	3.49 "	3 "		4.24 "	1 "	
3.14 "	4 "		3.50 "	3 "		4.25 "	1 "	
3.15 "	4 "		3.51 "	2 "		4.26 "	2 "	
3.16 "	4 "		3.52 "	2 "		4.27 "	3 "	
3.17 "	4 "		3.53 "	2 "		4.28 "	2 "	
3.18 "	4 "		3.54 "	1.5 "		4.29 "	2 "	
3.19 "	1 "		3.55 "	1.5 "		4.30 "	1.5 "	
3.20 "	1 "		3.56 "	1 "		4.31 "	1.5 "	
3.21 "	0.5 "		3.57 "	0.5 "		4.32 "	2 "	
3.22 "	8.5 "		3.58 "	0.5 "		4.33 "	2 "	
3.23 "	25 "		3.59 "	0 "		4.34 "	1.5 "	
3.24 "	23 "		4. "	0.5 "		4.35 "	2 "	
3.25 "	23 "		4.01 "	0.5 "		4.36 "	2 "	
3.26 "	22 "		4.02 "	0 "		4.37 "	2 "	
3.27 "	21 "		4.03 "	0.5 "		4.38 "	1.5 "	
3.28 "	20 "		4.04 "	0 "		4.39 "	2 "	
3.29 "	21 "	4.05 "	0.5 "		4.40 "	2 "		
3.30 "	18 "	4.06 "	0.5 "		4.41 "	2 "		
3.31 "	15 "	4.07 "	0.5 "		4.42 "	2 "		
3.32 "	12 "	4.08 "	0.5 "		4.43 "	2 "		
3.33 "	11 "	4.09 "	1 "		4.44 "	" "		
3.34 "	11 "	4.10 "	0.5 "		to	" "		
3.35 "	10 "	4.11 "	1 "		5.—	2 "		
3.36 "	9 "							

6 ccm. 5% CaCl₂
injection in iliac vein

TABLE II

RABBIT 2 KG. URETHANE NARCOSIS.

Original Eye pressure 20 mm. Hg. — Blood pressure 90 mm. Hg. in iliac artery.

Displacement of liquid per min.		Blood pressure	Displacement of liquid per min.		Blood pressure
2.53 p.m.	3 mm ³ . p. min.	90 mm. Hg.	3.37 p.m.	—9 mm ³ . p. min.	84 mm. Hg.
2.54 "	4 "	90 "	3.38 "	—8 "	84 "
2.55 "	3 "	90 "	3.39 "	—7 "	82 "
2.56 "	4 "	90 "	3.40 "	—4 "	84 "
2.57 "	4 "	90 "	3.41 "	—6 "	86 "
2.58 "	3 "	90 "	3.42 "	—8 "	90 "
2.59 "	3 "	90 "	3.43 "	—5 "	90 "
3.— "	4 "	90 "	3.44 "	—2 "	88 "
3.01 "	4 "	90 "	3.45 "	—2 "	86 "
3.02 "	3 "	90 "	3.46 "	—3 "	90 "
3.03 "	4 "	60 "	3.47 "	—3 "	90 "
3.04 "	4 "	70 "	3.48 "	—2 "	90 "
3.05 "	3 "	70 "	3.49 "	—1 "	90 "
3.06 "	5 "	60 "	3.50 "	—2 "	88 "
3.07 "	4 "	60 "	3.51 "	—1 "	92 "
3.08 "	3 "	60 "	3.52 "	1 "	94 "
3.09 "	3 "	60 "	3.53 "	1 "	88 "
3.10 "	5 "	65 "	3.54 "	3 "	96 "
3.11 "	5 "	65 "	3.55 "	2 "	88 "
3.12 "	4 "	68 "	3.56 "	2 "	88 "
3.13 "	4 "	70 "	3.57 "	0 "	98 "
3.14 "	3 "	70 "	3.58 "	1 "	100 "
3.15 "	4 "	74 "	3.59 "	0 "	100 "
3.16 "	3 "	72 "	4.— "	2 "	98 "
3.17 "	1 "	74 "	4.01 "	0 "	98 "
3.18 "	1 "	78 "	4.02 "	2 "	98 "
3.19 "	0 "	76 "	4.03 "	1 "	98 "
3.20 "	—1 "	76 "	4.04 "	3 "	98 "
3.21 "	—3 "	76 "	4.05 "	4 "	98 "
3.22 "	—4 "	74 "	4.06 "	1 "	92 "
3.23 "	—5 "	76 "	4.07 "	3 "	96 "
3.24 "	—6 "	76 "	4.08 "	1 "	96 "
3.25 "	—6 "	78 "	4.09 "	2 "	88 "
3.26 "	—7 "	80 "	4.10 "	1 "	88 "
3.27 "	—8 "	80 "	4.11 "	1'5 "	86 "
3.28 "	—10 "	80 "	4.12 "	2'5 "	90 "
3.29 "	—16 "	82 "	4.13 "	3 "	88 "
3.30 "	—14 "	82 "	4.14 "	3 "	88 "
3.31 "	—18 "	84 "	4.15 "	2 "	86 "
3.32 "	—19 "	84 "	4.16 "	3 "	84 "
3.33 "	—17 "	84 "	4.17 "	2 "	88 "
3.34 "	—17 "	86 "	4.18 "	2 "	88 "
3.35 "	—12 "	84 "	4.19 "	3 "	88 "
3.36 "	—10 "	84 "	4.20 "	2 "	86 "

After about half an hour this increased production ceases and a decrease takes place to such an extent that fluid is displaced into the eye with a speed equal to that before the injection of

calcium. Since the previous experiments show that a decrease of fluid production takes place at this stage, it seems reasonable to expect that in experiments with an "over-pressure" manometer a greater quantity of liquid would be displaced into the eye than before the calcium injection. That this does not happen probably

FIG. 3.

Registration of the ocular pressure.

indicates that there is a lesser permeability of the draining apparatus of the anterior chamber (canal of Schlemm, etc.).

We further investigated whether, as a result of calcium injection, there was actually any change of pressure in the intact eye. For this purpose the eye was connected with Rochat's sensitive registration manometer (*Arch. néerlandaises de Physiologie*, Vol. VII, p. 265, 1922) so that the ocular as well as the blood pressure could be simultaneously recorded photographically as seen in the curve reproduced (Fig. 4).

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The results corresponded with those of the foregoing experiment. Immediately after the intravenous injection of calcium chloride the intraocular pressure rose to about 45 mm. Hg. for a period of about half an hour and then gradually fell well below the normal pressure during the rest of the experiment, which lasted about an hour. It is not practical to continue the experiment much longer as abnormal changes take place in the eye after that time, such as redness, and clotting in the canula connecting the eye with the manometer. We, therefore, considered

FIG. 4.

Influence of CaCl_2 injection on eye—and blood pressure

it necessary to extend the experiments with the assistance of a tonometer, which, however, is less accurate but has the advantage that the experiments can be extended over an unlimited space of time.

A curve had first to be constructed for the Schiötz tonometer for the rabbit's eye, as the curve for the human eye is not suitable for that of the rabbit.

Tonometrically it also appeared that, immediately after the calcium injection, the tension was raised for a short period to be followed by an abnormally low pressure which could be observed for many hours as seen in the following tables.

TABLE III

Rabbit 1.75 Kg. Eye pressure 25 mm. Hg.

26-3-'23	3.—	p.m.	2 c.cm. 10 % CaCl_2 injected in ear vein.	
	3.08	..	eye pressure 30 mm. Hg.	
	3.20	..	18	..
	3.30	..	14	..
	3.45	..	12	..
	4.30	..	13	..
	5.—	..	12	..
	8.—	..	13	..
27-3-'23	9.—	a.m.	20	..
	2.—	p.m.	25	..
	5.—	..	20	..
28-3-'23	9.—	a.m.	25	..

TABLE IV

Rabbit 3 Kg. Eye pressure O. S. 22 mm. Hg.

28-9-'23	3.—	p.m.	5 c.cm. 5% CaCl_2 injected in ear vein.	
	3.03	..	eye pressure O. S. 35 mm. Hg.	
	3.05	..	35	..
	3.07	..	40	..
	3.10	..	35	..
	3.15	..	25	..
	3.20	..	20	..
	3.30	..	16	..
	3.40	..	14	..
	4.—	..	13	..
	4.15	..	12	..
	4.30	..	12	..
	5.—	..	12	..
	6.—	..	13	..
29-9-'23	9.—	a.m.	22	..

The initial height of the intraocular pressure only returned after 12 to 24 hours.

We made a further series of experiments on the production of the ocular fluid by investigating the influence of injection of calcium on the secretion of fluorescein in the anterior chamber. The injection of 1 c.c. of a 3 per cent. solution of uranin intravenously into the ear of a rabbit causes after some time the appearance of the so-called line of Ehrlich. Long before this, however, we can see with the help of the slit-lamp and corneal microscope a green fluorescence in the anterior chamber. The intensity of the colour may be estimated, though only approximately, by placing in front of the slit-lamp small tubes containing a much diluted solution of uranin of different strengths and comparing their colour with that appearing in the anterior chamber.

We found that the injection of calcium chloride accelerates the appearance of the green colour in the intraocular fluid. The animals in which calcium had been injected exhibited fluorescence

in the anterior chamber sooner than the control animals and the green colour got more intense and could be perceived longer in the former. This is in agreement with the results obtained by the previously described methods of experimentation.

Lastly, we repeated the experiments of Chiari and Januschke⁽¹⁾. These observers found that injections of calcium chloride had a pronounced inhibitory effect on the oedema produced by the action of mustard oil. Their experiments have frequently been repeated by other observers. Our object in repeating their experiments was to test the observation made by Magnus, de Kleijn, and Storm van Leeuwen⁽⁷⁾, that while it was true that rabbits previously treated with calcium chloride exhibited very little reaction on the instillation of mustard oil into the conjunctival sac, they were afterwards much worse off than the control animals, as they developed panophthalmitis with phthisis bulbi instead of severe oedema. Our experiments did not confirm this observation. We found that the animals treated with calcium as well as the control animals developed corneal ulcers which healed after a few days whether the application of mustard oil was followed by oedema or not. Nothing was seen of a more severe course of the affection in the animals which had been protected by the calcium injection. The general condition, however, of the protected animals was worse, as they got extensive necrosis of the skin and became thin. In some cases the protecting action of the calcium did not take place or was very weak. As a rule, however, the protecting action could be clearly observed.

The experiments clearly show that it is possible to inhibit the production of fluid in the eye by the administration of calcium chloride. In the case of man it is only possible to administer calcium chloride by the mouth, as subcutaneous injections cause extensive necrosis of the skin, and intravenous injections of any considerable quantity are dangerous on account of their action on the heart. Further investigations must teach us how far it is possible in the case of man to inhibit the production of intraocular fluid by intestinal administration of calcium chloride.

It is necessary to distinguish between two clearly different actions of calcium chloride on the production of ocular fluid, the one inhibiting and the other promoting the production. The former can be readily explained by the facts already known about the action of calcium in general, i.e. it renders the walls of the blood-vessels less permeable and also causes contraction of the small blood-vessels. The latter on the contrary cannot be explained without recurring to theoretical suppositions, since it was not previously known that calcium chloride for a short time promotes the production of ocular fluid. Action on the nervous system of the eye is a possible explanation. There are vaso-constrictors, and,

in all probability, vaso-dilators in the eye. Bayliss has demonstrated their presence in the ophthalmic branch of the trigeminal nerve. It is also possible that calcium chloride (which according to Overton and Locke acts on the synapses of some nerves) by either paralysing the constrictors or stimulating the dilators causes an increased circulation in the eye, while the specific action of calcium chloride which causes constriction and lessens the permeability of the vessel walls is temporarily masked.

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AN ARABIC BRONZE NEEDLE FROM ANTIQUITY FOR DEPRESSION OF CATARACT

BY

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AMONG some antique surgical bronze instruments collected from the ruins of Palmyra by the late Russian Baron Ustinov (1872-1890) and now in my possession^(6 and 3) there is one to which some interest for the history of ophthalmology is attached; it was exhibited at the Eleventh Annual Meeting of the Oxford Ophthalmological Congress, 1920. Baron Ustinov has never published anything about his finds.

In Fig. 1 the instrument is seen in natural size. Though the sharp end was broken off in antiquity and not found I have good reasons to believe that the instrument is an Arabic cataract couching needle from the centuries immediately after the Mohammedan conquest of Palmyra; in a spatula found from the same source a Palmyrene man's name 'Αδῆκαβος is stamped *Ati'akab* in basso-relievo with Arabic letters^(3 and 6).

I have the following facts to support my opinion:

(1) The diameter of the square handle, 4 mm., is about the same as in the ophthalmic instruments of the present day; I do not, however, lay great stress upon this point.