THE EFFECT OF SUCCINYLCHOLINE ON INTRAOCULAR PRESSURE IN ADULTS, INFANTS AND CHILDREN DURING GENERAL ANESTHESIA

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THE ABILITY of succinylcholine chloride to increase intraocular tension in adults has been reported by several groups of investigators.[1-6] It has been suggested that such a rise in intraocular tension may be harmful to patients with glaucoma and to those undergoing operation for cataract. Also, some believe that succinylcholine causes contraction of the extraocular muscles and that this may interfere with operations on these muscles. We frequently administer succinylcholine to facilitate tracheal intubation of patients prior to ophthalmologic operations and have, therefore, been interested in these phenomena. This report deals with the effect on intraocular tension of succinylcholine administered as an intravenous drip to adults and intramuscularly, admixed with hyaluronidase, to children and infants. All subjects were anesthetized; a variety of anesthetic agents and depths of anesthesia were selected.

METHODS

Adults. Thirty-seven patients were studied. None had a history of glaucoma. The ages ranged from 19 to 79 years. Twenty-three were female. About one hour after the intramuscular injection of 100 mg. secobarbital or 50–100 mg. meperidine, and 0.4 mg. atropine, the patients' corneas were anesthetized with two drops of 0.5 per cent tetracaine.

Inhalational anesthesia was administered via a closed system carbon dioxide absorbing unit. Depth of anesthesia was estimated by standard clinical criteria (Guedel). Efforts were made to avoid hypoxia and hypocarbia by strict attention to ventilation. Intraocular pressure was determined by means of a Schiotz tonometer. Measurements were made in most instances just before the induction of general anesthesia, and repeatedly during anesthesia. Data were obtained immediately after tracheal intubation had been accomplished in 14 subjects with the aid of 40 mg. succinylcholine by vein. Most of the observations, however, were made during the continuous intravenous injection of 0.1 or 0.2 per cent succinylcholine. The effects of apnea vs. spontaneous respiration, of various depths of anesthesia, and of various anesthetics were studied. Many of the measurements were made during operation.

Infants and Children. Seventeen patients were observed. The age range was from two months to ten years. Thirteen were male. Five had been previously operated upon for infantile (wide-angle) glaucoma. One hour prior to anesthesia the patients received secobarbital and atropine; secobarbital and scopalomine; secobarbital, morphine and scopalomine; or, scopalomine alone, intramuscularly. When possible a "steal" technique was used for the induction of anesthesia. Anesthesia was induced with cyclopropane, nitrous oxide-oxygen, or halothane-nitrous oxide-oxygen. When the eyes became central and fixed, the intraocular pressure was measured using a Schiotz tonometer. Readings were made to the nearest marking on the tonometer. Succinylcholine 1 mg./pound body weight, freshly admixed with hyaluronidase, was administered by deep intramuscular injection into the thigh, and the anesthetic was changed to nitrous oxide and oxygen. When the respiration became markedly depressed the intraocular pressure was again measured. The patient was usually apneic before this measurement was completed. The intraocular pressure was measured in one eye and then in the other and these measurements were again repeated as soon as possible. If there was a difference between readings in one eye, a third set of measurements was made. All measurements were made while the patient was in the first plane of the third stage of anesthesia and before operation was begun. Tracheal intubation was not performed. An oral airway was

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TABLE 1

THE EFFECT OF A CONTINUOUS INTRAVENOUS INFUSION OF 0.1 OR 0.2 PER CENT SUCCINYLCHOLINE UPON THE INTRAOCULAR TENSION OF ANESTHETIZED ADULTS

Patient No.	Anesthetic Agent(s)	Plane of Stage III	Total Dose of Succinylcholine (mg.)	Time of Injection (min.)	Intraocular Pressure (mm. Hg)			
					After Preanesthetic Medication	After Anesthesia	Maximum Reading After Succinylcholine	Maximum Rise
1	Cyclopropane	2	250	5	27.1	26.5	55.1	28.6
2			500	45	14.2	16.9	23.4	6.5
3		2	500	1	20.1	20.1	23.4	3.3
4		1	600	60	20.1	20.1	26.5	6.5
5		1	500	55	20.1	20.1	23.4	3.3
6		1	800	45	23.4	23.4	27.1	3.8
7		1	650	105	16.9	16.9	14.2	−2.7
8		2	500	35	16.9	16.9	20.1	3.2
9		2	375	55	14.2	14.2	23.4	9.2
10		1	200	25	23.4	23.4	20.1	−3.3
11	Cyclopropane-ether	1	50	1	16.0	16.0	30.0	14.0
12		2	600	70	14.2	11.9	23.4	11.5
13		1	150	30	23.4	20.1	32.0	11.9
14	N_2O-ether	1	150	7	27.1	23.4	28.3	4.9
15		3	600	30	23.4	--	42.5	19.1
16		3	300	3	23.4	27.1	33.1	6.0
17		1	250	9	23.4	27.1	27.1	0
18		1	400	10	19.2	19.9	23.0	3.1
19		1	300	6	—	20.1	23.4	3.3
20		1	400	20	—	27.1	32.0	4.9
21	Thiopental-N_2O	1	150	8	16.9	17.1	20.1	3.0
22		1	200	10	16.9	--	22.3	5.4
23		1	350	10	19.4	19.4	22.4	3.0
24		1	160	10	20.1	20.1	23.4	3.4
25		1	30	0.3	27.1	27.1	37.4	10.3
26		1	300	3	20.1	20.1	27.1	7.0
27		1	100	2	—	23.4	27.1	3.7
28		1	200	4	—	20.1	20.1	0
29		1	300	8	--	23.4	27.1	3.7
30		1	750	10	—	23.4	32.0	8.6

inserted only when necessary to avoid respiratory obstruction. Anesthesia was administered via a bag and mask. To avoid carbon dioxide accumulation strict attention was paid to pulmonary ventilation, respiration was assisted or controlled when necessary, and the anesthetic gases were delivered at a minute flow rate in excess of twice the patient's minute volume. The excess gas was allowed to escape through the "tail" of the bag.

RESULTS

Adults. The maximum elevations in intraocular pressure noted in 30 patients in whom the depth of anesthesia remained fairly constant throughout the period of observation are listed in table 1. Thirteen subjects showed a rise in pressure above 5 mm. of mercury at some time. Increased intraocular pressure associated with the intravenous injection of succinylcholine was seen during anesthesia with cyclopropane, cyclopropane-ether, nitrous oxide-ether, and thiopental-nitrous oxide. Elevations were found during estimated planes 1, 2, and 3 of surgical anesthesia. The presence or absence of spontaneous respiration did not appear to influence the results nor did the occurrence of fasciculation after the rapid in-

jection of succinylcholine. There was no relationship between pupillary size and rise in intraocular pressure, some of the larger elevations occurring in patients with constricted pupils.

After the rapid injection of succinylcholine the rise in intraocular tension was steep and was followed by a return to control values within two to five minutes. In the majority of instances the rate of continuous infusion required to produce satisfactory relaxation for intra-abdominal operations was insufficient to cause a rise in intraocular pressure. To produce this latter effect the drip rate had to be increased considerably. After the continuous infusion of succinylcholine had been discontinued, intraocular pressure returned to control values within ten minutes.

The effects of succinylcholine on intraocular pressure measured during "light" and "deep" ether anesthesia are listed in table 2. In general, during deeper anesthesia the rise in tension was less.

Infants and Children. Ten of 17 patients showed a rise in intraocular pressure in both eyes following the intramuscular administration of succinylcholine admixed with hyaluronidase. The greatest rise was 20 mm. of mercury, but the majority were in the range of 2–9 mm. of mercury. The control values for intraocular pressure were not equal in both eyes in many cases (table 3), but in all but three of these the difference was less than one division on the tonometer scale. The increase in intraocular pressure following succinylcholine was not the same in both eyes in most of the patients. In one patient there was no change in pressure following the intramuscular administration of succinylcholine although the drug caused apnea. In another, the intraocular pressure decreased (2 mm. of mercury in each eye) following succinylcholine, and in three cases intraocular pressure fell below the control value in one eye but rose above it in the other.

During operation on the extraocular muscles no evidence of increased tone in these muscles was seen. Since intermittent intramuscular injections of succinylcholine were made during operation this observation is believed valid. None of the patients had fasciculations following succinylcholine administered intramuscularly. Marked increase in intraocular pressure following succinylcholine was not seen in the 5 patients who had infantile glaucoma which had been previously treated surgically. The absolute duration of the rise in intraocular pressure was difficult to determine, but ap-

TABLE 2

THE EFFECT OF INCREASING DEPTH OF ANESTHESIA UPON INTRAOCULAR PRESSURE CHANGES ASSOCIATED WITH THE ADMINISTRATION OF SUCCINYLCHOLINE

All patients were adults anesthetized with ethyl ether.

Patient No.	Plane of Stage III	Total Dose of Succinylcholine I.V. Drip	Time of Injection (min.)	Intraocular Pressure (mm. Hg)			
				After Preanesthetic Medication	After Anesthesia	Maximum Reading After Succinylcholine	Maximum Change
1	1	120	3	16.9	14.2	20.1	+5.9
	3	500	20	—	14.2	14.2	0
2	1	200	7	—	20.1	16.9	−3.2
	3	600	18	—	16.9	16.9	0
3	1	100	2	—	26.5	30.3	+3.3
	3	350	9	—	23.0	23.0	0
4	1	220	5	—	23.4	27.1	+3.7
	3	550	15	—	23.4	23.4	0
5	1	175	3	27.1	23.4	32.0	+9.6
	3	380	10	—	20.1	20.1	0
6	1	80	1	27.1	27.1	27.1	0
	3	240	9	—	27.1	27.1	0
7	1	300	10	23.4	23.4	27.1	+3.7
	3	500	20	—	20.1	20.1	0

TABLE 3

THE EFFECT OF THE INTRAMUSCULAR INJECTION OF SUCCINYLCHOLINE AND HYALURONIDASE ON INTRAOCULAR PRESSURE IN INFANTS AND CHILDREN

Patient No.	Age (years)	Weight (pounds)	Control Pressure† Tonometer Readings on Left; mm. Hg in Brackets		Pressure After Succinylcholine		Change in Intraocular Pressure (mm. Hg)
1	(5 months)	18	R 6.0	(15)	R 1.0	(35)	+20
			L 5.5	(16)	L 5.0	(17)	0
2	4	47	R 4.0	(21)	R 3.0	(24)	+ 3
			L 5.0	(17)	L 5.0	(17)	0
3	10		R 5.0	(17)	R 4.0	(21)	+ 4
			L 6.0	(15)	L 5.0	(17)	+ 2
4	5	42	R 7.0	(12)	R 5.0	(17)	+ 5
			L 7.0	(12)	L 4.0	(21)	+ 9
5	4	36	R 9.0	(9)	R 6.0	(15)	+ 6
			L 5.0	(17)	L 3.0	(24)	+ 7
*6	(2 months)	12	R 4.0 with 7.5 weight	(30)	R 3.0 with 7.5 weight	(36)	+ 6
			L 4.0 with 7.5 weight	(30)	L 3.0 with 7.5 weight	(36)	+ 6
*7	2	38	R 8.0	(10)	R 6.0	(15)	+ 5
			L 6.0	(15)	L 9.0 with 7.5 weight	(13)	− 2
8	4	34	R 5.0	(17)	R 4.0	(21)	+ 4
			L 5.0	(17)	L 6.0	(15)	− 2
9	1	27	R 6.0	(15)	R 4.0	(21)	+ 6
			L 6.0	(15)	L 4.0	(21)	+ 6
*10	2	25	R 5.0	(17)	L 5.0	(17)	0
			L 4.0	(21)	L 4.0	(21)	0
*11	2	26	R 4.0 with 7.5 weight	(30)	R 3.0 with 7.5 weight	(36)	+ 6
			L 5.0 with 7.5 weight	(26)	L 4.0 with 7.5 weight	(30)	+ 4
12	4	36	R 8.0	(10)	R 3.0	(24)	+14
			L 7.0	(12)	L 5.0	(17)	+ 5
*13	3	33	R 6.0	(15)	R 3.0	(24)	+ 9
			L 6.0	(15)	L 3.0	(24)	+ 9
14	2	25	R 4.0	(21)	R 6.0	(15)	− 6
			L 7.0	(12)	L 6.0	(15)	+ 3
15	8	59	R 6.0	(15)	R 4.5	(19)	+ 4
			L 5.5	(16)	L 4.0	(21)	+ 5
16	8	57	R 5.0	(17)	R 6.0	(15)	− 2
			L 5.0	(17)	L 6.0	(15)	− 2
17	9	50	R 9.0	(9)	R 6.0	(15)	+ 6
			L 8.0	(10)	L 7.0	(12)	+ 2

* Patients who have previously been operated upon for infantile glaucoma.

† Tonometer readings with 5.5 weight unless otherwise stated.

All patients were anesthetized with cyclopropane-nitrous oxide and oxygen except cases 15, 16 and 17 who had halothane-nitrous oxide and oxygen.

peared to coincide with the respiratory depressant action of succinylcholine. In other words, it was brief.

DISCUSSION

Our results in adults confirm the data of others that intraocular pressure may rise following the intravenous administration of succinylcholine during general anesthesia. The rise in tension accompanied the continuous infusion of the relaxant, as well as a single injection. That a similar effect can be demonstrated for infants and children is not surprising, even though succinylcholine was injected intramuscularly. To the anesthetic agents previously studied in this regard, namely cyclopropane, ether, thiopental and nitrous oxide, can be added halothane. And, as had been reported previously, the elevation in intraocular pressure was only partially dependent upon depth of anesthesia, and appeared independent of the type of respiration, the presence of fasciculation and change in pupil size. We were unable to measure the

enophthalmos reported by Bjork and colleagues.[7]

The cause of the rise in intraocular tension is generally believed related to contraction of the extraocular muscles. That this may not be the complete explanation is evident by the fact that a rise in tension may occur after severance of all four rectus muscles. It is of interest that succinylcholine, which relaxes the majority of normal mammalian muscles, exerts this opposite effect on extraocular muscles. Normal bird muscle and frog belly muscle, however, are also contracted by succinylcholine.

We have been unable to demonstrate any harm done to the visual acuity either of the patients in this study or of the many others who have received succinylcholine under our care. Scheie [8] states that such procedures as the injection of air into the anterior chamber of the eye results in greater increases in intraocular pressure than seen in any of our patients, and that he had not noted ill effects from this practice.

It would seem that the intelligent view to take of the relationship between intraocular pressure and succinylcholine would include the following points: (1) a rise in pressure may occur; (2) such a rise may endanger the patient undergoing operation for cataract; and (3) patients, particularly infants and children whose tensions are checked frequently as part of the management of glaucoma, may be subjected to an unnecessary operation if intraocular pressure figures obtained immediately after the injection of succinylcholine are used as criteria. In general, however, the use of succinylcholine appears quite safe for patients on an ophthalmologic surgical service.

Summary and Conclusions

Succinylcholine administered either by single or continuous intravenous injection to adults, or with hyaluronidase intramuscularly to infants and children, caused a rise in intraocular pressure in about one half of a group of 54 patients. The rise in tension disappeared promptly after cessation of action of succinylcholine. It was unrelated to anesthetic agent, pupil size, or fasciculation, and was only moderately reduced by increasing depth of anesthesia. No harm in visual function was noted, nor is there likely to be harm except during operation for cataract.

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