resulted secondary to massive embolization of trophoblastic cells.[4,5] Autopsy findings in these patients consistently show patchy areas of pulmonary infarction and the presence of hyaline membrane formation. The larger pulmonary arteries remain patent, but numerous smaller arteries and arterioles are completely occluded by trophoblastic cells.[4,5]

Unlike most pulmonary embolization secondary to venous blood clots, this case of trophoblastic embolization resulted in marked intrapulmonary shunting. In addition, the severe hypoxemia was refractory to 100 per cent inspired oxygen. The initial measured shunt in our patient was 75 per cent. Another possible explanation for this large degree of shunt is opening of an arteriovenous pulmonary anastomosis, which became patent when many of the small arterioles were occluded by trophoblasts. This type of intrapulmonary shunting secondary to an acute increase in pulmonary vascular pressure has been demonstrated experimentally in animals and angiographically demonstrated in patients with metastatic choriocarcinoma.[6]

Our patient's response to appropriate PEEP therapy, carefully monitored, is well documented, and we believe it was a primary factor in her survival. Therefore, we believe this therapeutic regimen must be kept in mind whenever a patient has significant respiratory distress, with associated refractory hypoxemia, following uterine curettage of a hydatidiform mole.

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Plasma Catecholamine Levels during Local Anesthesia for Cataract Operations

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Cataract operations may be performed either with general anesthesia[1] or after retrobulbar injection of local anesthetic[2] (usually with added epinephrine) into the eyelid and retrobulbar area. Many patients who have cataracts are elderly and have significant cardiovascular disease[1] such as hypertension, angina, and previous myocardial infarctions.[3] The goal of safe anesthetic management of these patients is to reduce the stress response. Significant increases in the release of catecholamines, as reflected by plasma levels, may cause hemodynamic changes resulting in tachycardia, hypertension, ischemia, angina, or dysrhythmias. With retrobulbar block there are two possible sources of catecholamines: those endogenously released in response to stress, and exogenous epinephrine added to the local anesthetic solutions.

The purposes of this study were to determine whether: 1) there is hemodynamically significant systemic uptake of exogenous epinephrine following eyelid infiltration and retrobulbar block; and 2) patients undergoing this procedure manifest elevated endogenous plasma norepinephrine levels.

Methods and Materials

Seventeen patients, ASA class II, scheduled for elective cataract operations with local anesthesia, were selected. The age range was 43 to 84 years (mean, 64.5 years) and weight range was 60 to 94 kg (mean, 71.8 kg). These patients were premedicated with meperidine, 0.7 mg/kg, im, and promethazine, 0.4 mg/kg, im, an hour before operation.

An 18-gauge heparin lock intravenous catheter was placed in a forearm vein 20 min before the patient was

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TABLE 1. Plasma Epinephrine

	Plasma Epinephrine (pg/ml)		
	Control	2 Min	7 Min
Patient 1*	43	42	815
Patient 2*	48	2801	383
Patient 3	120	181	273
Patient 4	23	56	108
Patient 5	46	377	539
Patient 6	128	350	501
Patient 7	126	251	447
Patient 8	72	62	153
Patient 9	294	212	504
Patient 10	32	387	303
Patient 11	79	116	302
Patient 12	208	765	766
Patient 13*	114	780	944
Patient 14	66	94	124
Patient 15	109	106	152
Patient 16	279	360	538
Patient 17	180	263	383
MEAN ± SE (n = 17)	116 ± 8	424 ± 65†	429 ± 25†
MEAN ± SE (n = 14)	126 ± 9	256 ± 19‡	368 ± 19‡

* As per text, three patients with pharmacologic evidence of stress response were removed from analysis.
† Significantly different, $P = 0.044$.
‡ Significantly different, $P = 0.002$.

taken to the operating room. In the operating room, a control blood sample was drawn. Eyelid infiltration and retrobulbar block injection were given using a total of 10–12 ml 2 per cent lidocaine with 1:200,000 epinephrine. Venous blood samples were drawn at 2 and 7 min after retrobulbar injection. Vital signs were recorded and the EKG was continuously monitored during this period.

Blood samples were collected in heparinized tubes, immediately iced, and centrifuged at 4 C. Plasma was separated and stored at −80 C. These samples were coded and analyzed blindly for epinephrine and norepinephrine levels using a modification of the radioenzymatic assay technique of DaPrada and Zurcher.[4] This assay method has a sensitivity of 20 pg/ml.[5]

The resulting data were compared statistically by one-way analysis of variance, using the Newman-Keuls test of multiple comparisons based on the Studentized range statistic Q.[6]

RESULTS

Epinephrine. These values are shown in table 1. Values at 2 and 7 min were significantly different from control by analysis of variance ($P = 0.044$, $Q = 3.33$).

Evaluation of the epinephrine data after eliminating three patients who had 50 per cent increases in both epinephrine and norepinephrine levels (suggestive of an endogenous sympathoadrenal response) yielded a mean control epinephrine value of 129 ± 9 pg/ml. The mean 2-min value was 256 ± 19 pg/ml, and the mean 7-min value was 368 ± 19 pg/ml. By analysis of variance, these mean values at 2 and 7 minutes are statistically significantly different from control ($P = 0.002$, $Q = 7.45$).

Norepinephrine. Table 2 lists these data. The differences, analyzed by analysis of variance were found to be insignificant ($P = 0.647$, $Q = 0.439$).

Rate–Pressure Product. As an indirect indication of myocardial oxygen consumption,[7] a systolic pressure × rate product was calculated for each patient during the control period, and 2 and 7 min after the retrobulbar injection. During the control period this product was 10,779 torr/min. At 2 min it was 11,775 torr/min, and at 7 min, 11,406 torr/min. Statistical comparison by analysis of variance show that these means do not differ.

DISCUSSION

Local anesthesia with epinephrine to increase the duration of action is conventionally used for retrobulbar block during cataract operations. Since most patients who have cataracts are elderly and may have arteriosclerotic cardiovascular disease, the question arises whether the systemic uptake of epinephrine is sufficient to cause systemic cardiovascular effects. Ballin *et al.*[8] have shown that 0.5 mg of topically applied epinephrine (ten times the amount used in this study), in the eye, can cause increased cardiac ventricular irritability. Smith *et al.*,[9] however, have instilled as

TABLE 2. Plasma Norepinephrine

	Plasma Norepinephrine (pg/ml)		
	Control	2 Min	7 Min
Patient 1*	438	464	2675
Patient 2*	399	2300	440
Patient 3	218	226	212
Patient 4	251	288	325
Patient 5	451	570	692
Patient 6	376	388	325
Patient 7	923	919	607
Patient 8	752	803	1020
Patient 9	537	590	502
Patient 10	637	664	906
Patient 11	759	490	596
Patient 12	959	765	921
Patient 13*	168	311	540
Patient 14	341	421	411
Patient 15	401	485	227
Patient 16	773	834	680
Patient 17	806	594	390
MEAN ± SE (n = 17)†	540 ± 25	653 ± 45	674 ± 57

* As per text, three patients with pharmacologic evidence of stress response.
† Not significantly different from control, $P = 0.647$.

much as 0.7 mg epinephrine in the anterior chamber of the eye during cataract procedures without untoward cardiac effect. In neither study were plasma epinephrine and norepinephrine levels measured.

There appears to be some systemic uptake of exogenous epinephrine within 2 min of injection, sustained at 7 min. The measurement value of 429 pg/ml, while significantly different from control, is similar to epinephrine levels recorded during the psychological stress of public speaking,[10] and is less than epinephrine levels found during stressful clinical states.[11] When the three patients with pharmacologic evidence of endogenous sympathoadrenal responses are removed from the analysis, the gradual increase in epinephrine levels is even more apparent ($P = 0.002$). This increase is probably due to uptake of epinephrine into the systemic circulation from the retrobulbar area. Despite this gradual increase in epinephrine, arrhythmias were not seen during the study, and rate–pressure products remained constant. Common surgical practice militates against use of local anesthesia without epinephrine. The usual clinical dose of epinephrine with local anesthetics in ophthalmologic surgery is 0.06 mg. This is much less than the 0.2 mg epinephrine limit suggested by the New York Heart Association[12] for epinephrine added to the local anesthetics used in oral surgery for patients with cardiac disease.

Norepinephrine, an endogenous catecholamine, is useful as an indicator of a patient's stress response.[13] Two patients with marked changes in epinephrine levels also had considerable elevations of norepinephrine. One of the patients was outwardly distressed and complained bitterly at the time of the retrobulbar injection. Since norepinephrine had not been added exogenously, this probably represented endogenous release due to a sympathetic stress response in these patients. That plasma norepinephrine levels and rate–pressure products were constant during retrobulbar block and the ensuing surgical procedure indicates that the patients were not stressed physiologically. Therefore, any significant change in the epinephrine levels were probably due to the exogenous epinephrine.

When the amount of exogenous epinephrine added to the eyelid and retrobulbar local anesthetic injection is limited to approximately 0.06 mg (12 ml volume with 1:200,000 epinephrine), some systemic uptake may occur, but it should not be sufficient to produce untoward clinical effects. An endogenous sympathoadrenal stress response is the most potent source of catecholamines and, therefore, anesthetic management must include allaying anxiety, pain, and stress as much as possible.

With proper planning, sedation, and management, it should be possible to use local retrobulbar anesthesia for cataract operations in elderly patients with coronary disease without causing increased cardiac stress.

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