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Maintenance of Mydriasis with One Bolus of Epinephrine Injection During Phacoemulsification

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ABSTRACT

Surgically-induced miosis commonly occurs during cataract extraction surgery, complicating removal of lens cortex and placement of a posterior chamber intraocular lens. To maintain intraoperative mydriasis, one bolus of epinephrine injection was used in our study. The pupillary response to various doses of intracameral epinephrine (0.1 ml of 1:25,000, 1:50,000, 1:100,000, 1:200,000, 1:400,000) was assessed in 60 consecutive patients. The pupil size was measured just prior to the incision, one min after epinephrine injection, after phacoemulsification and after irrigation/aspiration. There was no significant difference among the mean mydriatic responses to the epinephrine concentrations we tested. The 1:400,000 concentration appeared to be as effective as 1:25,000, but two cases of the 1:400,000 group failed to maintain the pupil diameter after irrigation/aspiration. In addition, we found that blood pressure did not elevate after injection of any concentration of epinephrine. We concluded that one bolus of an extremely dilute concentration of epinephrine (i.e., 1:400,000) injection might be effective in maintaining mydriasis during cataract surgery without systemic side effects.

INTRODUCTION

Surgically-induced miosis during phacoemulsification has been demonstrated to be the major cause of complications, such as iris damage, incomplete cortex removal, and posterior capsule rupture (1). Cataract extraction is performed more easily if mydriasis can be maintained until the intraocular lens has been inserted (2). Furthermore, postoperative inflammation would be less severe if the iris were not disturbed during lens manipulation. Intracameral irrigation with epinephrine may be of benefit in this respect (3). However, systemic absorption of epinephrine during the operation may cause systemic side effects, such as elevated heart rate and blood pressure (4). Moreover, several studies reported that intracameral injection of high concentration epinephrine might lead to corneal injury (5–7). The purpose of the present study was to investigate the lowest concentration of epinephrine which was effective in maintaining pupil size during cataract surgery, and to evaluate its influence on heart rate and blood pressure.

TABLE 1.
Pupil Size Changes (mm) Among Control and Study Groups

Pupil size	Pre-incision	Post-injection	Post-phaco	Post-I/A
Control group	6.9±0.5	7.1±0.5	5.5±0.4	5.0±0.4
1:25,000	7.2±0.5	7.7±0.5	8.0±0.6*	8.1±0.6*
1:50,000	7.2±0.6	7.9±0.7	8.1±0.8*	8.0±0.5*
1:100,000	6.3±0.4	7.3±0.5	7.7±0.7*	7.8±0.6*
1:200,000	6.4±0.5	7.4±0.6	7.5±0.7*	7.7±0.6*
1:400,000	6.0±0.6	6.9±0.6	6.9±0.9*	6.8±0.2*

*$p<0.05$

MATERIALS AND METHODS

Sixty consecutive patients who underwent phacoemulsification by one surgeon were included in this study. A written informed consent was given to every patient. There were 28 males and 32 females; their mean age was 69 years (range 55 to 83 years). The sixty study cases were assigned randomly into 5 groups with different concentrations of epinephrine injection (1:25,000, 1:50,000, 1:100,000, 1:200,000, or 1:400,0000, respectively). The background of the five different groups of patients was: group 1: 6 males and 5 females, mean age was 67 ± 1.1; group 2: 7 males and 6 females, mean age was 71 ± 0.9 ; group 3: 4 males and 6 females, mean age was 66 ± 1.5; group 4: 6 males and 8 females, mean age was 68 ± 1.3; and group 5: 5 males and 7 females, mean age was 70 ± 1.0. One drop of the topical 0.5% tropicamide, which was about 2.5 mm in diameter, was administered to every patient half an hour before surgery, ten min before surgery and five min before surgery. Horizontal pupil diameters were measured with calipers under standard illumination of an operating microscope. The depth of anterior chamber was maintained normal during measurements to minimize optically-induced errors. Pupil size, heart rate and systolic/diastolic blood pressure were measured by the surgeon just prior to the initial incision at surgery, one min after intracameral injection of epinephrine, after phacoemulsification and after irrigation/aspiration (I/A). One bolus injection of 0.1 cc epinephrine into the anterior chamber directly over the center of the pupil was performed in all cases. The 1:25,000 concentration was prepared by adding 0.2 cc of 1:1,000 epinephrine to balanced salt solution to reach 5 cc. The other concentrations were made by diluting the 1:25,000 preparation. The control group (10 eyes) received the same amount of injection. The mean time of operation was 31 ± 1.6 min in the study group and 30 ± 2.0 min in the control group. Data were analyzed with the paired or unpaired ANOVA test. $P < 0.05$ was considered statistically significant.

TABLE 2.
Pulse Rate Changes Among Study and Control Groups

Pulse rate	Pre-incision	Post-injection	Post-phaco	Post-I/A
Control group	75±7.7	77±6.9	73±9.6	73±7.7
1:25,000	76±7.7	77±8.9	77±6.6	75±7.5
1:50,000	74±7.5	79±7.6	78±9.7	78±6.5
1:100,000	75±7.4	76±6.8	79±7.7	76±8.9
1:200,000	72±7.5	75±7.6	76±8.7	74±6.6
1:400,000	74±7.6	76±7.6	76±8.0	76±5.4

$p>0.05$

TABLE 3.
Systolic Blood Pressure Changes Among Study and Control Groups

Pulse rate	Pre-incision	Post-injection	Post-phaco	Post-I/A
Control group	141±17.7	146±13.7	143±19.6	143±17.7
1:25,000	140±27.7	144±18.9	143±16.6	141±17.5
1:50,000	141±22.5	144±17.6	139±19.7	140±26.5
1:100,000	144±21.4	145±26.8	141±17.7	144±18.9
1:200,000	140±17.5	142±17.6	139±18.7	141±16.6
1:400,000	140±17.6	143±17.6	140±18.0	138±25.4

$p>0.05$

RESULTS

Sixty patients were enrolled in the study, with no excluded cases. There was no significant difference in pupil size between the study and control groups before the initial incision. Pupil size remained stationary during the operative procedures in the five study subgroups; progressive miosis was noted in the control group (Table 1). Therefore, postphacoemulsification and post I/A pupil sizes were significantly greater in the study group regardless of epinephrine concentration compared with the control group (Table 1). However, there was no significant difference in pupil size among the five different epinephrine concentrations (Table 1).

There was no significant change in heart rate and blood pressure (systolic and diastolic) during the operation in the study and control groups (Tables 2–4). There was also no significant difference in heart rate and blood pressure (systolic and diastolic) between the study and control groups (Tables 2–4).

DISCUSSION

Phacoemulsification is a major technique in the treatment of cataract, but pupillary constriction during the operation may not only hinder the progress of surgery, but also result in iris damage, incomplete removal of nucleus and cortex and, most seriously, posterior capsule rupture and loss of lens material into the vitreous (1). Thus, maintenance of mydriasis is important to improve the ease with which surgery can be performed and to avoid complications.

Previous studies have shown that intracameral irrigation with I/A fluid containing 1:1,000,000

TABLE 4.
Diastolic Blood Pressure Changes Among Study and Control Groups

Pulse rate	Pre-incision	Post-injection	Post-phaco	Post-I/A
Control group	67±11.7	70±11.5	73±9.6	69±8.7
1:25,000	66±12.7	73±11.9	72±6.6	75±9.5
1:50,000	69±8.5	72±10.6	68±10.8	68±8.5
1:100,000	66±9.4	70±10.8	71±11.2	68±12.9
1:200,000	72±10.0	72±12.6	69±9.7	74±9.6
1:400,000	71±9.6	73±8.6	76±9.0	72±11.4

$p>0.05$

epinephrine is a safe and effective means of maintaining mydriasis during cataract surgery (3). However, this procedure has potential disadvantages, including prolonged exposure of the anterior segment to epinephrine and its preservative, and less control over the total amount of drug administered (since this is governed by the amount of infusion necessary for the surgical procedure) (8). Thus, some surgeons have advocated a bolus injection of epinephrine into the anterior chamber. Nevertheless, early experience with intraocular infusion of 1:1,000 epinephrine resulted in a few cases of severe corneal decompensation (9). *In vitro* studies of functional and morphological changes in animal corneas have also shown corneal swelling and endothelial damage after perfusion with commercial epinephrine 1:1,000. Because of potential toxicity of intraocular epinephrine infusion, dose-response data are necessary for determining the minimal effective dose without increasing the risk of corneal endothelial damage.

The results in the present study demonstrate that pupil size remained stationary during the operation in patients receiving intraocular epinephrine injection regardless of epinephrine concentration; in contrast, progressive miosis was noted in the control group. Furthermore, maintenance of mydriasis during surgery was similar between 1:400,000 and 1:25,000 epinephrine. However, we found that pupil diameter began to decrease in the 1:400,000 group during irrigation/aspiration. The decrease was not statistically significant ($p > 0.05$).

Theoretically, systemic absorption of epinephrine infused into the eye can potentially occur both *via* the vascular structures of the anterior segment, and *via* the nasolacrimal duct from overspill into the conjunctival sac (3,4). In the present study, there were no significant changes in heart rate and blood pressure (systolic and diastolic) during the operation in patients receiving intracameral epinephrine injection.

Some authors have advocated the addition of epinephrine to the bottle of irrigation solution to maintain mydriasis during phacoemulsification (3). Advantages of this procedure include the elimination of an additional intracameral injection, and the use of extremely diluted epinephrine. Potential disadvantages include prolonged exposure of anterior segment tissue to epinephrine and its preservative, and less control over the total amount of drug administered.

Epinephrine maintains mydriasis by a direct action on the dilator pupillae of the iris. In addition, mechanical stimulation of the iris by lens materials or instruments during surgery may lead to release of prostaglandins causing pupillary constriction. Therefore, some studies have used nonsteroidal anti-inflammatory medications, such as indomethacin (10–13), flurbiprofen (12,13), diclofenac (14) and suprofen (15) to inhibit miosis during surgery, but they did not maintain mydriasis as effectively as epinephrine infusion.

In conclusion, a single bolus injection of an extremely diluted concentration of epinephrine (1:400,000) is a safe and effective means of maintaining mydriasis during phacoemulsification with posterior chamber lens implantation, without significant influence on heart rate and blood pressure.

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