

monitored and dantrolene should always be available for immediate use in case an MH episode occurs. Local and regional anesthesia may be adequate for many surgical procedures these patients require.

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Atracurium and Vecuronium Do Not Affect Extraocular Muscle Function After Outpatient Surgery

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Postoperative visual disturbances, such as double vision, may affect up to 71% of patients who have received long-acting nondepolarizing muscle relaxants at the time of discharge from the hospital.¹ Such problems

may continue for a day or more after surgery.² These disturbances may be especially serious for outpatients. Extraocular muscle tone (EMT) of the medial recti may be measured in prism diopters using horizontal scale of the Maddox wing test,³ a simple hand-held device (fig. 1). This study was designed to compare EMT after the new intermediate-acting nondepolarizers atracurium (ATR) and vecuronium (VEC) with succinylcholine (SDC) in outpatients after a standardized anesthetic technique.

MATERIALS AND METHODS

After approval by the Human Subjects Research Committee, 35 ASA physical status I or II females undergoing outpatient laparoscopy were selected. Written informed consent was obtained from each patient. All patients received fentanyl 50-150 µg iv and glycopyrrolate 0.2 mg iv when the intravenous catheter was inserted. After baseline Maddox readings, measured be-

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FIG. 1. Maddox wing apparatus.

fore the fentanyl had been administered, each patient was randomly assigned to one of the three groups. Following induction with thiopental 4–6 mg/kg, group 1 (n = 8) received 0.40 mg/kg ATR; group 2 (n = 14) received 0.08 mg/kg VEC; and group 3 (n = 13) received SDC 1 mg/kg followed by a SDC infusion. The patients' eyes were taped during surgery and nothing was instilled into the eyes. The investigators were blinded as to the relaxant given. All patients underwent endotracheal intubation. Anesthesia was maintained with isoflurane up to 1.2% inspired (from a calibrated vaporizer) in 70% N₂O/30% O₂. The effect of muscle relaxants on groups 1 and 2 was antagonized with neostigmine 0.04 mg/kg and glycopyrolate 0.5 mg after surgery. Starting 30 min after surgery and each 30 min thereafter until discharge, Maddox readings were obtained. Patients requiring eyeglasses used them. In

TABLE 1. Maddox Wing Readings Preoperatively and Postoperatively for Patients Undergoing Laparoscopy with either Atracurium (ATR), Vecuronium (VEC), or Succinylcholine (SDC)

Time (Prism Diopters of Exophoria)	Maddox Wing Readings (Prism Diopters of Exophoria)		
	Group 1 (n = 8) (ATR)	Group 2 (n = 14) (VEC)	Group 3 (n = 13) (SDC)
Preop	2.2 ± 2.0	0.5 ± 4.3	1.9 ± 1.3
Postop (h)			
0.5	10.8 ± 3.9*	8.7 ± 6.3*	12.8 ± 4.5*
1.0	6.6 ± 6.8	5.6 ± 5.4	9.0 ± 5.0*
1.5	4.8 ± 4.3	4.2 ± 5.0	6.5 ± 5.5
2.0	4.9 ± 5.5	3.6 ± 4.5	5.0 ± 4.8
2.5	5.3 ± 5.4	3.0 ± 4.7	4.8 ± 4.6
3.0	5.1 ± 5.7	3.5 ± 3.8	5.6 ± 5.0
3.5	3.6 ± 3.4	3.3 ± 3.9	4.2 ± 4.3
4.0	4.1 ± 2.7	0.5 ± 3.3	4.4 ± 5.3
4.5	5.3 ± 3.1	1.4 ± 3.2	3.1 ± 5.8

Mean ± SD.

* Different at $P < 0.01$ from its baseline.

some cases, more than one Maddox reading was obtained at a specific time. These readings were averaged. The patients were contacted on the day after surgery regarding postoperative morbidity by an investigator blinded to the relaxant used. The differences among the groups and the differences within each group as a function of the time (repeated measures) were tested by ANOVA followed by Duncan's multiple range test. A $P < 0.05$ was considered significant. The data are presented as mean ± SD.

RESULTS

The results of the study are summarized in table 1 and figure 2. There were no statistically significant differences among the groups in terms of age, duration of surgery, or weight. All patients were able to sustain 5 s head lift in the recovery room, and all were oriented within 30 min. All were able to use the Maddox scale at this time. The readings were highest 30 min after surgery. All had declined to readings which were not significantly different from preoperative readings by 1.5 h. There were no statistically significant differences among the groups at any time. No patient complained of diplopia on the day of surgery or on postoperative day 1.

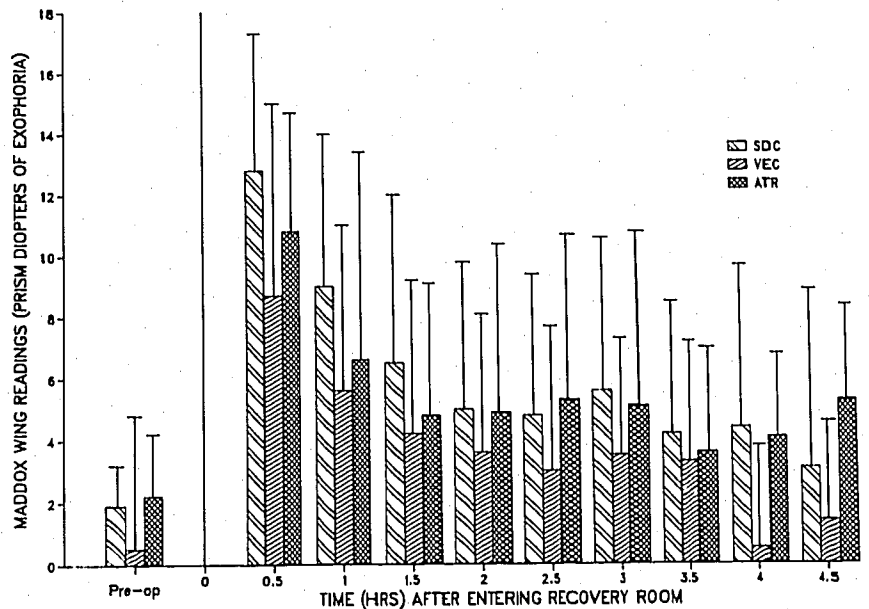
DISCUSSION

Eye divergence can easily be measured in prism diopters in cooperative patients using the Maddox wing test.^{3,4} To utilize this device, the patient looks through two slits. The fields to which each eye is exposed are separated by a diaphragm. The right eye sees an arrow while the left sees a horizontal row of figures. The degree of deviation is determined from the apparent position of the arrow on the scale. The readings may be negative, indicating esophoria, or positive, indicating exophoria.

Diplopia is a common side effect of nondepolarizing relaxants given preoperatively for the prevention of SDC-induced fasciculations. This is due to the fact that the medial recti, whose tone is necessary for conjugate gaze, are extremely sensitive to relaxants. The occurrence of diplopia postoperatively, even after clinically adequate antagonism of the effects of long-acting relaxants, has been noted in several studies (table 2) utilizing alcuronium^{2,5} and pancuronium,^{6–8} VEC,⁶ and ATR.⁵ However, this side effect is not widely recognized, and few reports of it have been published in North America.

In one study, Henegan *et al.*¹ studied outpatients having dental surgery. He compared a group receiving N₂O/O₂/fentanyl and alcuronium with one receiving no relaxant. At discharge, 71% of the patients receiving alcuronium had blurred or double vision. None of those in the other group had this complaint. By the evening

FIG. 2. Maddox wing readings in prism diopters of exophoria preoperatively and postoperatively.



after surgery, 29% of patients in the alcuronium group still had double vision. Similarly, Harvey *et al.*,² in a study of women undergoing laparoscopy, noted a 41% incidence of blurred or double vision 4 h postoperatively, which had only decreased to 13% by postoperative day 2. None of the studies listed in table 2 used quantitative methods to assess ocular function. The patients were simply asked about visual problems. This study marks the first systematic blinded comparison study of these side effects.

The importance of anesthesia related visual impairment after outpatient surgery was suggested by a follow-up study by Ogg,⁹ which noted that 31% of patients returned home alone from the hospital, 73% of those owning automobiles drove within 1 day of discharge and 9% actually drove home from the hospital.

Employing a Maddox wing test for the quantitative determination of extraocular muscle tone, Hannington-Kiff¹⁰ noted that patients undergoing gynecological surgery receiving gallamine had changes in their Maddox readings for 3 h after surgery, even though the effect of the relaxant had been antagonized. Those receiving SDC had a rapid restoration of these readings. During this postoperative period, neither group of his patients was clinically paralyzed. Aromma,¹¹ also using the Maddox test, showed that outpatients undergoing vein stripping procedures receiving alcuronium had changes in EMT 3 h after surgery, while those who received no nondepolarizers did not.

Our results show that normal Maddox readings are restored as rapidly after antagonism of ATR or VEC induced neuromuscular blockade as after SDC. This is consistent with the short duration (1 h) of diplopia

noted by Fragen and Shanks using VEC,⁶ or the low incidence of diplopia at discharge observed by Collins *et al.* using ATR in outpatients.⁵ Normal patients should be able to return to their baseline pre-anesthetic state after proper antagonism of blockade with any of the relaxants used here without diplopia using the doses employed in this study. These findings are in accord with those of Skacel *et al.*,¹² who found no significant difference in the frequency of diplopia between laparoscopy patients receiving ATR and SDC. However, in contrast to our results, the incidence of double vision was 17 and 22% in the SDC and ATR groups, respectively, at the time of discharge from their outpatient facility, as determined by a patient interview.

The rapid decline in serum levels of ATR and VEC compared to longer-acting relaxants, such as gallamine or alcuronium, is probably responsible for our observations. Comparison of our results with previous stud-

TABLE 2. Summary of Reports Noting a Significant Postoperative Occurrence of Diplopia after Non-depolarizing Muscle Relaxants

Relaxant	Blurred or Double Vision (Highest Percentage Noted Postoperatively)	Reference
Alcuronium	71	1
	55	2
	24	5
Pancuronium	55	6
	7-14	7
	13	8
Atracurium	5	5
	22	12
Vecuronium	25	6

ies^{1,2,5,8} suggests that long-acting nondepolarizing relaxants may not be as suitable for outpatient surgery as ATR, VEC, or SDC. A direct comparison with longer-acting nondepolarizers would have been desirable to standardize all variables other than the relaxant administered. However, relaxant doses comparable to those of the ATR and VEC ($1.5-2 \times ED_{95}$), as used in this study, were considered inappropriate for the duration of these short outpatient procedures.

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