Due to the relative simplicity of the technique, many anesthesiologists consider intravenous regional anesthesia to be both virtually foolproof and, barring tourniquet failure, a guarantee of adequate analgesia. However, many studies have shown that failure to provide good analgesia is not uncommon and may be related to the particular technique used. Inadequate analgesia (defined differently in each study) occurs[7,13,14,16,17] at rates varying from 7% to 15%. Of particular interest is the work of Sorbie and Chacha,[7] which noted a much higher percentage of unsuccessful blocks following proximal cubital injections (22.7%) as compared with distal hand injections (4.1%). Hollingworth *et al.*[16] revealed the apparent importance of individual technique on the success of the block. Aside from specifying uniform drugs and dosages, their study[16] does not report the precise techniques used in providing intravenous regional anesthesia. Inadequate analgesia occurred with widely different frequencies among eight physicians—from 0% to 31%. These physicians might have used different injections rates, tourniquet pressures, *etc.*, and thereby affected the number of successful blocks.

In conclusion, our data indicate that injections for intravenous regional anesthesia should be made over at least 90 s, into a distal vein, with a tourniquet pressure of at least 300 mmHg, and after exsanguination with an Esmarch's bandage. By avoiding MVP and thus keeping all the anesthetic isolated in the limb, a decrease in the incidence and severity of toxic symptoms and an increased percentage of successful blocks should result.

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Anesthesiology
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Bradycardia Delays the Onset of Action of Intravenous Atropine in Infants

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Atropine, a vagolytic drug, is commonly used in pediatric patients to prevent or reverse bradycardia.[1] Routine preoperative administration of an anticholinergic is decreasing in adults,[2] and some have recommended that this practice be discontinued in pediatric patients.[3] Atropine is then administered only if indicated (*e.g.*, to treat bradycardia or precede succinylcholine). To achieve a rapid effect in treating bradycardia, iv atropine is often used. Sometimes a long delay in restoring normal heart rate has been observed, especially if severe bradycardia is present. This delay may be caused by the low cardiac output and prolonged circulation time associated with severe bradycardia.

To study this further, we collected data on pediatric patients to examine the relationship between the heart

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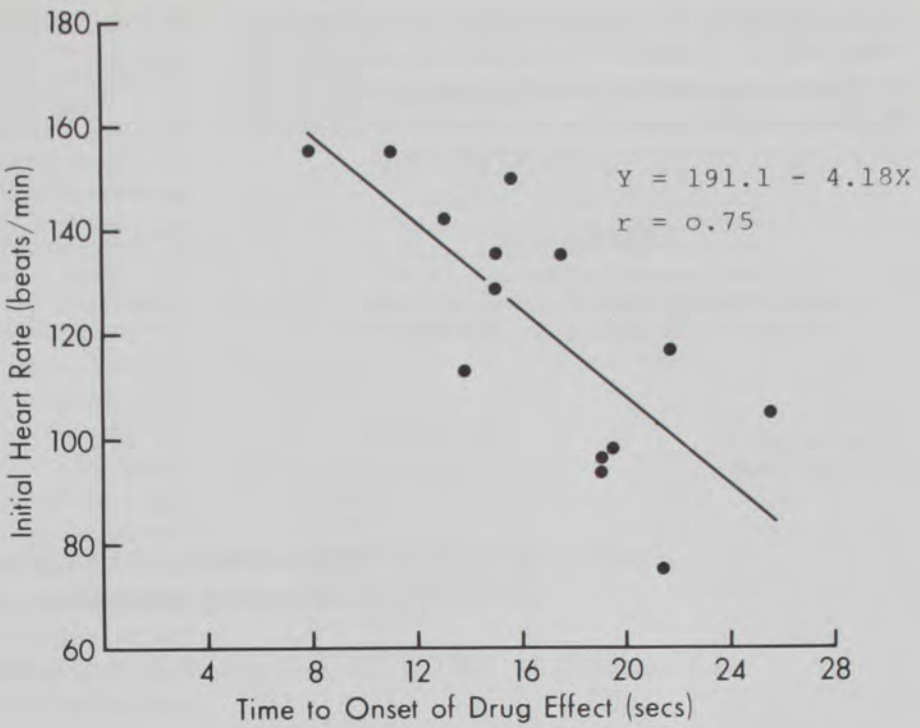

FIG. 1. Relationship between initial heart rate and delay in onset of action of intravenous atropine in 14 infants less than 2 yr of age (Group 2).

rate at the time of iv injection of atropine and the delay in the onset of action on the heart.

METHODS

This study was approved by the Human Investigation Review Committee. It is a common practice with pediatric patients to omit im premedication and to commence an inhalation induction with halothane. Once the patient is anesthetized, a venipuncture is performed and iv atropine administered.[4] Following this procedure we also recorded a strip of the electrocardiogram tracing. This tracing was marked with the time at which atropine (0.02 mg/kg) was injected rapidy into a vein on the dorsum of the hand. The tracing was later examined to determine the heart rate at the time of atropine administration and the delay in seconds until a sustained increase in heart rate occurred. This point was defined at the R wave after which four successive R–R intervals were shorter than the preceding series of R–R intervals.

RESULTS

Data were obtained from a total of 29 patients. After preliminary analysis, when it became apparent that the results in infants were different from those in older children, the patients were divided into two groups: Group 1 comprised 15 children aged 2 to 10 yr (mean age 4.5 yr ± 2.0 yr SD). Group 2 comprised 14 infants aged under 2 yr (mean age 8.8 months ± 5.2 months SD). The children in Group 1 demonstrated no relationship between initial heart rate and the delay in drug action. The infants in Group 2 showed an inverse relationship between initial heart rate and the delay in drug action. The slower the initial heart rate, the longer was the delay in onset of drug action (fig. 1).

DISCUSSION

Our results show that the time of onset of cardiac vagolytic action of iv atropine in infants is significantly influenced by the heart rate at the time of drug administration. In older children no such relationship was demonstrated. These results might be anticipated from a knowledge of the factors that influence the distribution of a drug from its iv injection site to its site of action.

The speed of onset of the effect of iv atropine will be dependent on the circulation time from the site of injection to the postganglionic parasympathetic nerve endings in the cardiac plexi.[5] The circulation time is related inversely to the cardiac output, and a decrease in cardiac output is followed by an increased circulation time.[6] Cardiac output is a function of heart rate and stroke volume. Small infants have a relatively fixed stroke volume due to the presence of less compliant ventricles.[7] The cardiac output of the infant is therefore closely related to the heart rate. In children, as in adults, the cardiac output is less dependent on the heart rate, as increased diastolic filling of the ventricle and consequent increased stroke volume can partially compensate for a reduced heart rate. Thus, beyond infancy, circulation time depends less on heart rate. Our findings are consistent with this.

We conclude that in the infant, bradycardia should be treated promptly, before a serious decrease in cardiac

output results. As the common causes of intraoperative bradycardia are hypoxia or vagal activity, such therapy should consist of ventilation with oxygen and iv atropine. To obtain a rapid response, iv atropine should be administered before marked bradycardia is present.

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Anesthesiology
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Effect of Droperidol Pretreatment on Postanesthetic Vomiting in Children Undergoing Strabismus Surgery

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Vomiting is a frequent and often disturbing complication following strabismus surgery, particularly in children.[1–5] Droperidol, a potent antiemetic, reduces the incidence of vomiting after many types of surgery, including strabismus surgery.[6–14] Abramowitz *et al.* reported that intravenous droperidol 0.075 $mg \cdot kg^{-1}$ reduces the incidence of vomiting in children undergoing strabismus repair from 85% (control group) to 43% when administered after manipulation of the eye.[1] However, Meyers and Tomeldan observed that intramuscular droperidol 0.10 $mg \cdot kg^{-1}$ reduces the incidence of vomiting after eye surgery in adults to 10% when administered preoperatively and before manipulation of the eye.[15] The lower incidence of vomiting in the latter study may be attributed, in part, to the more effective antiemetic action of droperidol when administered before manipulation of the eye rather than afterward. We speculated that if intravenous droperidol were administered before manipulation of the eye, the incidence of vomiting after strabismus repair in children might be reduced to a similar extent as in adults.[15] Therefore, we determined the incidence of vomiting after strabismus repair in children who received intravenous droperidol pretreatment, or one of the routine postanesthetic analgesics used in our institution: rectal acetaminophen or intramuscular codeine.

Methods

With approval from the Committee on Human Research, a prospective, randomized study was undertaken. Informed written consent was obtained from the parents of 100 children scheduled for elective strabismus repair. The children were ASA Physical Status 1 or 2, fasting, unpremedicated, and older than 2 yr of age. Children with a history of motion sickness or vomiting after previous strabismus surgery were not excluded from the study.

The children were randomly assigned to one of three treatment groups: intravenous droperidol (0.075 $mg \cdot kg^{-1}$) (n = 31); rectal acetaminophen (10 $mg \cdot kg^{-1}$) (n = 35); or intramuscular codeine (1.5 $mg \cdot kg^{-1}$) (n = 34). Droperidol was given at induction of anesthesia immediately after succinylcholine. Acetaminophen and codeine were given in the postanesthetic room (PAR) when the children were arousable. Acetaminophen was administered instead of a placebo to alleviate any possible discomfort after surgery. Intramuscular codeine was included as the third treatment after it was incriminated as a possible cause of vomiting after strabismus repair by one of our ophthalmologists.§

After a precordial stethoscope, electrocardiogram, blood pressure cuff, and Doppler probe were applied, general anesthesia was induced with intravenous thiopental (5 $mg \cdot kg^{-1}$), atropine (0.02 $mg \cdot kg^{-1}$), and succinyl-

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§ Smith DR: Personal communication.