Haemodynamic effects of rectal methohexitone for induction of anaesthesia in children

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Pulsed Doppler and two-dimensional echocardiography were used to determine the haemodynamic effects of rectal methohexitone in 12 children 32.4 ± 3.8 months old and weighing 13.3 ± 1.1 kg (mean $\pm$ SEM). Heart rate, blood pressure and echocardiographic measurements of cardiac output, stroke volume and left ventricular end-diastolic and end-systolic volumes were obtained prior to the induction of anaesthesia. Anaesthesia was induced with $25 \text{ mg} \cdot \text{kg}^{-1}$ two per cent rectal methohexitone. Immediately following the onset of sleep all cardiovascular measurements were repeated. Following the induction of anaesthesia with rectal methohexitone there was a significant increase in heart rate. Blood pressure, cardiac index, stroke volume and ejection fraction were unchanged. It is concluded that rectal administration of two per cent methohexitone for the induction of anaesthesia in healthy paediatric patients has minimal haemodynamic effect.

Key words

ANAESTHESIA: paediatric; ANAESTHETIC TECHNIQUES: induction; PREMEDICATION: rectal, methohexitone; HEART: myocardial function, anaesthetics; MEASUREMENT TECHNIQUES: echocardiography, Doppler, two-dimensional.

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The rectal administration of methohexitone is a safe and effective technique for the induction of anaesthesia in children.¹⁻⁴ Because the bioavailability of rectally administered methohexitone is low when compared with intravenous administration,^{5,6} relatively large doses of methohexitone must be used to insure that a prompt, reliable onset of sleep is achieved.^{7,8} The haemodynamic response to the administration of short-acting barbiturates is complex and includes a decrease in mean arterial pressure and cardiac output and an increase in heart rate.⁹⁻¹¹ Myocardial depression and alterations in vascular tone may both contribute to the hypotension that was seen in clinical investigations of adults.⁹⁻¹¹ Extrapolation of the results of these haemodynamic studies to the paediatric patient is difficult and little information is available that adequately evaluates the haemodynamic effects of intravenous or rectal administration of short-acting barbiturates in children. The large doses of rectal methohexitone required for induction of anaesthesia in paediatric patients may have important haemodynamic consequences, particularly because plasma methohexitone concentrations vary widely with this induction technique. Therefore, the purpose of this investigation was to determine, non-invasively, the haemodynamic changes produced by induction of anaesthesia with rectal methohexitone in children.

Methods

Twelve ASA physical status I or II children, less than five years of age and scheduled for elective surgery, were studied after the protocol was approved by the institutional Human Studies Committee and informed parental consent was obtained.

All patients were unpremedicated and accompanied to the presurgical care unit by their parents. Approximately 15 minutes before the induction of anaesthesia, heart rate by ECG and blood pressure by automated oscillotonometer (Dinamapp®) were determined. In addition, in each patient, left ventricular area and length in systole and diastole were assessed by two-dimensional echocardiog-

raphy and pulmonary artery blood flow velocity was measured using pulsed Doppler echocardiography. Following completion of the initial two-dimensional and pulsed Doppler studies, anaesthesia was induced by the rectal administration of $25 \text{ mg} \cdot \text{kg}^{-1}$ methohexitone.

The methohexitone was prepared by dissolving 500 mg sodium methohexitone in 25 ml sterile water to form a two per cent solution which was instilled through a soft, plastic catheter inserted approximately 5 cm into the rectum. Parents remained with their children and comforted them until the child was asleep. For the purposes of this investigation sleep was defined as loss of consciousness, unresponsiveness to verbal stimuli and absence of voluntary movement when unstimulated. Immediately following the onset of sleep all haemodynamic measurements were repeated.

The two-dimensional and pulsed Doppler echocardiographic measurements were performed with the patient in the supine position using the technique described by Murray *et al.*^{12,13} An Ultra Imager 2600 (Biosound, Inc., Indianapolis) mechanical sector scanner with a 5-MHz single element transducer and a 3.5-MHz Doppler interrogation frequency was used to obtain short-axis views at the levels of the high papillary muscle of the left ventricle and great vessels, as well as an apical four-chamber view. Studies were recorded on videotape and later left ventricular cross-sectional area and left ventricular length were measured at the level of the papillary muscles and in the apical four-chamber views, respectively. Pulmonary artery diameter was measured directly above the semilunar valve.

Pulmonary artery blood flow velocity was measured by directing the Doppler probe parallel to pulmonary artery blood flow and a pulsed Doppler wave was directed to collect a flow measure from within the pulmonary artery. This sample was measured above the pulmonic valve and averaged over three cardiac contractions to determine mean pulmonary artery blood flow velocity. Continuously updated two-dimensional images, Doppler profiles, and ECG tracings were displayed on a video monitor and recorded on tape.

Selective frozen images were recorded on a strip-chart for measurement by the ultrasonographer. Using a micro-sonic CAD-886 image processing and video quantifications system (Microsonics, Inc., Indianapolis), images were traced along the endocardium using the leading edge method. Left ventricular area and length were then used to calculate left ventricular volume at end-systole and end-diastole. Cardiac output was determined from the pulmonary artery diameter and mean velocity of pulmonary artery blood flow.¹⁴⁻¹⁷

The pre-induction haemodynamic measurements were compared with the haemodynamic values following

TABLE I Demographic data (mean $\pm$ SEM)

Age	32.4 $\pm$ 3.8 months
Weight	13.3 $\pm$ 1.1 kg
Body surface area	0.56 $\pm$ 0.03 m ²
Sleep time	7.9 $\pm$ 0.5 min

administration of rectal methohexitone using the paired *t* test or, if the data were not normally distributed, the Wilcoxon signed ranks test. The Shapiro-Wilk test was used to test normality of the data. Statistical significance was accepted at $P < 0.05$. All values are expressed as mean $\pm$ SEM.

Results

The mean age and weight of the children studied were 32.4 ± 3.8 months (range 10–57 months) and 13.3 ± 1.1 kg (range 7.1–19.1 kg) (Table I). Eleven children were asleep within 15 min and the time to the onset of sleep was 7.9 ± 0.5 minutes (range 7–11 min). One child, although very sedated, did not fall asleep following the administration of methohexitone and post-induction haemodynamic measurements were obtained 15 min after administration of the drug in this child.

Following the rectal administration of $25 \text{ mg} \cdot \text{kg}^{-1}$ methohexitone the heart rate increased significantly above awake values. Systolic, diastolic and mean blood pressures were unchanged. Cardiac index, stroke volume, left ventricular end-diastolic and end-systolic volumes, and ejection fraction did not change significantly from the pre-induction echocardiographic and pulsed Doppler measurements (Table II). No apnoea or arterial desaturation occurred following the onset of sleep and no other complications were encountered.

Discussion

The haemodynamic response to the intravenous injection of short-acting barbiturates is complex. Most authors have reported an increase in heart rate and a decrease in mean arterial pressure and cardiac index following the

TABLE II Cardiovascular data before and following rectal methohexitone (mean $\pm$ SEM)

	Pre-induction	Post-induction
Heart rate (beats $\cdot$ min ⁻¹)	113 $\pm$ 6.6	126 $\pm$ 4.5*
Mean blood pressure (mmHg)	73 $\pm$ 2.4	68 $\pm$ 2.0
Cardiac index (L $\cdot$ min ⁻¹ $\cdot$ m ⁻²)	2.86 $\pm$ 0.2	3.07 $\pm$ 0.18
Left ventricular end-diastolic volume (ml)	24.4 $\pm$ 3.2	24.9 $\pm$ 3.4
Stroke volume (ml)	13.3 $\pm$ 1.7	13.9 $\pm$ 1.4
Ejection fraction	0.56	0.57

* $P < 0.05$. Pre-induction vs post-induction.

administration of methohexitone in animals and humans.^{9-11, 18, 19} In this study we demonstrated that the rectal administration of 25 mg·kg⁻¹ methohexitone in children results in an increase in heart rate following the onset of sleep with no significant change in cardiac index, stroke volume and systolic, diastolic, or mean arterial pressure.

Laishley *et al.*⁸ used rectal methohexitone in combination with atropine for induction of anaesthesia in children and also found an increase in heart rate following the onset of sleep. The tachycardia seen in Laishley's patients continued to increase for 30 min after administration of the methohexitone-atropine solution at which time peak plasma atropine concentrations would be expected to occur following rectal administration of atropine.²⁰ Therefore, it is likely that some of the tachycardia seen in Laishley's study was a result of the anticholinergic effect of atropine. Laishley did not measure changes in cardiac output, stroke volume or ejection fraction in his study.

An increase in heart rate may occur if airway obstruction, which is a potential complication of this technique, results in changes in oxygenation or alveolar ventilation.²¹ The children in this study were carefully observed to prevent airway obstruction and pulse oximetry was used to monitor oxygenation following the onset of sleep. Ventilation by clinical assessment was adequate and no child became apnoeic. However, if PaCO₂ increased significantly, associated sympathetic stimulation may have caused the increase in the heart rate that was observed.

In other studies the haemodynamic changes that occurred following intravenous thiopentone were affected by both the depth of anaesthesia achieved and by the rate of drug administration. Deeper levels of anaesthesia, as determined by EEG burst-suppression, were associated with greater decreases in cardiac output and blood pressure.²² Slower induction of anaesthesia using incremental doses of thiopentone, rather than rapid bolus administration, also produced less profound haemodynamic effects.^{22,23} Following rectal administration of methohexitone the onset of sleep is usually achieved within 15 min, coincident with peak plasma methohexitone concentrations.^{4,5} Although rectal and intravenous administration of methohexitone produce similar peak plasma concentrations,^{4,5} the relatively slower rise in plasma concentration that follows rectal administration of methohexitone may lessen the haemodynamic effects that are seen. Also, although methohexitone inhibits sympathetic nervous activity, the barostatic reflexes remain active,¹⁰ and this too may contribute to the cardiovascular stability seen following rectal methohexitone. Although baroreceptor stimulation secondary to vasodilatation has been suggested as a cause of increased heart rate follow-

ing methohexitone,^{11,18,19} no change in blood pressure or left ventricular end-diastolic volume was seen. This suggests that methohexitone may have a direct cardiac effect causing the increase in heart rate.

In this study pulsed Doppler and two-dimensional echocardiography were used to determine the haemodynamic effects of rectal administration of two per cent methohexitone in children. Induction of anaesthesia with rectal methohexitone resulted in an increase in heart rate following the onset of sleep, but no significant decrease in blood pressure, stroke volume, cardiac index, or ejection fraction. Because these findings are based upon the evaluation of healthy children, extrapolation of the results to paediatric patients with hypovolaemia, congenital heart disease or other associated medical conditions should be made with caution. We conclude that rectal administration of methohexitone for the induction of anaesthesia in healthy paediatric patients has minimal haemodynamic effect.

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Résumé

Nous avons utilisé un appareil à échographie bi-dimensionnelle couplé à un Doppler pulsé pour mesurer l'impact hémodynamique du méthohexital par voie rectale chez 12 enfants de 32.4 ± 3.8 mois pesant 13.3 ± 1.1 kg (moyenne $\pm$ erreur-type). La dose d'induction de l'anesthésie était de $25 \text{ mg} \cdot \text{kg}^{-1}$ d'une solution à deux pour cent. Nous mesurons la fréquence cardiaque, la pression artérielle, le débit cardiaque et les volumes téléstistoliques et télé-diastoliques du ventricule gauche juste avant l'induction et dès la perte de conscience de l'enfant. Avec l'induction, le pouls s'est accéléré mais la pression artérielle, l'index cardiaque et les volume et fraction d'éjection n'ont pas changé. Il semble donc que l'induction de l'anesthésie avec du méthohexital deux pour cent par voie rectale ait peu d'effets hémodynamiques chez les enfants en santé.