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Original Contribution

Impact of isoproterenol infusion on BIS and metabolic values in pediatric patients undergoing electrophysiology studies☆,☆☆

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Abstract

Study Objective: To study changes in BIS values and metabolic parameters during an infusion of isoproterenol in pediatric patients.

Design: Retrospective study approved By Committee For The Protection Of Human Subjects at University Of Texas Medical School at Houston.

Setting: University-affiliated children's hospital.

Measurements: The records of pediatric patients undergoing general anesthesia for electrophysiology procedures were analyzed. Electronic data collected included Bispectral Index (BIS) values, anesthetics (eg, opioids, expired concentration of inhaled anesthetics, muscle relaxants), hemodynamic values (ie, heart rate, invasive blood pressure), respiratory parameters [ie, tidal volume, respiratory rate, end-tidal CO_2 ($ETCO_2$)], and routine arterial blood gases. These parameters were analyzed 10 minutes prior to the start of the isoproterenol infusion (T-pre) and 10 minutes after isoproterenol had reduced the cardiac cycle length by 20% (T-infusion).

Main Results: Of the 29 records that were screened, 22 met the above criteria (mean age 13 ± 5 yrs). BIS values increased by an average of 8 (33 ± 8 to 41 ± 10; $P < 0.001$) during the isoproterenol infusion. Statistically significant increases in $ETCO_2$ (median 33 - 36 mmHg; $P = 0.01$), $PaCO_2$ (35 - 38 mmHg; $P = 0.002$), and lactate (1.1 -1.5 mg/dL; $P < 0.001$) occurred with infusion of isoproterenol. Patients undergoing controlled mechanical ventilation showed an increase in $ETCO_2$ (mean 34 ± 6 mmHg to 37 ± 5 mmHg; $P = 0.001$) whereas those breathing spontaneously had an increase in minute ventilation (average increase 111 ± 30 mL/kg).

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Conclusions: Isoproterenol increases metabolic, respiratory, and BIS values in pediatric patients during general anesthesia. We recommend the use of BIS, close monitoring of $ETCO_2$, and careful titration of anesthetics during isoproterenol infusion, especially when lighter planes of general anesthesia are requested for pediatric electrophysiologic procedures.

1. Introduction

Electrophysiologic studies of the heart are performed to map, localize, and ablate cardiac conduction anomalies. Isoproterenol, a direct, short-acting, beta-sympathetic stimulant (half-life 2.5 - 5 min), is routinely used during electrophysiologic studies to expose, incite, and study these abnormal heart rhythms. Previous studies have suggested that isoproterenol infusion increases electroencephalogram (EEG) - derived Bispectral Index (BIS; Aspect Medical Systems, Norwood, MA, USA) values, which may be interpreted as a decrease in the depth of anesthesia in adult patients during general anesthesia [1,2].

Electrophysiologic procedures have lengthy periods of minimal tactile stimulation with borderline hemodynamics interspersed with stimuli of varying intensity (pharmacologic, surgical) such as infusion of isoproterenol, radiofrequency ablation, and vascular catheter manipulations. In pediatric patients, minimizing patient movement enables accurate mapping and requires deep sedation or general anesthesia. Institutional protocols vary in choice of anesthetic regimens tailored to type of arrhythmia, procedure, length of procedure, and patient and physician's comfort. Electrophysiologists often request a minimal plane of general anesthesia to help elicit these abnormal pathways. The ASA Task Force on Intraoperative Awareness agrees that the monitoring of brain electrical activity to assess depth of anesthesia should be used in patients who are judged to be at high risk for intraoperative awareness [3]. Bispectral Index Vista™ (Aspect Medical Systems) monitoring has been validated as a tool for assessing depth of anesthesia in the pediatric population (age > 1 yr) undergoing procedural sedation, as it enables clinicians to titrate anesthetic depths [4–6]. In this study, we sought to evaluate the effect of isoproterenol on BIS indices and respiratory, hemodynamic, and metabolic parameters in pediatric patients undergoing electrophysiologic studies during general anesthesia.

2. Materials and methods

This retrospective study was approved by the Committee for the Protection of Human Subjects at The University of Texas Medical School at Houston. Based on a pilot review considering a change in BIS as the primary objective, a sample size of 20 patients was estimated adequate to have a power of 0.8 at the significance level of 0.05. Inclusion criteria consisted of all patients undergoing electrophysiologic procedures during general anesthesia with BIS monitoring in the pediatric electrophysiology suite between November 2011 and August 2012. Exclusion criteria were 1) patients with missing BIS data as well as respiratory and hemodynamic variables during isoproterenol infusion; 2) patients in whom significant arrhythmia was invoked within 10 minutes of achieving a 20% decrease in cardiac cycle length on heart rate after the start of isoproterenol; 3) patients in whom isoproterenol was stopped within 10 minutes after initiating a 20% decrease in cycle length; 4) mechanical stimulation of the patient or exchange of arterial venous sheaths and catheters during the 10 minutes of isoproterenol infusion; and 5) patients in whom anesthetic interventions were made within 30 minutes of start of isoproterenol to 10 minutes after reaching a 20% cycle length change.

Isoproterenol infusion was started at the discretion of the electrophysiology physician either before or after ablation of lesions. Infusion of isoproterenol (no bolus) was typically started at 0.1 μg/kg/min and titrated until a 20% decrease in cycle length was noted. No electrophysiologic interventions were performed until this change in cycle length had occurred.

The institutional anesthesia protocol for electrophysiologic procedures during the period of the study primarily consisted of maintenance of 1 - 1.3 minimum alveolar concentration (MAC) of volatile anesthetic agent and neuromuscular blockade. Changes in inhaled anesthetic concentration were avoided once suitable hemodynamic values were achieved. Agents that alter effective refractory periods of the electrical pathways (eg, opioids, anticholinergics) typically were omitted throughout the procedure. Arterial blood gases (ABGs) were drawn every hour during the procedure or after a significant arrhythmia.

Disposable pediatric sensors (XP Platform; Covidien, Mansfield, MA, USA), with enhanced electromyographic filtering had been used with settings defaulted to a smoothing window of 30 seconds, update rate at two seconds, frequency rate 30 Hz, power scale 0.0625 - 4 microvolts (mV), and EEG scale of 100 mV/div. BIS values averaged every three minutes in the electronic database were included in the data analysis.

Electronic data collected were for demographics, BIS, respiratory, hemodynamics, ABGs, all medication dosages, and duration of the electrophysiology procedure, events