Intraoperative ST segment, T wave changes in two infants during general anesthesia

Emily D. Geyer, BS1, Richard S. Cartabuke, MD, MBA1,2, Brian Schloss, MD1,2, Joseph D. Tobias, MD1,2

ABSTRACT

When compared to the adult population, intraoperative cardiac events related to coronary ischemia are uncommon in the pediatric population. However, continuous electrocardiographic (ECG) monitoring is still recommended in infants and children. The authors report two infants who developed intraoperative ST-T wave changes during routine surgical procedures. The role of intraoperative ECG monitoring in infants and children is discussed, the etiology of ST-T wave changes is presented, and previous reports of such events are reviewed.

Key words: Monitoring; ST segment; T wave; Electrocardiography; Infant; General anesthesia

INTRODUCTION

The risk of morbidity and mortality during general anesthesia in the pediatric population remains low.1,2 In 2000, Morray et al. reported, in the initial findings of the Pediatric Perioperative Cardiac Arrest (POCA) registry, that the major cause of pediatric cardiac arrest was medication related (37%) followed by cardiovascular etiology (32%).3 The follow-up study by Bhananker et al. noted a significant decrease in medication-related causes attributed to improvement in pharmacology, specifically the replacement of halothane by sevoflurane.2 This was supplanted by cardiovascular (41%) and respiratory (27%) causes. The authors concluded that these causes could be decreased by implementing unidentified preventive measures. The Australian Incident Monitoring Study (AIMS) demonstrated that there is a preventable factor that can be identified in more than half of intraoperative cardiac arrests.4 Out of 1256 critical intraoperative events, which occurred in association with general anesthesia, 52% were “monitor detected”. More than half were detected by either pulse oximetry (27%) or capnography (24%).4,5 The remaining events were detected by ECG (19%), a blood pressure monitoring device (12%), a low pressure circuit

1Department of Anesthesiology & Pain Medicine, Nationwide Children’s Hospital, Columbus, Ohio (USA)
2Department of Anesthesiology & Pain Medicine, The Ohio State University College of Medicine, Columbus, Ohio (USA)

Correspondence: Joseph D. Tobias, MD, Chairman, Department of Anesthesiology & Pain Medicine, Nationwide Children’s Hospital, Columbus, Ohio (USA); Phone: (614) 722-4200; FAX: (614) 722-4203; E-mail: Joseph.Tobias@Nationwidechildrens.org

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disconnection alarm (8%), or an oxygen analyzer (4%). The American Society of Anesthesiologists recommendations for standard intraoperative monitoring include all of these modalities, including continuous electrocardiography (ECG) monitoring.

In the pediatric cohort analyzed by Bhananker et al., although respiratory issues, such as laryngospasm, lead to cardiac arrest, the majority of intraoperative events leading to cardiac arrest were related to the cardiovascular system, specifically hemorrhage during major surgical procedures. Unlike the adult population, intraoperative cardiac effects related to coronary ischemia are rare. However, continuous ECG monitoring is still recommended in the pediatric population. The authors report two infants who developed intraoperative ST-T wave changes indicative of ischemia. The role of intraoperative ECG monitoring in infants and children is discussed, the etiology of ST-T wave changes is presented, and previous reports of such events are reviewed.

**CASE REPORT 1**

Institutional Review Board approval is not required for presentation of a case series with two or fewer patients at Nationwide Children's Hospital (Columbus, OH).

At the time of the surgery, the patient was a 6-week-old, 5.96 kg infant scheduled for left eye lensectomy with anterior vitrectomy to correct a congenital cataract of the left eye. He had no significant past medical history, allergies, or previous anesthetic encounters. Current medications included ofloxacin 0.3% ophthalmic solution, cyclopentolate 1% ophthalmic solution, and phenylephrine 2.5% ophthalmic solution. On the morning of the procedure, the patient presented with a mild cough. Otherwise, his physical exam was unremarkable and his vital signs were normal. The patient was held nil per os (NPO) for clear liquids and breast milk. After arrival in the operating room (OR), the patient was placed in the supine position and standard American Society of Anesthesiologists (ASA) monitors placed including a 3 lead ECG monitoring lead II. No topical ophthalmic medications were administered. The induction of anesthesia was carried out with incremental inhalation of sevoflurane in oxygen. During anesthetic induction, a decrease in the pulse oximeter waveform amplitude was noted, as well as a decrease in the oxygen saturation followed by disappearance of the waveform. End-tidal CO2 was still present, blood pressure (BP) was 55/25 mmHg, and mean arterial pressure (MAP) was 32 mmHg. The sevoflurane was discontinued, peripheral intravenous access promptly obtained, and atropine (100 µg) administered with prompt resolution and return of the pulse oximeter waveform with a saturation of 100%. The anesthesia and surgical team elected to proceed with the procedure. Propofol (15 mg), fentanyl (5 µg), and rocuronium were administered intravenously, and followed by direct laryngoscopy. During laryngoscopy, the pulse oximeter waveform decreased in size and then disappeared, with a BP of 56/22 mmHg (MAP of 28 mmHg). The patient’s trachea was intubated and epinephrine (5 µg) was administered with return of perfusion and the pulse oximeter waveform. However, at this point, ECG changes were observed, including significant ST segment depression and T wave inversion. Due to concern for a potentially undiagnosed cardiac lesion, a cardiology consult was requested while the patient remained anesthetized with sevoflurane (0.5-1%). There were no abnormalities noted on the physical exam, echocardiogram, or 12-lead ECG, by which time the ST segment and T waves had returned to baseline. The pediatric cardiologist discussed the findings with the patient’s parents and since no prior history of cardiac disease in the family was elicited, the consultant agreed that surgery could proceed and additional outpatient cardiology follow-up was not required. The surgical procedure was performed without further problems. The total anesthetic time was 162 minutes. At the completion of the surgical procedure, the patient’s trachea was extubated and he was transferred to the post-anesthesia care unit (PACU) in stable condition. He was discharged to home later that day and his post-discharge course was unremarkable.

**CASE REPORT 2**

The patient was a 4-year-old, 18.1 kg boy scheduled for a circumcision. The patient had a known history of autism spectrum disorder, insomnia, night terrors, preterm birth (26 weeks, twin gestation), developmental delay, history of a febrile seizure, abnormal EEG, and constipation. The patient had previously undergone ligation of a patent ductus arteriosus (PDA) during the neonatal period. He had no allergies, significant medication history, or previous anesthetic complications. Current medications included diphenhydramine as needed and a pediatric multivitamin. On the morning of the procedure, the patient's examination was unremarkable and preoperative vital signs were normal. After arrival in the OR, the patient was placed in supine position, routine ASA monitors were placed including a 3 lead...
ECG changes in infants

ECG monitoring lead II. Anesthesia was induced with inhalation of incremental concentrations of sevoflurane in nitrous oxide and oxygen (70%/30%). After anesthetic induction, peripheral intravenous access was obtained and a laryngeal mask airway (LMA) placed. Fourteen minutes after anesthetic induction, ST segment depression was noted with a biphasic T wave, but there was no change in vital signs. The ST segment changes gradually returned to baseline as the patient's heart rate (HR) decreased and the inspired concentration of the volatile anesthetic agent was decreased. Maintenance anesthesia included sevoflurane (2-3%) in air/oxygen with fentanyl (2 µg/kg). Additional medications included ondansetron (0.15 mg/kg), dexamethasone (0.15 mg/kg), and ketorolac (0.5 mg/kg). The surgery lasted 66 minutes and progressed successfully without incident. Immediately prior to airway removal, ST segment depression was again noted with an increase in HR to 120-140 beats/minute. The LMA was removed and the ST segment returned to baseline. The patient was transported to the PACU in stable condition with 100% O₂ and continuous pulse oximetry. Pediatric cardiology was consulted and recommended an ECG and echocardiogram. Both tests were unremarkable and it was their opinion that the telemetry changes may have been artifactual, based on the single lead nature of monitoring, or secondary to the anesthetic agents. The patient was discharged home without need for cardiology follow up. His post-discharge course was unremarkable.

DISCUSSION

As the majority of pediatric-aged patients are free from co-morbid cardiac diseases that may predispose the development of intraoperative coronary ischemia or arrhythmias, a 3-lead ECG is typically used as a routine part of intraoperative monitoring during general anesthetic. Lead II is monitored routinely from the 3-lead ECG for P-wave morphology identification and arrhythmia analysis. A 5-lead ECG to monitor anterior and inferior leads is more common in the adult population and may be considered for those patients at risk for ischemic heart disease, severe hypertension, during surgery for congenital heart disease (CHD), or in patients with other types of co-morbid cardiac disease.6,7 Hypoxemia, hypothermia, alterations in intracranial pressure, increased vagal tone during insufflation for laparoscopy, or the oculocardiac/trigeminocardiac reflex may cause bradycardia, making continuous ECG monitoring mandatory.8 Medication-induced changes in HR and rhythm may also occur as volatile anesthetic agents (halothane or sevoflurane) or dexmedetomidine can affect the HR.9

The need for vigilant monitoring of cardiovascular status including continuous ECG and blood pressure are magnified in neonates and infants given the delayed development of the sympathetic nervous system resulting in physiologic limitations when responding to the cardio-depressant effects of volatile anesthetic agents especially in the setting of intravascular depletion or bradycardia. Furthermore, continuous ECG monitoring is mandatory during regional anesthesia as T wave or HR changes may indicate inadvertent systemic injection.10 Thus, in the pediatric-aged patient, lead II is routinely monitored for changes in heart rate or rhythm.

Changes in the ST segment or T waves are less frequently noticed in the pediatric-aged patient than the adult patient. Non-pathologic ST-T wave changes may be seen with J-point depression, early repolarization, or due to sympathetic stimulation related to surgical stimulation or an inadequate depth of anesthesia. However, they may be a sign of significant cardiovascular disease including myocardial ischemia or infarction, left or right ventricular hypertrophy with strain, medication effects, inflammatory processes such as myocarditis and pericarditis, or electrolyte and acid-base disturbances (hypokalemia, hypernatremia, alkalosis).11

Myocardial oxygen delivery occurs during diastole and is regulated by the myocardial perfusion pressure (diastolic blood pressure minus end-diastolic pressure, generally of the left ventricle) and the diastolic time which is dependent on HR. Myocardial oxygen demand is primarily dependent on HR but also end-diastolic pressure, afterload, and myocardial contractility. Given its dual involvement in both delivery and consumption, HR remains the key component of the balance of the myocardial oxygen supply-demand ratio. To date, there are a limited number of previous reports of ST-T segment wave changes during intraoperative anesthetic care in infants and children (Table 1).12-14

As noted in these case reports, although ST-T waves are generally of limited consequence, they may be a warning of cardiac ischemia or impending cardiac arrest. Given these concerns, prompt attention and investigation into such changes is necessary regardless of the clinical situation. Of primary importance during the intraoperative care of these patients is prompt recognition of ST-T segment changes, with a rapid determination of the etiology. Pathological
Table 1: Previous reports of intraoperative ST-T wave changes in infants and children

<table>
<thead>
<tr>
<th>Authors and reference</th>
<th>Cohort description</th>
<th>Summary</th>
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<tbody>
<tr>
<td>Bell C et al.12</td>
<td>1 month old, 790 gm, 26 week gestation infant for PDA ligation.</td>
<td>3 mm ST-segment elevations during awake laryngoscopy resolved after intubation of the trachea. Second episode of 2 mm ST-segment elevation during lung compression with a decrease in oxygen saturation.</td>
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<td></td>
<td>2 day old, 3.5 kg, term infant with TGA for Senning procedure.</td>
<td>3 mm ST-segment elevations and increased HR, BP during chest closure, treated with dopamine, isoproterenol, and nitroglycerin. Patient had postoperative cardiac arrest and expired.</td>
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<tr>
<td></td>
<td>3 week old, 4 kg, term infant with complex CHD following cardiac surgery.</td>
<td>1 mm ST-segment depression, decreased BP, heart block, and ventricular tachycardia following termination of CPB. Successful resuscitation although there was depressed myocardial function which eventually resolved with inotropic support. Patient was discharged home on postoperative day 8 with return of normal myocardial function.</td>
</tr>
<tr>
<td>Alfirevic AJ et al.13</td>
<td>22 month old, 13 kg toddler for adenoidectomy.</td>
<td>ST-segment depression with decreased BP and oxygenation following laryngospasm. Changes resolved after 10 minutes.</td>
</tr>
<tr>
<td>Girshin M et al.14</td>
<td>4 week old, 1.7, term infant with Hanhart syndrome for tracheostomy.</td>
<td>ST-segment elevation and decreased BP following tracheotomy tube placement due to right tension pneumothorax which resolved with needle thoracostomy.</td>
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PDA = patent ductus arteriosus; TGA = transposition of the great vessels; HR = heart rate; BP = blood pressure; CHD = congenital heart disease; VF = ventricular fibrillation

causes, most notably myocardial ischemia, should be identified early and treated to prevent deterioration to hypotension, arrhythmias, and cardiac arrest. Support of the primary determinants of myocardial oxygen delivery includes assurance of adequate oxygenation and blood pressure. Although hypotension is generally well tolerated and common during intraoperative care with limited risk of coronary ischemia, as noted in our patients, high concentrations of sevoflurane used during anesthetic induction may not be well tolerated, especially by young infants and neonates. As such, prompt treatment of bradycardia or hypotension with epinephrine may be indicated. While the authors cannot identify the exact etiology of the ST-T wave changes in the two patients, one occurred during a period of relative hypotension and the other during tachycardia, likely increasing myocardial oxygen demand. As illustrated by previous reports, the risk of myocardial ischemia is significantly higher in patients with CHD or during surgery for CHD.15,16

In summary, the authors present two infants who developed intraoperative ST-T wave changes during elective surgical procedures. In both patients, cardiology workup failed to identify a cardiac etiology for the ST-T wave changes and the surgical procedure was completed without incident. While ST segment changes in the absence of CHD are uncommon and generally of no clinical significance, these changes warrant attention and significant cardiac disease must be considered and excluded as an etiology. Therefore, as reported herein, the authors suggest pausing the surgical procedure and obtaining expert consultation from pediatric cardiology to rule out undiagnosed congenital or acquired cardiac disease. This may require a formal 12-lead ECG and an echocardiogram. Once anatomic cardiac disease is eliminated, other causes including medication effect, electrolyte issues, and artifact should be considered as described above. Once the etiology is determined, appropriate therapeutic strategies can be implemented.

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Authors’ contribution:
EDG; RSC; BS; JDT: conduct of study work and manuscript editing
JDT: concept
REFERENCES


