Benzocaine-Induced Methemoglobinemia: A Case Report

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INTRODUCTION

Local anesthetics are classified by their chemical structures, with the two major categories being esters and amides (Table 1). The agent of choice depends on the method of administration, the length of time for which the affected areas require local anesthesia, and potential adverse effects.

Esters include benzocaine (Cepacol, Reckitt Benckiser; DERMoplast, Prestige Brands Holdings; Chloraseptic, Prestige Brands Holdings; Hurricaine, Beutlich Pharmaceuticals; Lanacane, Reckitt Benckiser; Orabase, Colgate-Palmolive Company; Orajel, Church & Dwight; and Zilactin, Blairex Laboratories); chloroprocaine (Nesacaine, APP Pharmaceuticals); procaine (Novocaine, Colgate-Palmolive Company); and tetracaine.1

Amides include bupivacaine (Marcaine, Hospira; Sensorcaine, AstraZeneca); dibucaine (Nupercainal, Nucere Pharma); levobupivacaine (Chirocaine, Purdue Pharma); lidocaine (Dilocaine, Shire; Solarcaine, Bayer; Lidoderm, Endo Pharmaceuticals; and Xylocaine, Pfizer); mepivacaine (Carbocaine, Cooke-Waite; Isocaine, Novo- col Pharmaceutical; Polocaine, Novocol Pharmaceutical); prilocaine (Citanest, Dentsply Pharmaceutical); and ropivacaine (Naropin, Fresenius Kabi).1

Some combination products contain both amides and esters; the most commonly used of these agents include lidocaine/prilocaine (Emla, Akorn, Inc.) and benzocaine/tetracaine/butamben (Cetacaine, Cetlyte Industries).1

Amides have largely replaced the esters because they produce fewer adverse effects and generally have a longer duration of action.1

Pramoxine (Analpram, Sebela Pharmaceuticals; Pramox, Ferndale Laboratories; and Tronolane, Abbott Laboratories) is a local anesthetic that does not belong to either the amide or ester class.1

Local anesthesia can be achieved by various methods, including topical administration, infiltration, field block, nerve block, and intravenous regional injection. The method by which a local anesthetic is administered aids its effectiveness by delivering the agent directly to the area that is causing or will cause pain. This decreases systemic absorption and related toxic effects. Systemic absorption could produce toxic effects on both the cardiovascular and nervous systems.1

Recently, topical anesthetics have been reported to cause methemoglobinemia, an elevated fraction of methemoglobin (an unstable type of hemoglobin within erythrocytes). The popularity of benzocaine as
a topical anesthetic has diminished as a result of increasing concerns regarding its potential to induce this hematological disorder. Numerous case reports have been published.\textsuperscript{2–17} As of 2009, a review of 242 published cases implicated benzocaine in 66% of methemoglobinemia related to local anesthesia, while lidocaine accounted for only about 5% of cases.\textsuperscript{11}

**PATHOPHYSIOLOGY**

Hemoglobin is composed of four heme groups: deoxyhemoglobin, oxyhemoglobin, carboxyhemoglobin, and methemoglobin. Each group contains an iron atom capable of binding oxygen. This binding, however, can occur only if the iron is in the reduced state (Fe\(^{2+}\)). The removal of an electron from reduced iron—oxidizing it from Fe\(^{2+}\) to Fe\(^{3+}\)—produces methemoglobin. In addition, the production of a ferric (Fe\(^{3+}\)) heme group interferes with oxygen unloading by the other ferrous (Fe\(^{2+}\)) heme groups on the hemoglobin molecule. Red blood cells are continuously under stress by oxidative processes and undergo numerous structural changes that result in the formation of methemoglobin. The development of methemoglobin is regulated by various enzymatic processes, which include the major pathway nicotinamide adenine dinucleotide methemoglobin reductase and the minor pathway nicotinamide adenine dinucleotide phosphate (NADPH) methemoglobin reductase.\textsuperscript{2,4,7,9} A small amount of methemoglobin is reduced via nonenzymatic pathways, such as by ascorbic acid, reduced glutathione, riboflavin, and cysteine.\textsuperscript{5} During these major and minor processes, iron is in the ferrous form (Fe\(^{2+}\)) and combines with oxygen for transportation to the tissues.\textsuperscript{2,4,7–9}

Because methemoglobin prevents oxygen transport to cells, patients presenting with methemoglobinemia become cyanotic despite an adequate respiratory status. Increased oxygenation has no effect on either the cyanotic state or oxygen saturation. Pulse oximetry will most likely be inaccurate, and readings will be inconsistent with the patient’s increasing cyanosis.\textsuperscript{7} Oxygen saturation measured by pulse oximetry is typically in the range of 80% to 85% regardless of the severity of methemoglobinemia.\textsuperscript{4} Routine analysis of arterial blood gas is used to determine the partial pressure of oxygen (PO\(_2\)), which is then used to calculate oxygen saturation in the blood. However, the measurement of PO\(_2\), is not affected by the presence of methemoglobin, and as a result, pulse oximetry readings that are inconsistent with oxygen saturation are suggestive of methemoglobin.\textsuperscript{4,5}

A pulse oximeter is a noninvasive device attached to the finger, earlobe, or nose that emits two separate wavelengths of light, red (660 nm) and infrared (940 nm). A co-oximeter is used to measure the absorbance of oxyhemoglobin and deoxyhemoglobin circulating throughout the capillaries. It reflects the amount of oxygen in the blood, expressed as a percentage, measuring light absorbance at four different wavelengths, correlating to the absorption characteristics of all four heme groups.\textsuperscript{16} Carboxyhemoglobin has an almost identical absorption spectrum (660 nm) to that of oxyhemoglobin.\textsuperscript{16} Methemoglobin absorbs light at both wavelengths (660 nm and 940 nm) that standard oximeters emit.\textsuperscript{16} Therefore, a definitive diagnosis should be confirmed by co-oximetry in patients who present with cyanosis of an uncertain cause.

A “filter paper test” provides a rapid bedside method for diagnosing methemoglobin. In patients with this disorder, arterial blood, when drawn and placed on the filter paper, is often chocolate brown or black and does not change color when exposed to oxygen.\textsuperscript{4,5,9}

The clinical manifestations of methemoglobinemia directly correlate with the level of measured methemoglobin. Symptoms can be worse in those at age extremes (e.g., very young or very old) or with multiple comorbidities. Elderly and pediatric patients, as well as hypoxic patients, are more prone to the formation of methemoglobin. Neonates express low levels of functional NADPH methemoglobin reductase, and this enzyme becomes less efficient in the elderly.\textsuperscript{17} A normal methemoglobin level is less than 1% to 3% of the fraction of hemoglobin in healthy individuals. When the methemoglobin level indicated through arterial co-oximetry is 15% to 20%, patients are usually cyanotic, but they may be asymptomatic. When methemoglobin levels reach 20% to 50%, the patient may experience headache and lightheadedness, weakness, chest discomfort, palpitations, and dyspnea. Death can occur when methemoglobin levels exceed 70%.\textsuperscript{23–7,20}

Methemoglobinemia usually results from exposure to an external oxidizing agent that compromises the physiological cellular defenses of red blood cells. The disorder can also be hereditary. It is associated with the production of abnormal hemoglobin, which usually presents as cyanosis at birth or as a secondary feature of NADH reductase deficiency.\textsuperscript{5,12} Exogenous agents that pose a risk for methemoglobinemia are listed in Table 2.

**Table 2 Selected Agents Associated With Methemoglobinemia\textsuperscript{5–7, 9, 16}**

<table>
<thead>
<tr>
<th>High Risk</th>
<th>Moderate Risk</th>
<th>Low Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Benzocaine</td>
<td>- Acetaminophen</td>
<td>- Benzodiazepines</td>
</tr>
<tr>
<td>- Chloroquine</td>
<td>- Fentanyl</td>
<td>- Ibuprofen</td>
</tr>
<tr>
<td>- Ciprofloxacin</td>
<td>- Aspirin</td>
<td>- Inhalational anesthetics</td>
</tr>
<tr>
<td>- Dapsone</td>
<td>- Mepivacaine</td>
<td>- Phenelzine</td>
</tr>
<tr>
<td>- Flutamide</td>
<td>- Nitroglycerin</td>
<td>- Phenothiazines</td>
</tr>
<tr>
<td>- Isosorbide dinitrate</td>
<td>- Nitric oxide</td>
<td>- Propofol</td>
</tr>
<tr>
<td>- Metoclopamide</td>
<td>- Phenazopyridine</td>
<td>- Succinylcholine</td>
</tr>
<tr>
<td>- Naphthalene</td>
<td>- Phenelzine</td>
<td>- Thiopental</td>
</tr>
<tr>
<td>- Nitrofurantoin</td>
<td>- Phenobarbital</td>
<td>- Benzocaine</td>
</tr>
</tbody>
</table>

**PRINCIPLES OF TREATMENT AND REPLACEMENT**

The topical anesthetics benzocaine 20% (HurriCaine spray) and lidocaine are readily available in most emergency departments and are commonly used to anesthetize a patient’s airway before elective endotracheal intubations or endoscopic procedures.\textsuperscript{14} Both agents have been reported to cause methemoglobinemia. A recent review of the literature indicated that methemoglobinemia was reported more frequently with spray benzocaine used during dental or endoscopic procedures (such as for transesophageal echocardiography).\textsuperscript{24} The potentially fatal effects of benzocaine may be due to a toxic metabolite, an N-hydroxy derivative that has an aniline group incorporated into its structure.\textsuperscript{5,14} This compound has oxidizing properties.

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Case Report

The following report describes a patient with benzocaine-induced methemoglobinemia who was seen at our hospital.

A 46-year-old woman with a medical history of hypertension, anemia, depression, and morbid obesity (which persisted after a gastric bypass in 2003) presented on April 3, 2013, for laparoscopic fistula repair and revision of her 2003 gastric bypass. She felt well at discharge, but soon afterward she experienced chest pain that “felt as though an elephant was sitting on her chest.” She presented to the emergency department on April 12. An upper gastrointestinal series and computed tomography revealed free air in the upper abdomen and a large extraluminal contrast collection posterior to the gastric pouch, with free air bubbles in the upper quadrant. She decompensated, and a nasogastric (NG) tube was temporarily placed. After removal of the NG tube, benzocaine 20% topical oral spray (HurriCaine) was ordered, with nursing instructions to apply one spray to the back of the throat. The order also included instructions to repeat the spray every six hours for pain relief. The following day, the nurse accidentally left the HurriCaine spray canister at the patient’s bedside, and the patient subsequently overdosed as the result of continuous excessive administration of the anesthetic over the next four days.

On the morning of April 17, the patient was found to be cyanotic and “blue.” The patient stated that she felt short of breath, dizzy, and fatigued. She was immediately placed on 2 L of oxygen via nasal cannula. Later that morning, she desaturated to 83% and was placed on 100% fraction of inspired oxygen (FiO2). An arterial blood gas (ABG) was ordered “stat.” The ABG showed a methemoglobin level of 38.8%.

When the doses of benzocaine spray (or any other inpatient procedures that involve benzocaine administration) exceed the recommended levels (Table 3), the medical team continued trending the patient’s methemoglobin levels over the next 24 hours. This was advised because of the potential for a rebound effect, which could occur secondary to the presence of the circulating oxidant. Repeat methylene blue doses were not recommended unless the patient’s methemoglobin level exceeded 20%.

DISCUSSION

Numerous case reports have described methemoglobinemia after gastrointestinal endoscopy, endotracheal intubation, bronchosopic NG tube placement, and other inpatient procedures that involve prescription topical anesthetics. However, many over-the-counter (OTC) topical anesthetic gels, throat lozenges, or sprays can cause methemoglobinemia. The easy access to OTC benzocaine products, such as Cepacol anesthetic troches (Reckitt Benckiser) and Sucratoes maximum-strength lozenges (Prestige Brands Holdings), may lead clinicians to believe that these products are free from adverse effects, including methemoglobinemia. Methemoglobinemia often occurs when the doses of benzocaine spray (or other local anesthetic agents) exceed...
The manufacturers’ recommendations. Clinicians have long pointed out that ambiguous package instructions for use of the spray canisters of benzocaine products can be easily misinterpreted and can lead to potential overdoses. Package instructions commonly suggest that the user should “activate the spray with the forefinger for approximately one second. Maximum anesthesia is produced in the forefinger for approximately one second; congenital anomalies or birth defects; hospitalization; disability or permanent damage; initial hospitalization; prolonged hospitalization; or serious conditions for which medical or surgical intervention is needed. Table 4 lists several strategies to reduce the risk of methemoglobinemia when using topical anesthetics.

### Table 4 Minimizing the Risk of Methemoglobinemia When Using Topical Anesthetics

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Affix labels to topical anesthetic spray bottles warning staff of the danger of excessive patient use.</td>
<td></td>
</tr>
<tr>
<td>• Identify risk factors while obtaining the patient’s medical history.</td>
<td></td>
</tr>
<tr>
<td>• Document the amount of drug administered, including measuring and recording the number of sprays applied.</td>
<td></td>
</tr>
<tr>
<td>• Supplemental oxygen and methylene blue should be kept handy whenever topical anesthetics are used.</td>
<td></td>
</tr>
<tr>
<td>• Use delivery devices that provide more precision in drug administration, such as atomizers (many are available).</td>
<td></td>
</tr>
<tr>
<td>• Stock only one topical anesthetic product to reduce dosing confusion.</td>
<td></td>
</tr>
</tbody>
</table>

Lidocaine may be ordered for “sore throat.” Our staff has been educated on contacting the prescriber to recommend an alternative agent, such as benzocaine troches or lozenges, or phenol 0.5% spray (Chloraseptic, Prestige Brands Holdings), which can be administered to both adults and pediatric patients over the age of 2 years.

### CONCLUSION

Methemoglobinemia is a persistent and significant clinical condition that can result from the use of topical anesthetics, among other causes. Although it is treatable, its detection has been complicated by a general lack of awareness in the medical community and by the limited availability of standard co-oximetry for an accurate diagnosis in the inpatient setting. Clinicians should be on the alert for this potentially serious disorder if patients show an inconsistency between the oxygen saturation of arterial blood and the saturation calculated from partial pressure of oxygen. In addition, methylene blue should be readily available in facilities where topical anesthetics are administered.

### REPORTING ADVERSE DRUG REACTIONS

All ADRs should be reported to MedWatch at 1-888-INFO-FDA, 1-888-463-6332, or online. The FDA 3500 Voluntary Adverse Event Report Form can be accessed easily online for reporting ADRs at www.fda.gov/Safety/Medwatch/HowToReport/ucm085568.htm.

The FDA is interested in serious reports that include any of the following patient outcomes: death; life-threatening condition; initial hospitalization; prolonged hospitalization; disability or permanent damage; congenital anomalies or birth defects; and other serious conditions for which medical or surgical intervention is needed to prevent one of the aforementioned outcomes. The FDA is also interested in any unlabeled ADRs for new drugs.

### REFERENCES


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Table 3 Arterial Blood Gases and Co-Oximetry Values

<table>
<thead>
<tr>
<th>Arterial Blood gas</th>
<th>Normal Values</th>
<th>Time of Diagnosis</th>
<th>Time after Administration of Methylene Blue</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.350–7.450</td>
<td>7.490</td>
<td>7.398</td>
</tr>
<tr>
<td>PCO₂ (mm Hg)</td>
<td>35.0–45.0</td>
<td>31.7</td>
<td>43.1</td>
</tr>
<tr>
<td>PO₂ (mm Hg)</td>
<td>80–100</td>
<td>180.0</td>
<td>57.3</td>
</tr>
<tr>
<td>HCO₃ (mmol/L)</td>
<td>22.0–28.0</td>
<td>23.9</td>
<td>26.0</td>
</tr>
<tr>
<td>SaO₂</td>
<td>94–100</td>
<td>96.3</td>
<td>88.2</td>
</tr>
</tbody>
</table>

Arterial co-oximetry

| O₂Hb (%)          | 60–90         | 59.6              | 69.9                                      | 85.7 | 94.3 |
| MetHb (%)         | < 9.1         | 0.0               | 0.4                                       | 0.7  | 1.4  |
| Deoxy Hb (%)      | < 1.6         | 38.8              | 20.4                                      | 7.1  | 2.2  |
| O₂Hb (%)          | < 2           | 2.3               | 9.3                                       | 6.5  | 2.2  |
| FiO₂ (%)          | 4L NC         | 6L NC             | 4L NC                                     | 80%  |      |

Carboxy Hb = carboxyhemoglobin; deoxy Hb = deoxyhemoglobin; FiO₂ = fraction of inspired oxygen; Hb = hemoglobin; HCO₃ = plasma bicarbonate; metHb = methemoglobin; NC = nasal canula; O₂Hb = oxyhemoglobin; PO₂ = partial pressure of carbon dioxide; PO₂ = partial pressure of oxygen; SaO₂ = arterial saturation of oxygen.
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