

Methemoglobinemia

A plain-English guide for you and your family

WHAT IS HAPPENING

Inside every red blood cell, hemoglobin (the oxygen-carrying protein) holds iron in a form called Fe^{2+} (ferrous iron). This form can grab oxygen in the lungs and release it in your tissues. Normally, a tiny enzyme crew keeps almost all the iron in that good Fe^{2+} form. But when certain drugs or chemicals—like dapsone (an antibiotic), benzocaine (a numbing gel), nitrites (in some foods or water), or fumes from aniline dyes—get into the blood, they steal an electron from the iron and flip it to Fe^{3+} (ferric iron). That Fe^{3+} form cannot hold oxygen at all. The hemoglobin becomes methemoglobin, which is useless for oxygen transport. Your lungs keep working, oxygen enters the blood fine, but the blood cannot deliver it to your brain, heart, or muscles. So you turn blue (cyanotic) even though oxygen levels measured in the blood gas look normal. The blood itself looks chocolate brown instead of bright red. A pulse oximeter gets confused by the brown color and reads around 85 percent no matter what you do. If more than 20 percent of your hemoglobin is locked in this bad form, you feel dizzy, weak, and short of breath. Above 50 percent, your heart and brain are starving for oxygen and you can die. The fix is methylene blue (given through an IV), which flips the iron back to Fe^{2+} so hemoglobin can carry oxygen again. Bluish skin (Cyanosis) clears within minutes, and the chocolate blood turns red. People with a G6PD enzyme deficiency cannot use methylene blue safely, so doctors check for that first. Once the poison is stopped and the iron is fixed, the body recovers fully.

What you might feel

- Blue or gray skin and lips (cyanosis)
- Headache
- Feeling tired or weak
- Dizziness or lightheadedness
- Fast breathing (tachypnea)
- Fast heart rate (tachycardia)
- Nausea
- Confusion or altered mental status

- Shortness of breath (dyspnea)
- Seizures or loss of consciousness

Call the doctor right away if...

- Methemoglobin level above 20% (serious oxygen delivery problem; may need the antidote methylene blue)
- Confusion, seizures, or passing out (sign the brain is dangerously low on oxygen)
- Chest pain or irregular heartbeat (the heart is struggling because it's not getting enough oxygen)
- Severe shortness of breath or very fast breathing that doesn't improve with oxygen (oxygen therapy alone won't fix methemoglobinemia because the problem is in the blood, not the lungs)

What the care team will do

- Apply pulse oximetry and obtain arterial blood gas with co-oximetry panel immediately, then place patient on continuous SpO2 monitoring.
- Start high-flow oxygen by non-rebreather mask at 15 liters per minute even if pulse ox reads normal.
- Establish large-bore IV access and prepare methylene blue 1 to 2 milligrams per kilogram for IV push over 5 minutes if methemoglobin level is above 20 percent or patient has symptoms.
- Immediately remove or stop any suspected causative agent including topical anesthetics, medications, or chemical exposures, and document exact timing and dose.
- Check G6PD enzyme level before giving methylene blue, and if deficiency is known or suspected, prepare ascorbic acid 500 milligrams to 1 gram IV or arrange exchange transfusion instead.
- Perform neurologic checks every 15 minutes and monitor for chest pain, arrhythmias on telemetry, and lactate levels.
- Recheck methemoglobin level 1 hour after methylene blue dose and monitor for recurrence over the next 24 hours.
- Educate patient and family to avoid the identified trigger permanently and provide written list of medications and products containing benzocaine, dapsone, or nitrites.

Medicines you may be given — and why

Methylene blue

Methylene blue donates electrons to methemoglobin (the stuck, brown form of hemoglobin that can't carry oxygen) and flips it back into normal red hemoglobin that can grab oxygen again. It acts like a jump-start that resets the iron inside hemoglobin from its stuck +3 state back to the working +2 state, so oxygen can hook on and ride through the bloodstream to feed tissues.

Ascorbic acid (Vitamin C)

Ascorbic acid slowly donates electrons to methemoglobin, nudging the stuck iron back to its normal state so hemoglobin can carry oxygen again. It works much more slowly than methylene blue—taking hours to days instead of minutes—so it is used only for mild, chronic methemoglobinemia or when methylene blue cannot be given (such as in G6PD deficiency). Think of it as a gentle, steady reset rather than a quick jump-start.

Removal of the offending agent

This is not a medication, but it is the FIRST and most essential step in treating methemoglobinemia: identify and STOP the chemical or drug that is oxidizing hemoglobin. Methemoglobin forms when something keeps pushing the iron in hemoglobin from its normal Fe^{2+} state (which holds oxygen) into the stuck Fe^{3+} state (which cannot). If you keep pouring in the poison, even the best treatments cannot keep up. Once the oxidizing agent is removed, the body's natural methemoglobin reductase enzyme (which continuously repairs small amounts of methemoglobin every day) can start to catch up and gradually lower methemoglobin levels on its own, especially in mild cases.

Exchange transfusion or red cell transfusion

When methemoglobin levels are life-threateningly high (usually above 50–70%) and methylene blue has failed, cannot be given (G6PD deficiency), or is not working fast enough, the fastest way to restore oxygen-carrying capacity is to physically REPLACE the patient's blood with healthy donor blood that contains normal hemoglobin. Exchange transfusion removes brown, dysfunctional blood and swaps in fresh red cells that can immediately grab and deliver oxygen. Simple (additive) transfusion can also help by diluting the methemoglobin and adding functional hemoglobin, though it does not remove the abnormal blood. Think of it as swapping out a tank of bad fuel for good fuel when the engine cannot wait for a slow chemical fix.

Hyperbaric oxygen

Hyperbaric oxygen delivers 100% oxygen at pressures higher than normal atmospheric pressure (typically 2–3 atmospheres) inside a sealed chamber, forcing extra oxygen to dissolve directly into the plasma (the liquid part of blood) rather than relying solely on hemoglobin to

carry it. In severe methemoglobinemia, most hemoglobin is stuck in the methemoglobin form and cannot carry oxygen, but dissolved oxygen in plasma can still reach tissues and keep vital organs (brain, heart) alive while methylene blue or the body's natural systems slowly restore normal hemoglobin. Think of it as a temporary oxygen bypass, like breathing for the blood when the usual oxygen-delivery trucks (hemoglobin) are out of service.

Where this information comes from

- American College of Medical Toxicology (ACMT) Position Statement on Methemoglobinemia
- UpToDate Clinical Guidelines
- Annals of Emergency Medicine
- New England Journal of Medicine (NEJM)

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