

Barium (Elemental) and Selected Barium Compounds**Barium (Elemental) CAS 7440-39-3; UN 1400****Barium Carbonate CAS 513-77-9****Barium Chloride CAS 10361-37-2****Barium Hydroxide CAS 17194-00-2****Barium Sulfide CAS 21109-95-5**

- **Persons exposed to barium by inhalation do not pose secondary contamination risks. Persons whose clothing or skin is contaminated with barium can secondarily contaminate others by direct contact.**
- **At room temperature, barium is a silvery-white odorless metal that takes on a silvery-yellow color when exposed to air. It is non-combustible, but may decompose upon heating to produce corrosive or toxic fumes.**
- **Systemic effects (gastrointestinal, cardiovascular, muscular effects; hypokalemia) have been observed following relatively high-level oral exposure to soluble barium compounds such as barium acetate, barium chloride, barium hydroxide, and barium sulfide; similar effects occurred in rare cases of high level inhalation exposure.**

Description

Barium is a silvery-white to yellowish odorless metal that is found in nature primarily as barium sulfate or barium carbonate (ATSDR 2005; HSDB 2007a). Barium is non-combustible, but may decompose upon heating to produce corrosive or toxic fumes (HSDB 2007a). Elemental barium and barium sulfide may be flammable in moist air (ATSDR 2005).

Routes of Exposure*Ingestion*

Ingestion of relatively large amounts of barium compounds that dissolve in the gastrointestinal tract may cause rapid onset of gastrointestinal symptoms (nausea, salivation, vomiting, abdominal cramps, watery diarrhea), hypokalemia (a reduction in blood potassium levels that can result in ventricular tachycardia, hypertension and/or hypotension, muscle weakness, and paralysis), and kidney damage (ATSDR 2005; HSDB 2007a, 2007b).

Inhalation Limited human and animal data indicate that high-level inhalation exposure to soluble barium compounds may result in systemic effects similar to those elicited from high-level oral exposure (ATSDR 2005).

Sources/Uses In nature, barium exists primarily as the relatively water-insoluble compounds, barium sulfate and barium carbonate. Water-soluble barium compounds (barium acetate, barium chloride, barium hydroxide, barium sulfide) are manufactured from naturally-occurring insoluble barium compounds. Barium carbonate is soluble in acids, and is therefore a health concern following ingestion (ATSDR 2005; HSDB 2007a, 2007b).

Barium sulfate is used in drilling muds, which are used to lubricate drill bits in oil- and gas-drilling industries. Insoluble barium sulfate has been safely used as an x-ray contrast material of the gastrointestinal tract, including barium enemas. Barium sulfate and other barium compounds are used in a variety of manufactured products (ATSDR 2005; HSDB 2007b).

Standards and Guidelines OSHA PEL (permissible exposure limit) as an 8-hour TWA concentration = 0.5 mg/m^3 for barium (Ba; in soluble barium compounds), and 15 mg/m^3 (total dust) and 5 mg/m^3 (respirable fraction) for insoluble barium sulfate. The PELs for barium sulfate are the same as those for nuisance dust in general (OSHA 2006).

NIOSH IDLH (immediately dangerous to life or health) = 50 mg/m^3 for barium chloride (NIOSH 2005).

Physical Properties *Description:* Silvery-white (malleable metal); white to yellow powder or crystals (barium compounds) (ATSDR 2005; HSDB 2007a, 2007b)

Warning properties: Typically odorless, but barium sulfide releases a sulfurous (rotten egg) odor (ATSDR 2005; HSDB 2007a, 2007b)

Molecular weight: 137.3 (barium metal); 197.37 (barium carbonate); 171.38 (barium hydroxide); 233.4 (barium sulfate); 169.4 (barium sulfide) (ATSDR 2005)

Boiling point: $\geq 780 \text{ }^\circ\text{C}$ (compound specific) or decomposes upon heating (ATSDR 2005)

Freezing point: ≥ 408 °C (compound specific) (ATSDR 2005)

Vapor pressure: Expected to be essentially zero (ATSDR 2005)

Specific gravity: ≥ 3.5 for most barium compounds (water = 1) (ATSDR 2005)

Water solubility: Insoluble (barium carbonate, barium sulfate); soluble (barium chloride, barium hydroxide, barium sulfide); elemental barium decomposes (temperature unspecified) (ATSDR 2005; Lewis 2000)

Flammability: Most barium compounds nonflammable; elemental barium and barium sulfide may be flammable in moist air (ATSDR 2005).

Incompatibilities

Elemental barium reacts readily with water, ammonia, halogens, oxygen, and most acids (Lewis 2000). Barium sulfate is incompatible with aluminum and potassium (Lewis 2000).

Health Effects

- **Excessive blood levels of barium result in decreased blood potassium (hypokalemia), which may cause adverse cardiovascular and muscular effects such as tachycardia, increased or decreased blood pressure, muscle weakness, and paralysis.**
- **Mechanisms involved in barium poisoning are likely related to the metabolic control of potassium levels. Because overexposure to barium may cause adverse gastrointestinal effects and hypokalemia, individuals with compromised gastrointestinal tract, cardiac, or muscular function may be more susceptible to barium poisoning.**

Acute Exposure

Ingestion of relatively large amounts of barium compounds that dissolve in the gastrointestinal tract may cause rapid onset of gastrointestinal symptoms (nausea, salivation, vomiting, abdominal cramps, watery diarrhea) and hypokalemia (a reduction in blood potassium levels that can result in ventricular tachycardia, hypertension and/or hypotension, muscle weakness, and paralysis) (ATSDR 2005; HSDB 2007a, 2007b). Limited human and animal data indicate that high-level inhalation of barium may cause symptoms similar to those experienced following ingestion of large amounts of barium. Mechanisms of barium toxicity are not fully understood, but may be related to the action of barium as a competitive potassium channel antagonist that blocks the passive efflux of intracellular potassium, resulting in a shift of potassium from extracellular to intracellular compartments and a lowered intracellular resting potential, which may diminish the ability of nerve cells to respond to stimulation (ATSDR 2005; HSDB 2007a, 2007b).

Children do not always respond to chemicals in the same manner as adults. Different protocols for managing their care may be needed.

<i>Gastrointestinal</i>	Gastrointestinal effects such as gastric pain, nausea, vomiting, and diarrhea are signs of barium poisoning in humans exposed to high levels of barium or soluble barium compounds by ingestion (ATSDR 2005; HSDB 2007a, 2007b).
<i>Metabolic</i>	Exposure to high levels of barium or soluble barium compounds may result in hypokalemia (a reduction in blood potassium levels) that can result in ventricular tachycardia, hypertension and/or hypotension, muscle weakness, and paralysis (ATSDR 2005; HSDB 2007a, 2007b).
<i>Cardiovascular</i>	Cardiovascular abnormalities such as changes in heart rhythm and increased or decreased blood pressure have been observed following exposure to high levels of barium or soluble barium compounds by inhalation or ingestion (ATSDR 2005; HSDB 2007a, 2007b). These cardiovascular effects are likely the result of hypokalemia.
<i>Musculoskeletal</i>	Effects such as numbness, muscle weakness, and paralysis may occur following exposure to high levels of barium or soluble barium compounds by inhalation or ingestion (ATSDR 2005; HSDB 2007a, 2007b). These effects are likely the result of hypokalemia.
<i>Neurological</i>	Tremors, seizures, and mydriasis may occur following severe poisoning (HSDB, 2014).
<i>Potential Sequelae</i>	Persons surviving the first few days of serious barium poisoning following acute exposure are expected to improve quickly upon cessation of overexposure to barium (ATSDR 2005).
Chronic Exposure	<p>Chronic overexposure to barium or soluble barium compounds may cause adverse renal effects (ATSDR 2005; HSDB 2007a, 2007b).</p> <p>Chronic exposure may be more serious for children because of their potential for a longer life span.</p>

Carcinogenicity

The Department of Health and Human Services and the International Agency for Research on Cancer have not assessed the carcinogenicity of barium. The U.S. EPA has concluded that barium is not likely to be carcinogenic to humans following oral exposure and its carcinogenic potential cannot be determined following inhalation exposure (IRIS 2007).

*Reproductive and
Developmental Effects*

The potential for barium-induced reproductive or developmental effects has not been assessed in humans, and no well-designed reproductive or developmental animal studies were located (ATSDR 2005).

Prehospital Management

- **Victims of barium poisoning who were exposed only by inhalation do not pose contamination risks to rescuers. Victims whose clothing or skin is contaminated with barium or soluble barium compounds can secondarily contaminate response personnel by direct contact.**
- **Acute exposure to very high levels of barium may induce gastrointestinal effects, cardiac dysrhythmias, abnormal blood pressure, muscle weakness, and paralysis.**
- **There is no antidote for barium. Treatment consists of regulation of serum potassium levels and respiratory and cardiovascular support. Oral administration of soluble sulfates may limit the absorption of barium by causing precipitation of an insoluble form of barium (barium sulfate).**

Hot Zone

Rescuers should be trained and appropriately attired before entering the Hot Zone. If the proper equipment is not available, or if rescuers have not been trained in its use, assistance should be obtained from a local or regional HAZMAT team or other properly equipped response organization.

Rescuer Protection

Respiratory Protection: Positive-pressure, self-contained breathing apparatus (SCBA) is recommended in response situations that involve exposure to high levels (25–50 mg/m³) of barium compounds such as barium chloride or barium nitrate (NIOSH 2005). A lower level of respiratory protection may be appropriate for lower exposure levels.

Skin Protection: Some barium compounds may be dermal and ocular irritants. Chemical-protective clothing is recommended in situations involving potentially high-level dermal exposure.

ABC Reminders

Quickly establish a patent airway; ensure adequate respiration and pulse. If trauma is suspected, maintain cervical immobilization manually and apply a cervical collar and a backboard when feasible.

Victim Removal

If victims can walk, lead them out of the Hot Zone to the Decontamination Zone. Victims who are unable to walk may be removed on backboards or gurneys; if these are not available, carefully carry or drag victims to safety.

Victims with chemically-induced acute disorders may suffer from anxiety, especially children who may be separated from a parent or other adult.

Decontamination Zone

Patients who are exposed to barium only by inhalation and have no skin or eye irritation may be transferred immediately to the Support Zone. Other patients will require decontamination as described below.

Rescuer Protection

If exposure levels are determined to be safe, decontamination may be conducted by personnel wearing a lower level of protection than that worn in the Hot Zone (described above).

ABC Reminders

Quickly establish a patent airway; ensure adequate respiration and pulse. Stabilize the cervical spine with a collar and a backboard if trauma is suspected. Administer supplemental oxygen as required. Assist ventilation with a bag-valve-mask device if necessary.

Basic Decontamination

Victims who are able may assist with their own decontamination. Quickly remove and double-bag contaminated clothing and personal belongings.

Flush exposed skin and hair with copious amounts of water (ATSDR 2005). Use caution to avoid hypothermia when decontaminating victims, particularly children or the elderly. Use blankets or warmers after decontamination as needed.

Flush exposed or irritated eyes with tepid water for 20 minutes (HSDB 2007a, 2007b). Remove contact lenses if easily removable without additional trauma to the eye. Continue eye irrigation during other basic care and transport. If pain or injury is evident, continue irrigation while transferring the victim to the Support Zone.

In cases of ingestion, **do not induce emesis**. Do not attempt to neutralize because of exothermic reaction (HSDB 2007b). Oral administration of soluble sulfates may limit the absorption of barium by causing precipitation of an insoluble form of barium (barium sulfate) (ATSDR 2005; HSDB 2007a, 2007b).

For victims who are conscious and able to swallow, consider administering 5 mL/kg up to 200 mL of water for dilution (HSDB 2007b). If the victim is symptomatic, delay decontamination until other emergency measures have been instituted.

Provide reassurance to chemically-contaminated victims during decontamination, particularly children who may suffer separation anxiety if separation from a parent occurs.

Transfer to Support Zone

As soon as basic decontamination is complete, move the victim to the Support Zone.

Support Zone

Be certain that victims have been decontaminated properly (see *Decontamination Zone*, above). Victims who have undergone decontamination or have been exposed only by inhalation pose no serious risks of secondary contamination to rescuers. In such cases, Support Zone personnel require no specialized protective gear.

ABC Reminders

Quickly establish a patent airway, ensure adequate respiration and pulse. If trauma is suspected, maintain cervical immobilization manually and apply a cervical collar and a backboard when feasible. Administer supplemental oxygen as required and establish intravenous access if necessary. Place on a cardiac monitor.

Additional Decontamination

Continue irrigating exposed skin and eyes, as appropriate.

In cases of ingestion, **do not induce emesis**. Do not attempt to neutralize because of exothermic reaction (HSDB 2007b). If not done previously, consider the oral administration of soluble sulfates such as magnesium sulfate (250 mg/kg up to 30 g maximum single dose) to reduce the absorption of barium from the gastrointestinal tract (ATSDR 2005; HSDB 2007a, 2007b).

For victims who are conscious and able to swallow, consider administering 5 mL/kg up to 200 mL of water for dilution if it has not been given previously. If the victim is symptomatic, delay decontamination until other emergency measures have been instituted.

Advanced Treatment

In cases of respiratory compromise, secure airway and support respiration according to ALS protocols.

Treat patients who have bronchospasm with an aerosolized bronchodilator such as albuterol. Consider that barium poisoning may include hypertension and tachycardia (ATSDR 2005; HSDB 2007a, 2007b), in which case the use of bronchodilators that are known cardiac sensitizing agents may pose enhanced risk.

Consider racemic epinephrine aerosol for children who develop stridor. Dose 0.25–0.75 mL of 2.25% racemic epinephrine solution; repeat every 20 minutes as needed while observing for myocardial variability.

Patients who are comatose, hypotensive, or having seizures or cardiac arrhythmias should be treated according to advanced life support (ALS) protocols.

If evidence of shock or hypotension is observed, begin fluid administration. For adults with systolic pressure less than 80 mm Hg, bolus perfusion of 1,000 mL/hour intravenous saline or lactated Ringer's solution may be appropriate. Higher adult systolic pressures may necessitate lower perfusion rates. For children with compromised perfusion, administer a 20 mL/kg bolus of normal saline over 10–20 minutes, then reassessment of perfusion and further management as clinically appropriate.

Transport to Medical Facility

Only decontaminated patients or patients not requiring decontamination should be transported to a medical facility. "Body bags" are not recommended.

Report to the base station and the receiving medical facility the condition of the patient, treatment given, and estimated time of arrival at the medical facility.

If barium has been ingested, prepare the ambulance in case the victim vomits. Have ready several towels and open plastic bags to quickly clean up and isolate vomitus.

Multi-Casualty Triage

Consult with the base station physician or the regional poison control center for advice regarding triage of multiple victims.

Patients who are seriously symptomatic (as in cases of chest tightness or wheezing), patients who have histories or evidence of significant exposure, and all patients who have ingested barium should be transported to a medical facility for evaluation. Others may be discharged at the scene after their names, addresses, and telephone numbers are recorded. Those discharged should be advised to seek medical care promptly if symptoms develop (see *Patient Information Sheet* below).

Emergency Department Management

- **Hospital personnel in an enclosed area can be secondarily contaminated by direct contact from soaked skin or clothing. Patients do not pose contamination risks after contaminated clothing is removed and the skin is washed.**
- **Acute exposure to very high levels of barium may induce gastrointestinal effects, cardiac dysrhythmias, abnormal blood pressure, muscle weakness, and paralysis.**
- **There is no antidote for barium. Treatment consists of regulation of serum potassium levels and respiratory and cardiovascular support. Oral administration of soluble sulfates may limit the absorption of barium by causing precipitation of an insoluble form of barium (barium sulfate).**

Decontamination Area

Unless previously decontaminated, all patients suspected of direct contact with barium or soluble barium compounds and all victims with skin or eye irritation require decontamination as described below. Some barium compounds may be dermal and ocular irritants. Chemical-protective clothing is recommended in situations involving potentially high-level dermal exposure. All other patients may be transferred immediately to the Critical Care Area.

Be aware that use of protective equipment by the provider may cause anxiety, particularly in children, resulting in decreased compliance with further management efforts.

ABC Reminders

Evaluate and support airway, breathing, and circulation according to ALS protocols.

Treat patients who have bronchospasm with an aerosolized bronchodilator such as albuterol. Consider that barium poisoning may include hypertension and tachycardia (ATSDR 2005; HSDB 2007a, 2007b), in which case the use of bronchodilators that are known cardiac sensitizing agents may pose enhanced risk.

Consider racemic epinephrine aerosol for children who develop stridor. Dose 0.25–0.75 mL of 2.25% racemic epinephrine solution; repeat every 20 minutes as needed while observing for myocardial variability.

Patients who are comatose, hypotensive, or have seizures or ventricular arrhythmias should be treated in the conventional manner.

Basic Decontamination

Patients who are able may assist with their own decontamination. Remove and double-bag contaminated clothing and all personal belongings.

Flush exposed skin and hair with copious amounts of water (ATSDR 2005). Use caution to avoid hypothermia when decontaminating victims, particularly children or the elderly. Use blankets or warmers after decontamination as needed.

Flush exposed or irritated eyes with tepid water for 20 minutes (HSDB 2007a, 2007b). Remove contact lenses if easily removable without additional trauma to the eye. If pain or injury is evident, continue irrigation while transporting the patient to the Critical Care Area.

In cases of ingestion, **do not induce emesis**. Do not attempt to neutralize because of exothermic reaction (HSDB 2007b). If not done previously, consider the oral administration of soluble sulfates to reduce the absorption of barium from the gastrointestinal tract, (ATSDR 2005; HSDB 2007a, 2007b).

For victims who are conscious and able to swallow, consider administering 5 mL/kg up to 200 mL of water for dilution (HSDB 2007b) if it has not been given previously (see *Critical Care Area* below for more information on ingestion exposure).

Critical Care Area

Be certain that appropriate decontamination has been carried out (see *Decontamination Area* above).

ABC Reminders

Evaluate and support airway, breathing, and circulation as in ABC Reminders above under *Decontamination Zone*. Establish intravenous access in seriously ill patients if this has not been done previously. Continuously monitor cardiac rhythm.

Patients who are comatose, hypotensive, or have seizures or cardiac arrhythmias should be treated in the conventional manner.

Inhalation Exposure

Administer supplemental oxygen by mask to patients who have respiratory symptoms. Treat patients who have bronchospasm with an aerosolized bronchodilator such as albuterol. Consider that barium poisoning may include hypertension and tachycardia (ATSDR 2005; HSDB 2007a, 2007b), in which case the use of bronchodilators that are known cardiac sensitizing agents may pose enhanced risk.

Consider racemic epinephrine aerosol for children who develop stridor. Dose 0.25–0.75 mL of 2.25% racemic epinephrine solution; repeat every 20 minutes as needed while observing for myocardial variability.

Skin Exposure

If the skin was in contact with as barium hydroxide or other potentially corrosive barium compounds, chemical burns may occur; treat as thermal burns.

Because of their relatively larger surface area:body weight ratio, children are more vulnerable to toxicants affecting the skin.

Eye Exposure

Continue irrigation for at least 20 minutes. Test visual acuity. Examine the eyes for corneal damage and treat appropriately. Immediately consult an ophthalmologist for patients who have corneal injuries.

Ingestion Exposure

Do not induce emesis. Do not attempt to neutralize because of exothermic reaction (HSDB 2007b).

For victims who are conscious and able to swallow, consider administering 5 mL/kg up to 200 mL of water for dilution (HSDB 2007b) if it has not been given previously.

Antidotes and Other Treatments

There is no antidote for barium. Treatment consists of regulation of serum potassium levels and respiratory and cardiovascular support. Oral administration of soluble sulfates may limit the absorption of barium by causing precipitation of an insoluble form of barium (barium sulfate).

Laboratory Tests

Routine laboratory studies for all exposed patients include CBC, glucose, and electrolyte determinations, particularly serum potassium levels for the first 24 hours postexposure. Patients who have respiratory complaints may require pulse oximetry (or ABG measurements), chest radiography, and peak-flow and/or spirometry.

Disposition and Follow-up

Consider hospitalizing patients who have histories of significant inhalation exposure and are symptomatic (e.g., chest tightness or wheezing) or who have ingested barium.

Delayed Effects

In cases of barium poisoning, gastrointestinal symptoms may be expressed rapidly. However, cardiovascular and neuromuscular symptoms may be delayed for up to several hours (ATSDR 2005; HSDB 2007a, 2007b).

Patient Release

Patients who remain asymptomatic for 24 hours after exposure may be discharged with instructions to seek medical care promptly if symptoms develop (see the *Barium—Patient Information Sheet* below).

Follow-up

Obtain the name of the patient's primary care physician so that the hospital can send a copy of the emergency department (ED) visit to the patient's doctor.

Patients who have corneal injuries should be reexamined within 24 hours.

Reporting

If a work-related incident has occurred, you may be legally required to file a report; contact your state or local health department.

Other persons may still be at risk in the setting where this incident occurred. If the incident occurred in the workplace, discussing it with company personnel may prevent future incidents. If a public health risk exists, notify your state or local health department or other responsible public agency. When appropriate, inform patients that they may request an evaluation of their workplace from OSHA or NIOSH. See Appendix III for a list of agencies that may be of assistance.

Barium

Patient Information Sheet

This handout provides information and follow-up instructions for persons who have been exposed to barium.

What is barium?

Barium is a silvery-white to yellowish odorless metal that is found in nature primarily as barium sulfate or barium carbonate. Other barium compounds (barium acetate, barium chloride, barium hydroxide, barium sulfide) are manufactured from naturally-occurring barium compounds. Relatively water-soluble barium compounds (barium acetate, barium chloride, barium hydroxide, barium sulfide) and acid-soluble barium carbonate are a health concern. Barium sulfate is used in drilling muds. Insoluble barium sulfate has been safely used as an x-ray contrast material of the gastrointestinal tract, including barium enemas. Barium sulfate and other barium compounds are used in a variety of manufactured products.

What immediate health effects can be caused by exposure to barium?

High level inhalation or oral exposure to barium or soluble barium compounds may result in gastrointestinal effects (gastric pain, nausea, vomiting, and diarrhea), followed by hypokalemia (a reduction in blood potassium levels) that can result in ventricular tachycardia, hypertension and/or hypotension, muscle weakness, and paralysis.

Can barium poisoning be treated?

There is no antidote for barium, but its effects can be treated and most exposed persons get well. Seriously exposed persons may need to be hospitalized.

Are any future health effects likely to occur?

Barium-induced health effects appear quickly following high-level acute exposure. Symptoms usually resolve soon after exposure ceases. Chronic exposure may result in kidney damage.

What tests can be done if a person has been exposed to barium?

Doctors can measure barium in body tissues and fluids, such as bones, blood, urine, and feces, using very complex instruments. These tests may not be available and have limited value in treating the acute effects of barium exposure.

Where can more information about barium be found?

More information about barium can be obtained from your regional poison control center; your state, county, or local health department; the Agency for Toxic Substances and Disease Registry (ATSDR); your doctor; or a clinic in your area that specializes in occupational and environmental health. If the exposure happened at work, you may wish to discuss it with your employer, the Occupational Safety and Health Administration (OSHA), or the National Institute for Occupational Safety and Health (NIOSH). Ask the person who gave you this form for help in locating these telephone numbers.

Follow-up Instructions

Keep this page and take it with you to your next appointment. Follow *only* the instructions checked below.

Call your doctor or the Emergency Department if you develop any unusual signs or symptoms within the next 24 hours, especially:

- coughing, wheezing, difficulty breathing, shortness of breath, or chest pain
- gastrointestinal discomfort
- irregular heartbeat or abnormal blood pressure
- muscle weakness or paralysis
- persistent eye or skin irritation

No follow-up appointment is necessary unless you develop any of the symptoms listed above.

Call for an appointment with Dr. _____ in the practice of _____.
When you call for your appointment, please say that you were treated in the Emergency Department at _____ Hospital by _____ and were advised to be seen again in _____ days.

Return to the Emergency Department/_____ Clinic on (date) _____ at _____ AM/PM for a follow-up examination.

Do not perform vigorous physical activities for 1 to 2 days.

You may resume everyday activities including driving and operating machinery.

Do not return to work for _____ days.

You may return to work on a limited basis. See instructions below.

Avoid exposure to cigarette smoke for 72 hours; smoke may worsen the condition of your lungs.

Avoid drinking alcoholic beverages for at least 24 hours; alcohol may worsen injury to your stomach or have other effects.

Avoid taking the following medications: _____

You may continue taking the following medication(s) that your doctor(s) prescribed for you:

 Other instructions: _____

- Provide the Emergency Department with the name and the number of your primary care physician so that the ED can send him or her a record of your emergency department visit.

- You or your physician can get more information on the chemical by contacting: _____ or _____, or by checking out the following Internet Web sites: _____;

Signature of patient _____ Date _____

Signature of physician _____ Date _____

References

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