Cyanide & Hydrogen sulfide Poisoning

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การชี้แจงผ่านการประชุมทางไกลด้านพิษวิทยาคลินิกผ่านสื่ออิเล็กทรอนิกส์
เรื่อง การดูแลรักษาผู้ป่วยภาวะพิษด้วยยาต้านพิษและเซรุ่มต้านพิษงู โดย ศูนย์พิษวิทยา และ สำนักงานหลักประกันสุขภาพแห่งชาติ (ปี พ.ศ. 2564)

Outlines

- Examples of the cases

- Cyanide & hydrogen sulfide poisoning
  - Pathophysiology
  - Clinical Manifestations
  - Diagnosis
  - Management

Examples of the cases

Case 1

ผู้ป่วยชาย อายุ 32 ปี เชียงใหม่

1 ชั่วโมง PTA: .ผู้ป่วยเอาผง potassium cyanide ซึ่งใช้ล้างหัว computer ละลายน้ำกิน หลังกินอาเจียนแล้วหมดสติ (ประมาณ 8 นาทีหลังกิน) น้องสาวเป็นแพทย์จึงช่วย CPR ประมาณ 3 นาที หลัง CPR เริ่มขยับ หันตามเสียง จึงนำส่งรพ.

ที่ ER ผู้ป่วยยังดิ้นไปมา GCS 7

BP 106/80 mmHg PR 118/min RR 30/min

on O2 mask with bag -> O2 saturation 98% Otherwise: unremarkable


Potassium cyanide
โปแตสเซียมไซยาไนด์
Formula KCN
E.W. 65.12
Quantity 500 g
R: 26/27/28-32
S: 1/2-7-28-29-45
HEALTH 3
FLAMMABILITY 0
REACTIVITY 2
PROTECTIVE EQUIPMENT C
GAMMACO (THAILAND) CO.,LTD.
http://www.gammaco.com
3096106

Case 2

ผู้ป่วยหญิง อายุ 58 ปี กทม

1 ชม. PTA: ผู้ป่วยได้เข้าไปในห้องลูกชายที่เสียชีวิต และเปิดตู้เย็นกินน้ำจากขวดน้ำที่ทิ้งไว้เมื่อ 5 เดือนก่อน โดยดื่มไป 20 cc แล้วรู้สึกรสผิดปกติ จึงเดินกลับไปห้องนอน แต่ได้ล้มลง ตาค้าง ตัวเกร็ง หน้าแดง ญาติได้เป่าปากและ กดหน้าอก ญาติรีบนำส่งรพ.

ที่ ER: Coma, E1M1V1

BP 141/88 mmHg PR 60/min on ET intubation, O2 sat 100%

Pupil: slow react to light

ได้ทำ CT brain emergency ขณะทำ CT Brain มี bradycardia HR 30-40/min

ABG: pH=6.9, pCO2= 33, pO2=193, (FiO2 0.5)

electrolyte: Na= 142, K=4.3, Cl=104, CO2= 21, AG 17

Case 3

ผู้ป่วย 3 คน เกษตรกร

กินน้ำในหม้อแกงเดียวกัน 5 นาที

ผู้ป่วยหญิง 1 คน รู้สึกรสขม ๆ อาเจียน เวียนศีรษะ

อีก 2 คน หลังกินพร้อมกัน 5 นาที หมดสติ น้ำลายฟูมปาก เกร็ง ๆ

BP 124/87 mmHg, PR 114/min, O2 sat 99%

BP 163/105 mmHg, PR 100/min, RR 20/min

CT brain: normal

Na 136, K 4.3, Cl 97, CO2 17 (Anion gap 22)

Na 139, K 3.6, Cl 96, CO2 17 (Anion gap 26)

- Sudden collapse
- Metabolic acidosis

Case 4

ผู้ป่วยเด็ก 2 คน อายุ 4, 6 ปี

3 ชั่วโมงก่อนมา รพ: ผู้ป่วยกินมันสำปะหลังเผาไม่ทราบปริมาณ หลังกินมีอาการคลื่นไส้อาเจียนหลายครั้ง ญาติพามา รพ

- ที่ ER ผู้ป่วย 1 คนมีอาการชักเกร็งกระตุกทั้งตัวประมาณ 1 นาที

  BT 37.3 c, PR 150/min, Bp 110/60 mmHg,

  O2sat 95 %

- แพทย์ให้ Diazepam 4 mg และใส่ ET tube
- Na=134, K=3.4, Cl=103, HCO3=25
- ABG: pH=7.3 HCO3=11

- Group of patients
- GI symptoms
- Seizure
- Metabolic acidosis

Case 5

ผู้ป่วยชาย อายุ 27 ปี

30 นาที PTA: ขณะล้างถังบำบัดน้ำเสีย ในโรงงานถั่วงอก ผู้ป่วยหน้ามืดเป็นลม ล้มลงทันที ไม่มีชักเกร็งกระตุก เพื่อนรีบนำส่งรพ. เพื่อนบอกได้กลิ่นก๊าซไข่เน่า

- ER: Coma, air hunger
- BP 140/80 mmHg HR 110 /min RR 10/min

  O2 sat 88 %

  On ET tube FiO2 1 -> O2 sat 90 %
- Na=138, K=3.1, Cl=103, HCO3=19, AG 16
- CXR: bilateral alveolar and interstitial infiltration

Cyanide
&
Hydrogen sulfide

- **Cyanide:** a chemical group that consists of one atom of carbon bound to one atom of nitrogen by three molecular bonds ($C \equiv N$)
  - Inorganic, organic, gas

- **Hydrogen sulfide (H_2S):** a colorless gas, more dense than air, with an irritating odor of rotten eggs, highly lipid soluble

- In 1782, Swedish chemist Carl Wilhelm Scheele first isolated hydrogen cyanide
- Napoleon III was the first to use hydrogen cyanide in chemical warfare
- During World War II, cyanide (Zyklon B) caused

  > 1 million deaths in Nazi gas chambers

https://en.wikipedia.org/wiki/Zyklon_B

- In 1978, KCN used in a mass suicide led by Jim Jones of the People's Temple in Guyana:
  913 deaths

www.gettyimages.dk

- In 1982, 7 deaths from consumption of CN-tainted acetaminophen in Chicago
- In 2010, an Ohio emergency medicine physician who murdered his wife with a CN-laden calcium capsule

Goldfrank 11th ed, Tintinalli 9th ed

Morii *et al. Journal of Occupational Medicine and Toxicology* 2010, **5**:28
http://www.occup-med.com/content/5/1/28

JOURNAL OF OCCUPATIONAL MEDICINE AND TOXICOLOGY

SHORT REPORT **Open Access**

Japanese experience of hydrogen sulfide: the suicide craze in 2008

Daiichi Morii[1,2*], Yasusuke Miyagatani[1], Naohisa Nakamae[1], Masaki Murao[1], Kiyomi Taniyama[3]

Abstract

Most of hydrogen sulfide poisoning has been reported as industrial accidents in Japan. However, since January 2008, a burgeoning of suicide attempts using homemade hydrogen sulfide gas has become evident. By April 2008, the fad escalated into a chain reaction nationwide. Mortality of the poisoning was very high. There were 220 cases of attempted gas suicides during the period of March 27 to June 15, killing 208. An introduction of new method of making the gas, transmitted through message boards on the internet, was blamed for this "outbreak". The new method entailed mixing bath additive and toilet detergent. The National Police Agency instructed internet providers to remove information that could be harmful. Of the victims of the fad in 2008, several cases were serious enough that family members were involved and died. Paramedics and caregivers were also injured secondarily by the gas. This fad has rapidly spread by internet communication, and can happen anywhere in the world.

- The main component of the bath additive is lime sulfur, toilet detergent acts as an oxidant to produce H_2S gas.

Pathophysiology

- Inhibitor of multiple enzymes

- Inhibiting cytochrome oxidase at the cytochrome a3 portion of the electron transport chain:

  Binds ferric (3+) iron of mitochondrial cytochrome oxidase

↓

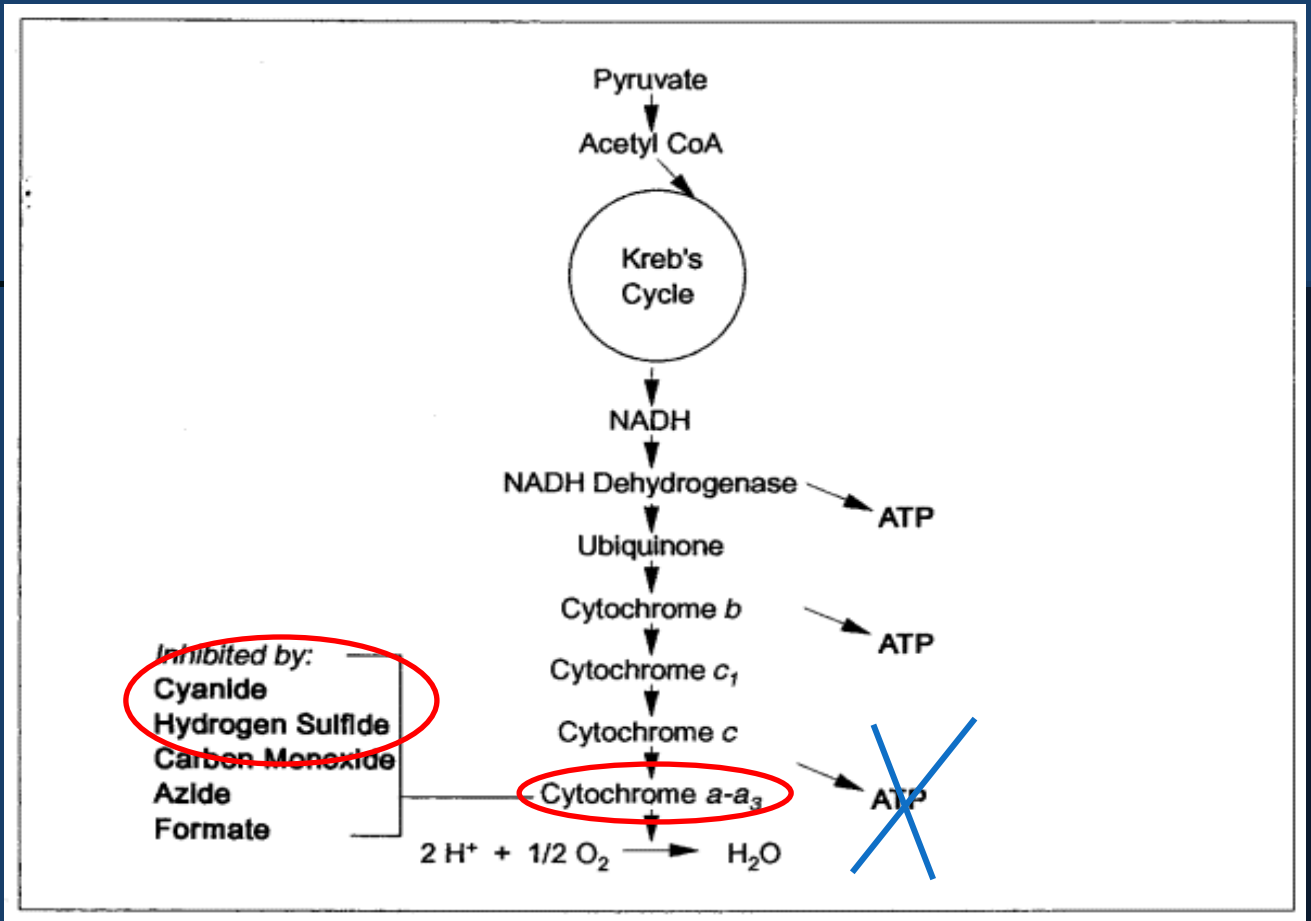
Abrupt cessation of electron transport & oxidative phosphorylation

↓

Inhibiting aerobic metabolism

↓

Anaerobic metabolism



cores33webs.mede.uic.edu/pres/Cyanide.ppt

- Final step in oxidative phosphorylation

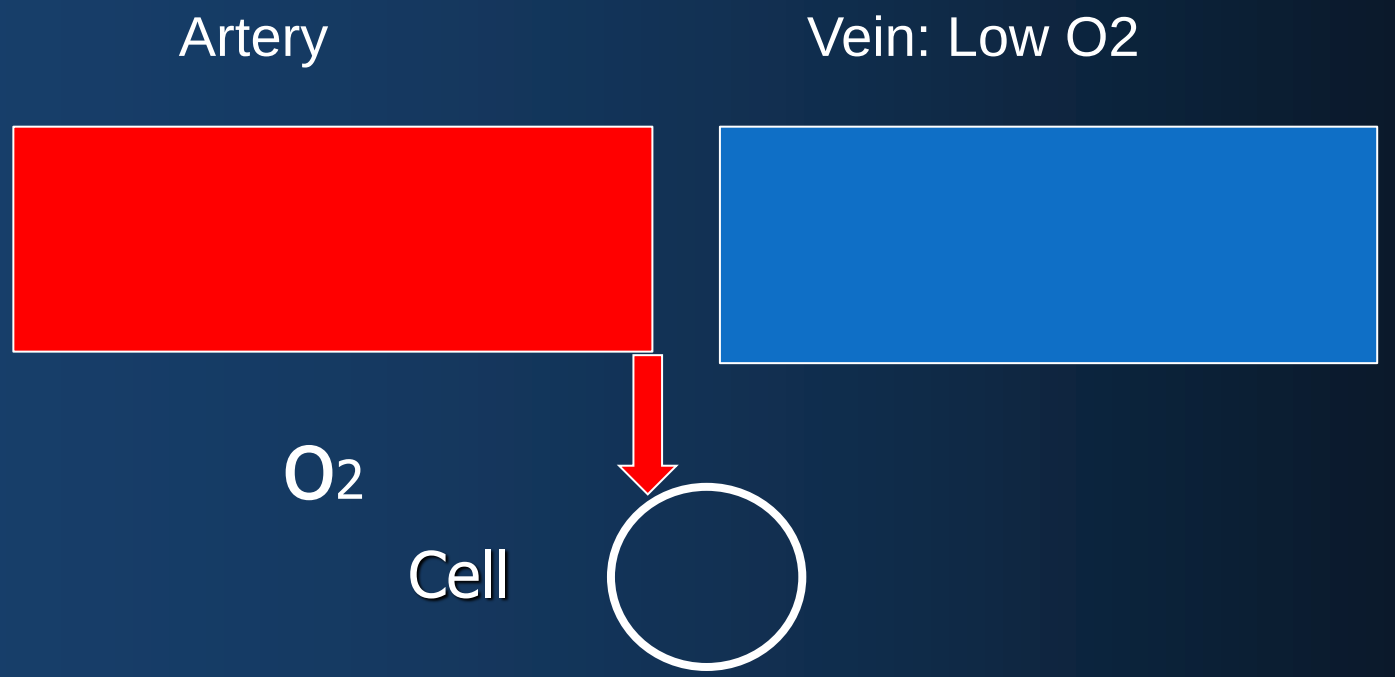
Anaerobic metabolism

- Cellular hypoxia
- Pyruvate converted to lactate ➡ hyperlactemia
- Lactic acidosis
- Unincorporated hydrogen ions accumulate, contributing to acidemia

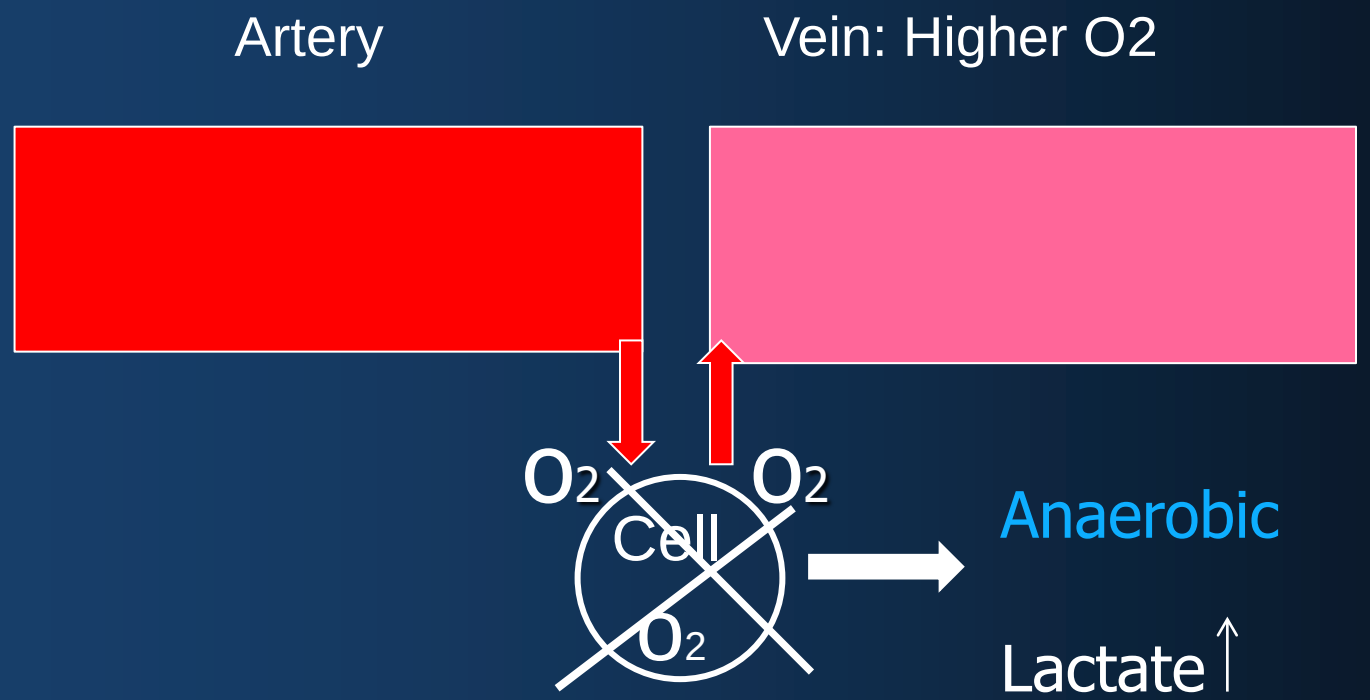
Cyanide: a potent neurotoxin, enhance NMDA receptor

H_2S: irritant gas, olfactory nerve paralysis

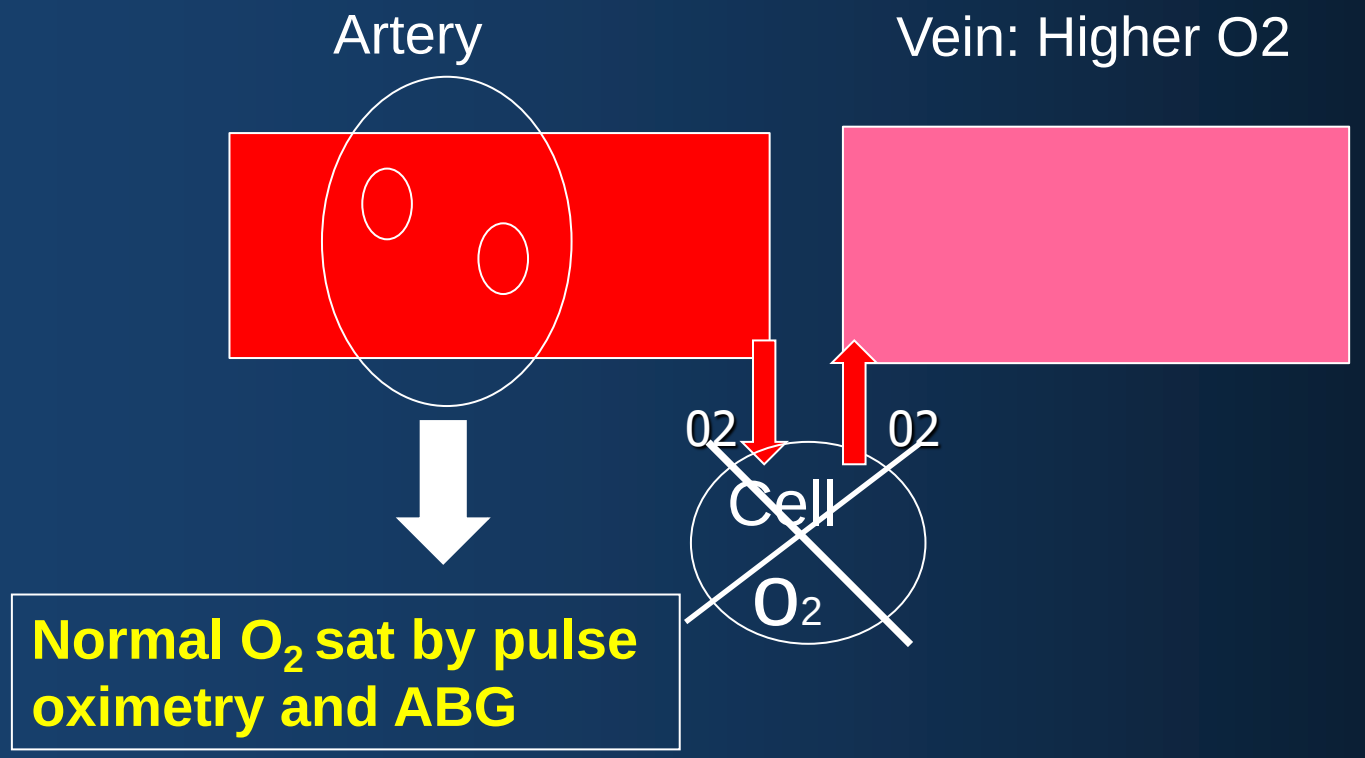
Normal physiology



Cyanide & H_2S Poisoning



Cyanide & H_2S Poisoning



Pharmacology

Cyanide

- Dose to produce toxicity
  - form of CN
  - duration of exposure
  - route of exposure
- Routes of exposure in acute toxicity
  - inhalation
  - ingestion
  - dermal
  - parenteral

H_2S

- Highly lipid soluble
- Systemic absorption usually through inhalation
- Distinct dose response e.g. > 500 ppm: systemic effects, rapid unconsciousness (knockdown), cardiopulmonary arrest

Detoxification

Cyanide

- The enzymatic conversion to thiocyanate
- Two sulfur transferase enzymes,

Rhodanese and β-mercaptopyruvate-cyanide sulfurtransferase

- T1/2 1.2-66 hours

H_2S

- Metabolized by multiple enzymes

Clinical Manifestations

Cyanide:

Amount, duration, route, premorbid condition, time to onset, severity

- CNS: Headaches, drowsiness, dizziness, seizures, coma, Alteration of consciousness, depress respiratory center
  Centrally mediated tachypnea followed by bradypnea, apnea
- Cardiovascular: Tachycardia, hypertension followed by hypotension with reflex tachycardia, then bradycardia, hypotension
- Pulmonary: Mild corrosive injury to respiratory tract mucosa
- Systemic: Metabolic acidosis, hyperventilation/ hypoventilation
- GI: Abdominal pain, nausea, vomiting
- Skin: Cherry red skin color

H_2S

- Massive exposures: rapid loss of consciousness **"knockdown"**
- Cardiovascular: Chest pain, bradycardia
- CNS: Headache, weakness, dysequilibrium, convulsions, coma
- Gastrointestinal: Pharyngitis, nausea, vomiting
- Ophthalmic: Conjunctivitis
- Olfactory nerve paralysis
- Pulmonary: Dyspnea, cyanosis, hemoptysis, crackles

Irritant

Forms of cyanide

- Gas: hydrogen cyanide (HCN):

  Colorless, bitter almond odor

  Cyanogen chloride (CNCl): Chemical Weapons Convention
- Inorganic: salts, solution: NaCN, KCN
- Organic: Nitriles: acetonitrile
- Natural: cyanogenic glycoside: Cassava
- Iatrogenic: nitroprusside

Common Sources Cyanide:

- Burning: wool, nylon, silk, acrylic, polyurethane, melamine, polyacrylonitrile, polyamide plastics, synthetic products, furniture
- Industries: fabrication of plastics, electroplating, mining, photography, precious metal reclamation,
- Chemistry laboratories
- Medicinal: laetrile (amygdalin), sodium nitroprusside
- Plants: seeds from Prunus species (apricots, cherries, plums, peaches), cassava, bamboo shoots

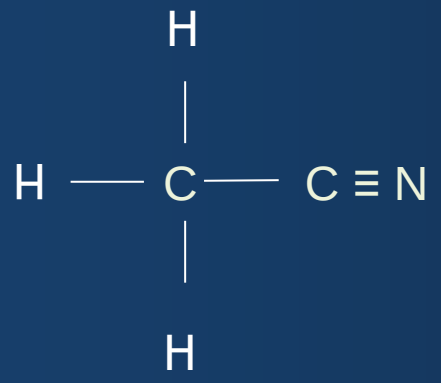
Silver/gold polishing agents

Cyanide salts

Artificial Nail Remover/ False nail remover

Cytochrome P 450

Acetonitrile → **HCN** + Formaldehyde



www.nailsmag.com

Cyanogenic glycosides

Manihot spp, Linum spp, Lotus spp, Prunus spp, Sorghum spp, Phaseolus spp

rebenke.deviantart.com

Amygdalin

- Prunus species: apricots, bitter almond, cherry, peaches
- Biotransformed by intestinal-d-glucosidase

Linamarin

- Cassava

Amygdalin $\xrightarrow{\text{β-D-glucosidase}}$ **HCN**, Glucose,benzaldehyde

Linamarin $\longrightarrow$ cyanohydrin $\longrightarrow$ **CN**

Nitroprusside Induced Cyanide Toxicity

- Molecule: 5 cyanide radicals, gradually released, occasionally produce cyanide or thiocyanate toxicity
- Coadministration of sodium thiosulfate
- Thiocyanate may accumulate, especially in patients with renal insufficiency
- Thiocyanate toxicity: nausea, vomiting, fatigue, dizziness, confusion, delirium, hemodynamic and intracranial pressure elevation
- Thiocyanate: hemodialyzable

Cyanide
Time to onset of symptoms

- Exposures: ingestion, inhalation, dermal, parenteral
- Inhalation gas, IV salts → seconds
- Ingestion inorganic salts → minutes
- Ingestion cyanogenic chemicals → delayed (3 -24 hr)
- Ingestion cyanogenic glycosides → delayed

Annals of Tropical Paediatrics (2010) 30, 39–43

Cyanide poisoning caused by ingestion of apricot seeds

B. N. AKYILDIZ, S. KURTOĞLU†, M. KONDOLOT* & A. TUNÇ*

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(Accepted December 2009)

The mean time of onset of symptoms was 60 minutes (20 minutes - 3 hours).

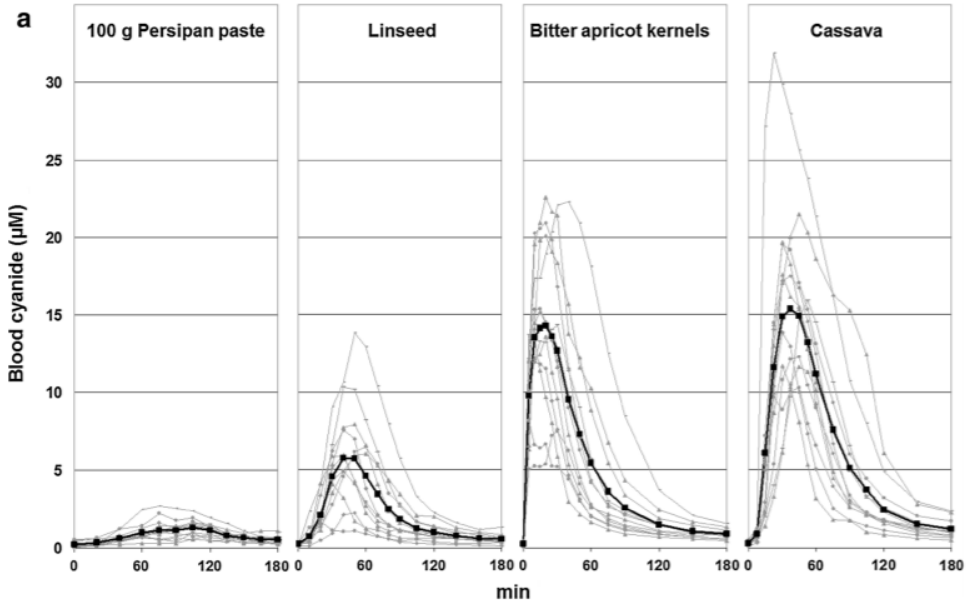
Abstract

Aim: To report diagnostic, clinical and therapeutic aspects of cyanide intoxication resulting from ingestion of cyanogenic glucoside-containing apricot seeds.

Methods: Thirteen patients admitted to the Pediatric Intensive Care Unit (PICU) of Erciyes University between 2005 and 2009 with cyanide intoxication associated with ingestion of apricot seeds were reviewed retrospectively.

Results: Of the 13 patients, four were male. The mean time of onset of symptoms was 60 minutes (range 20 minutes to 3 hours). On admission, all patients underwent gastric lavage and received activated charcoal. In addition to signs of mild poisoning related to cyanide intoxication, there was severe intoxication requiring mechanical ventilation (in four cases), hypotension (in two), coma (in two) and convulsions (in one). Metabolic acidosis (lactic acidosis) was detected in nine patients and these were treated with sodium bicarbonate. Hyperglycaemia occurred in nine patients and blood glucose levels normalised spontaneously in six but three required insulin therapy for 3–6 hours. Six patients received antidote treatment: high-dose hydroxocobalamin in four and two were treated with a cyanide antidote kit in addition to high-dose hydroxocobalamin. One patient required anticonvulsive therapy. All patients recovered and were discharged from the PICU within a mean (SD, range) 3.1 (1.7, 2–6) days.

Conclusion: Cyanide poisoning associated with ingestion of apricot seeds is an important poison in children, many of whom require intensive care.



Arch Toxicol (2016) 90:559–574
DOI 10.1007/s00204-015-1479-8

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TOXICOKINETICS AND METABOLISM

Bioavailability of cyanide after consumption of a single meal of foods containing high levels of cyanogenic glycosides: a crossover study in humans

Klaus Abraham · Thorsten Buhrke · Alfonso Lampen

Table 2 Results for the peaks of cyanide in whole blood (C_{max}, t_{max}) after application of different foods, potassium cyanide, and isolated cyanogenic glycosides in test person No. 5

Food	Amount ingested (g)	+ sweet almonds (g)	Equiv. dose of cyanide (mg)	C_{max} (µM)	t_{max} (min)
Cassava	62.0[a,c]		6.8	19.5	30
Bitter apricot kernels	2.1[a,c]		6.8	15.4	15
Linseed	7.5		1.7	1.2	30
	15.0		3.3	2.2	30
	30.9[a]		6.8	6.5	60
	60.0		13.2	19.8	80
	100.0		22.0	42.3	160
Persipan paste	100.0[a,c]		6.8	2.3	75
	100.0[c]	10.0	6.8	4.5	30
	100.0	30.0	6.8	3.4	50
	200.0[a,c]		13.6	9.1	150
	400.0[c]		27.2	17.1	270
KCN	0.006		2.4	6.0	5
	0.017[c]		6.8	20.1	10
Amygdalin	0.120[c]		6.8	3.4	60
	0.120[c]	10.0	6.8	10.0	30
	0.387		22.0	29.2	70
Linamarin	0.065[c]		6.8	0.4	–[b]
	0.209		22.0	0.9	–[b]

[a] Results obtained during the investigations within the study protocol for comparison

[b] No definite peak identifiable

[c] For concentration–time curves see Fig. 4 or 5

วิทยาคลินิกผ่านสื่ออิเล็กทรอนิกส์
ันสุขภาพแห่งชาติ (ปี พ.ศ. 2564)

J Med Assoc Thai 1999; 82 (11):162

Original Article Open Access

Cyanide Poisoning, 2 Cases Report and Treatment Review

Ruangkanchanasetr S, Wananukul V , Suwanjutha S

Abstract | Full Text | References | Citation | Response

Two patients, a 4-year-old girl and her brother 1 1/2 year-old, with cyanide poisoning are reported. They vomited and became comatose 9 hours after ingestion of boiled cassava. At a community hospital, they were intubated and given ventilatory support. The girl was transferred to Ramathibodi Intensive Care Unit. At 19 hours after ingestion, sodium nitrite and sodium thiosulfate were given as well as other supportive treatment. She recovered with normal breathing on the next day. The boy was referred to Ramathibodi 4 hours later. On arrival, he appeared normal except for the bitter almond breathe. Only supportive treatment was given. Their blood cyanide levels on arrival were 0.56 and 0.32 11g/ml (normal value < 0.3 11g/ml) respectively confirming the diagnosis of cyanide poisoning. Other abnormal laboratory findings included metabolic acidosis and lactic acidemia.

The pathogenesis and management of cyanide poisoning are reviewed.

Key word : Cyanide Poisoning, Cassava Ingestion

Cyanide poisoning by fire smoke inhalation: a European expert consensus

Kurt Anseeuw[a,*], Nicolas Delvau[b,*], Guillermo Burillo-Putze[d], Fabio De Iaco[e], Götz Geldner[f], Peter Holmström[g], Yves Lambert[h] and Marc Sabbe[c]

European Journal of Emergency Medicine 2013, 20:2–9

Findings suggesting cyanide toxicity:

- History of enclosed-space fire
- Any alteration in the level of consciousness
- Any cardiovascular changes
  (particularly inexplicable hypotension)
- Elevated plasma lactate

When to suspect cyanide poisoning

- Fire victim with coma or metabolic acidosis
- Suicide attempt with unexplained coma or metabolic acidosis
- Sudden collapse of a laboratory or industrial worker
- Ingestion of artificial nail remover
- Ingestion of seeds or pits from *Prunus* spp.
- Patient with altered mental status, metabolic acidosis, and tachyphylaxis to nitroprusside

Delayed clinical manifestations of acute cyanide exposure

- May develop delayed neurologic sequelae
- Parkinsonian symptoms: dystonia, dysarthria, rigidity, bradykinesia
- CT and MRI: basal ganglia damage to the globus pallidus, putamen, and hippocampus, with radiologic changes appearing several weeks after onset of symptoms

Chronic cyanide exposure

- Tobacco amblyopia: a progressive loss of visual function that occurs almost exclusively in men who smoke cigarettes
- Konzo: consumption of insufficiently processed "bitter" (cyanogenic) cassava

  spastic paraparesis: sudden and symmetrical affecting the legs more than the arms
- Leber hereditary optic atrophy: subacute visual failure affecting men
- Thyroid disorders: goiters,

  hypothyroidism

Figure 4. Children with konzo in a rural area of Mozambique
(ที่มาของรูป ไม่ระบุรายละเอียด).
doi:10.1371/journal.pntd.0001051.g004

H_2S

- Colorless, more dense than air, “rotten eggs”

- Bacterial decomposition of proteins
- Decay of the sulfur-containing products e.g. fish, sewage, manure
- Industrial sources: e.g. pulp paper mills, heavy-water production, the leather industry, roofing asphalt tanks, vulcanizing of rubber, oil/gas production
- Natural sources: volcanoes, caves, sulfur springs, underground deposits

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คนงานหมดสติคาบ่อหมักเยื่อกระดาษ ดับแล้ว 1 อีก 5 น่าห่วง

By TNA | 18 เม.ย. 2554 19:42 | 62 views | View Comment

ปทุมธานี 18 เม.ย.- พ.ต.ท.ชินกฤช ธิวงศ์คำ สารวัตรเวรสอบสวน สภ.ปากคลองรังสิต อ.เมือง จ.ปทุมธานี รับแจ้งเมื่อเวลา 15.30 น. วันนี้ (18 เม.ย.) มีเหตุคนงานโรงงานกระดาษในพื้นที่ ม.1 ต.บ้านใหม่ อ.เมือง หมดสติอยู่ในบ่อต้มเยื่อกระดาษ 6 ราย จึงประสานรถกู้ชีพโรงพยาบาลกรุงสยามเซ็นต์คาร์ลอส และโรงพยาบาลกรุงไทย เข้าช่วยเหลือนำคนงานขึ้นจากบ่อหมักและรีบนำส่งโรงพยาบาลทั้งสองแห่ง คือ นายปราโมท พูลศรี อายุ 32 ปี นายปาน กระสิริ อายุ 37 ปี นายอภิวัฒน์ ภาคลำเจียก อายุ 21 ปี นายอำนาจ เอมจิต นายมนูญศักดิ์ ปรามนอก และนายชาญยุทธ เจียมจำรัส ล่าสุดนายชาญยุทธ ได้เสียชีวิตในเวลาต่อมา ซึ่งขณะนี้อีก 5 คน ยังน่าเป็นห่วง และต้องใช้เครื่องช่วยหายใจ เนื่องจากขาดอากาศหายใจเวลานาน ต้องรอดูอาการว่าจะกลับมาเป็นปกติหรือไม่

ทั้งนี้ โรงงานกระดาษดังกล่าวได้ปิดทำการช่วงสงกรานต์ตั้งแต่วันที่ 11 เม.ย. และเพิ่งเปิดทำงานในวันนี้ โดยก่อนเกิดเหตุคนงานได้ลงไปดูแลความเรียบร้อยในบ่อหมักเยื่อกระดาษ เพื่อเดินเครื่องทำงาน แล้วเกิดหมดสติพร้อมกัน 6 คน.-สำนักข่าวไทย

Tags: หมดสติคาบ่อหมักเยื่อกระดาษ คนงานโรงงานกระดาษปทุมธานี

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When to suspect hydrogen sulfide poisoning

- Person rapidly loses consciousness ("knocked down")
- Rotten eggs odor
- Rescue from enclosed space, such as sewer or manure pit
- Multiple victims with sudden death syndrome
- Collapse of a previously healthy worker at work site

Goldfrank 11th ed

H_2S

- Delayed pulmonary edema and corneal injury
- Delayed neuropsychiatric sequelae

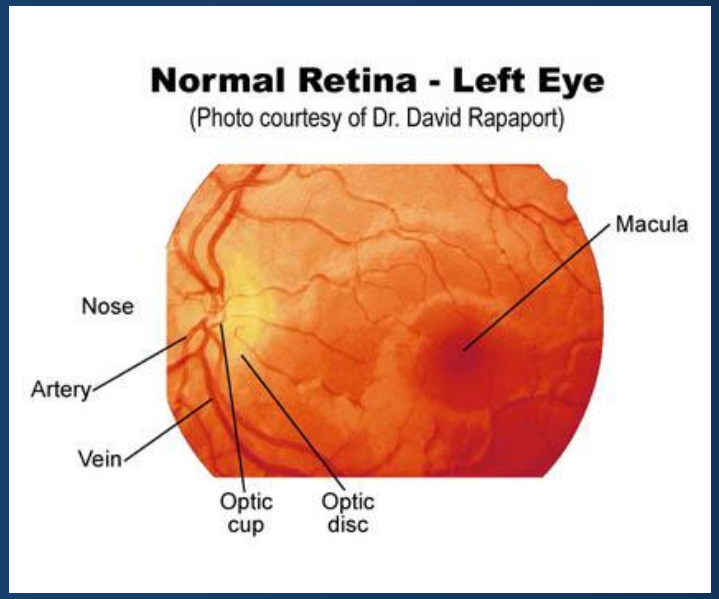
Chronic manifestations

- Mucous membrane irritation: the most prominent problem

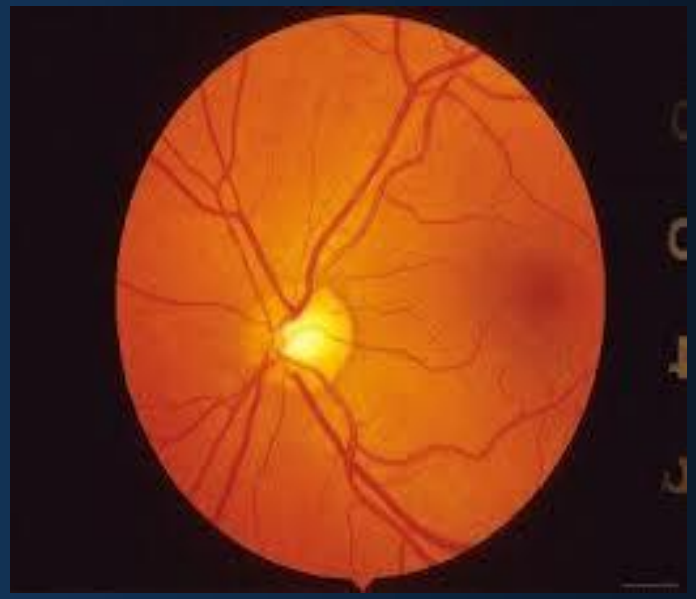
Diagnosis

Physical examination:

Eye ground: Color of retinal vein compares with retinal artery



A Practical Guide to Clinical Medicine, meded.ucsd.edu



Flashcards - Opthalmology - | StudyBlue www.studyblue.com

Cyanide

- Sudden (very rapid) onset of hypoxia

  Ingested Salts -> Symptoms within minutes

  Except: cyanogenic chemicals & glycoside ingestion
- NOT cyanosed
- SaO2, SpO2: normal
- Severe clinical of hypoxia
- Severe metabolic acidosis

H_2S

- Smell of rotten eggs, darkening of silver jewelry
- Rapidly loses consciousness "knocked down"

Physical examination:

- **Eye ground:** Color of retinal vein compares with artery

Laboratory

- Electrolyte: High gap metabolic acidosis, ↓HCO_3

  ABG: Low pH, Normal PaO_2
- Serum lactate
- Central venous blood gas for AV O_2 difference

  Decreased measured arterial-mixed venous oxygen difference
- Cyanide: Whole-blood cyanide concentration (for confirmation), toxic >0.5 mg/mL

  Serum, urinary thiocyanate: marker of CN exposure
- H_2S: paper impregnated with lead acetate changes color

  Serum, urinary thiosulfate: H_2S exposure
- Glucose, renal, ECG

Management

Supportive care

Prehospital

- PPE
- Administer 100% oxygen
- Evaluate for traumatic injuries
- Apply ACLS protocols as indicated

Emergency Room

- Control airway, ventilate, 100% oxygen
- Crystalloids and vasopressors for hypotension
- $NaHCO_3$; titrate according to blood gas analysis and serum HCO_3
- Control seizure

Cyanide

Antidotes: Emergency

Toxicity: Carbon Monoxide, Digoxin, and Cyanide

Recommendations for Carbon Monoxide, Digoxin, and Cyanide Poisoning

COR	LOE	Recommendations
1	B-R	1. Antidigoxin Fab antibodies should be administered to patients with severe cardiac glycoside toxicity.
2b	B-R	2. Hyperbaric oxygen therapy may be helpful in the treatment of acute carbon monoxide poisoning in patients with severe toxicity.
2a	C-LD	3. Hydroxocobalamin and 100% oxygen, with or without sodium thiosulfate, can be beneficial for cyanide poisoning.

Circulation

Part 3: Adult Basic and Advanced Life Support

2020 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

Several studies: patients with known or suspected cyanide toxicity presenting with cardiovascular instability or cardiac arrest who undergo prompt treatment with IV hydroxocobalamin, a cyanide scavenger can have reversal of life-threatening toxicity

https://www.ahajournals.org/doi/pdf/10.1161/CIR.0000000000000916

Cyanide

Decontamination

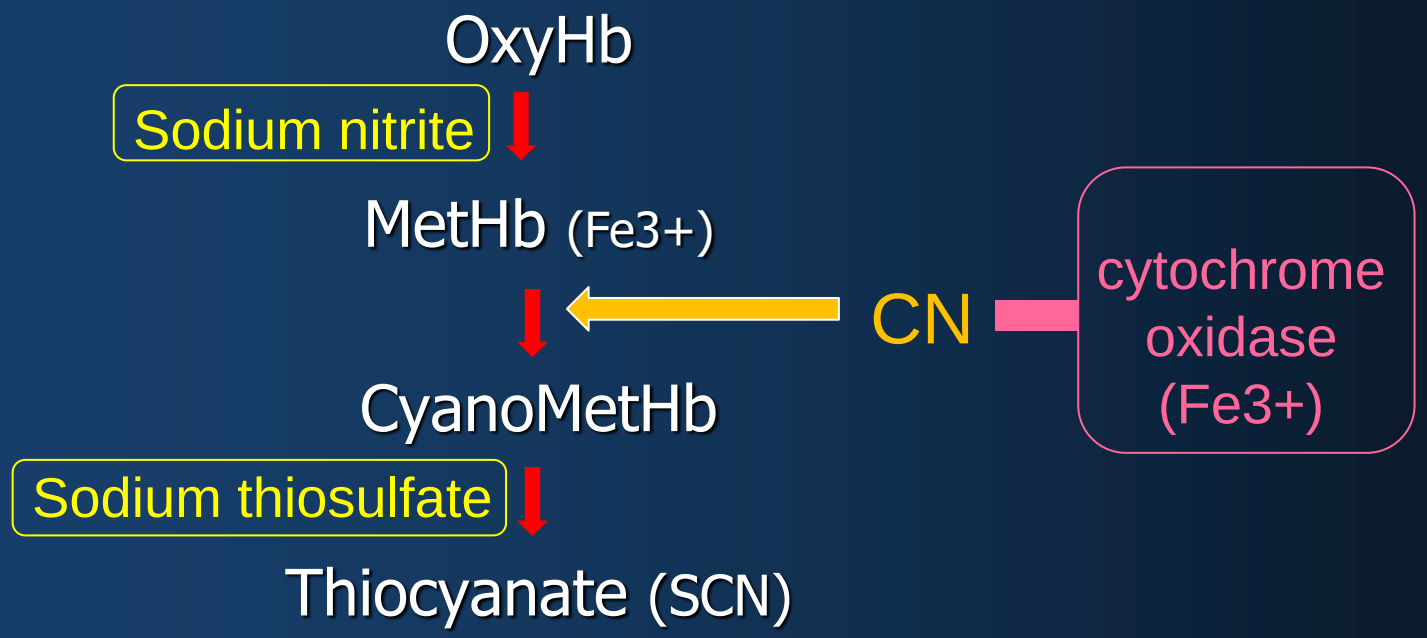
- Protect healthcare providers from contamination
- Immediate removal from the contaminated area
- Cutaneous: Carefully remove all clothing and flush the skin

- Ingestion: Cyanogenic glycoside

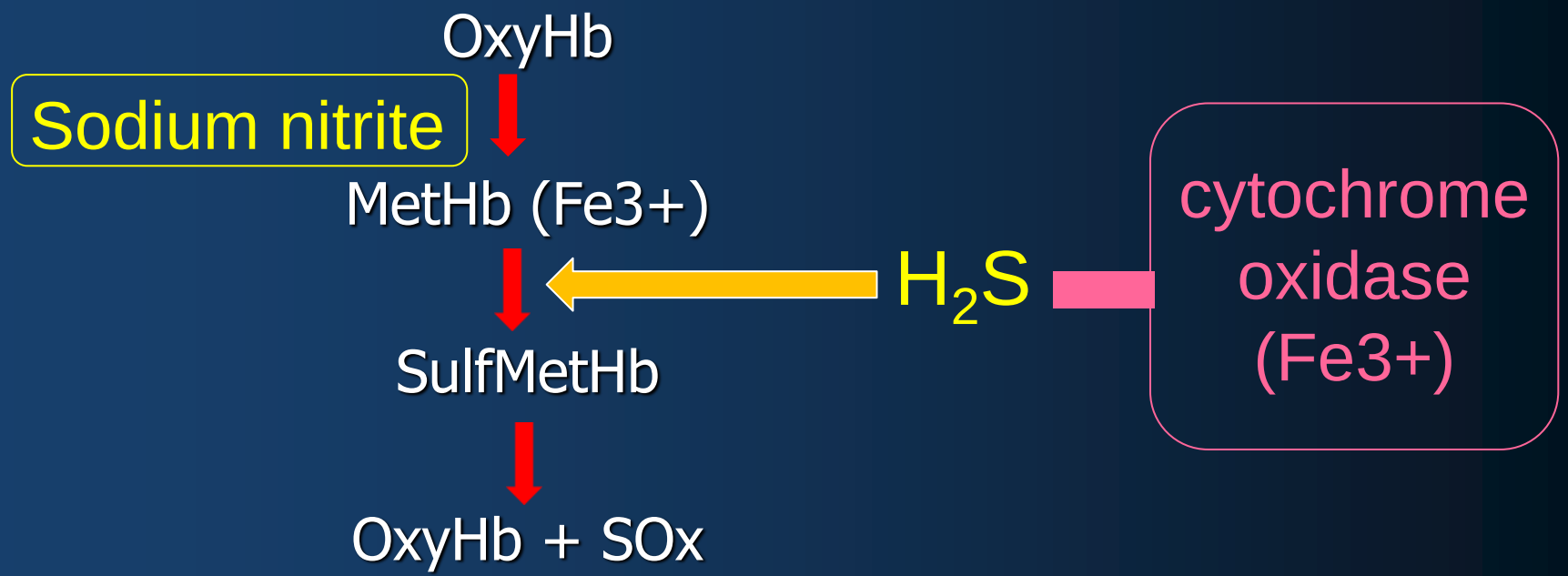
Oro- or nasogastric lavage and activated charcoal if protected airway, no contraindication

Cyanide & H_2S antidotes

- Amyl nitrite
- **3% Sodium nitrite**
- **25% Sodium thiosulfate**
- Hydroxocobalamin



- Thiosulfate donates the sulfur atoms necessary for rhodanese-mediated CN biotransformation to thiocyanate


OxyHb
Sodium nitrite
MetHb (Fe3+)
H2S
cytochrome oxidase (Fe3+)
SulfMetHb
OxyHb + SOx

3% Sodium nitrite (10 ml: 30 mg/cc)

Uses:

- Cyanide poisoning (together with sodium thiosulfate)
- H_2S poisoning (altered mental status, coma, hypo tension, or dysrhythmias, within 30 minutes)

Contraindication:

- Allergy to drugs
- Signifcant preexisting methemoglobinemia (>40%)
- Severe hypotension (relative)
- Concurrent carbon monoxide poisoning (relative)

Adverse effects:

- Methemoglobinemia
- Transient hypotension (vasodilators)
- Headache, tachycardia, palpitations, dysrhythmias, blurred vision, nausea, vomiting, facial fushing, dizziness

FDA Pregnancy Category: C

3% Sodium nitrite (10 ml: 30 mg/cc)

- Dose:

  Adults: 300 mg IV over 3-5 minutes

  further dose of 150 mg after 30 minutes if symptoms recur

  Children: 6 mg/kg or 0.2 ml/kg (max 300 mg) over 3-5 min

  Dose adjustment: according to Hemoglobin

- Monitor blood pressure frequently
- Treat hypotension by slowing the infusion rate and giving crystalloids and vasopressors
- Obtain methemoglobin level 30 minutes after dose

25% Sodium thiosulfate (50 ml: 250 mg/cc)

Uses:

- Cyanide poisoning
- Prophylaxis during sodium nitroprusside infusion

Contraindication:

- No known contraindications

Adverse effects:

- Burning sensation (IV) infusion
- Muscle cramping & twitching
- Nausea/ vomiting
- Hypotension

FDA Pregnancy Category: C

25% Sodium thiosulfate (50 ml: 250 mg/cc)

- **Dose:**

  Adults: 12.5 g (50 ml) IV 10 min

  further dose of 6.25 g after 30 minutes if symptoms recur

  Children: 400 mg/kg (1.6 ml/kg) iv 10 min (max 12.5gm)

Known or suspected cyanide poisoning

Antidotes(if available)

Sodium nitrite (3%; 30 mg/ml)

- Adult : 300 mg IV over 2 - 4 mins
- Child : 6 mg/kg or 0.2 ml/kg (maximum 300 mg) IV over 2 - 4 mins* (adjust according to Hb)

Sodium thiosulfate (25%; 250 mg/ml)

- Adult : 12.5 g IV over 5 - 10 mins
- Child : 400 mg/kg (1.65 ml/kg) (maximum 12.5 g) IV over 5 - 10 mins

Contraindication : known allergy to drugs

- Protect airway and provide adequate ventilation with 100% Oxygen
- Crystalloid and vasopressor for hypotension
- Benzodiazepine IV for seizure
- Decontamination*
- V/S and ECG monitoring

- CBC/Hb, Electrolytes, ABG, VBG, lactate
- Blood sugar/POCT glucose
- 12-lead ECG
- Whole blood cyanide level
- Other investigations as indicated

- $NaHCO_3$ IV titrate according to ABG or HCO_3
- Give 1 additional half the initial dose of both antidotes if signs of CN poisoning persist for 30 minutes **OR** recur after 30 minutes.

Forms of cyanide and suggested antidotes

HCN i.e. housefire, factory
- Onset : seconds
- Housefire : thiosulfate alone
- Non-fire incidence : nitrite and thiosulfate

Salt CN solution i.e. NaCN, KCN
- Onset : minutes
- Nitrite and thiosulfate

Cyanogenic glycoside i.e. cassava
- Onset : hours
- Nitrite and thiosulfate

Acetonitrile
- Onset : hours to days
- Nitrite and thiosulfate

Pediatric Sodium Nitrite Guidelines

Hb (g)	NaNO2 (mg/kg)	3% NaNO2 sol. (mL/kg)
7.0	5.8	0.19
8.0	6.6	0.22
9.0	7.5	0.25
10.0	8.3	0.27
11.0	9.1	0.30
12.0	10.0	0.33
13.0	10.8	0.36
14.0	11.6	0.39

Adapted from Berlin CM: The treatment of cyanide poisoning in children. *Pediatrics.* 1970;46:793–796.

Decontamination

- Protect health care provider from secondary contamination
- For dermal exposure : carefully remove all contaminated clothing and flush the skin
- For ingestion : lavage, activated charcoal (within 1 hour for salt CN, or 4 hours for cyanogenic glycoside) if no contraindications

Sodium thiosulfate: single agent

- Smoke inhalation

  Nitrites have a more detrimental side: methemoglobinemia,

  concern in the presence of tissue hypoxia from CO, lung injury, or other factors, rapid infusion causes hypotension secondary to vasodilation

  Patients with GCS score <10, signs of end-organ damage (i.e., cardiac arrest, seizures) should be empirically treated thiosulfate

- Prophylaxis during sodium nitroprusside infusion
- Moderate toxicity:

  e.g. recovered from a period of unconsciousness, convulsions

- Presume diagnosis of cyanide poisoning

Hydroxocobalamin (vitamin B12a)

- A metalloprotein with a cobalt center that binds cyanide, removing it from cytochrome oxidase and forming cyanocobalamin
- Dose:

  Adults: 5 g IV over 15 min

  If needed, may repeat 5 g for a total of 10 g

  Children: 70 mg/kg (maximum, 5 g) IV over 15 min. If needed, may repeat
- Low toxicity profile
- Adverse effects: transient hypertension, reddish discoloration of the skin, mucous membranes, anaphylactic reactions

Cyanide

- Cyanide salts → rapid onset
- Cyanogenic chemicals, glycosides → delayed onset

- Severe clinical of hypoxia: coma
- Severe metabolic acidosis
- Not cyanosed
- SaO2, SpO2: normal
- Metabolic acidosis, high lactate

- Treatment: antidote, supportive Rx

H_2S

- Irritant: Conjunctivitis
- Rapidly loses consciousness ("knocked down")
- SaO2, SpO2: normal
- Severe clinical of hypoxia
- Severe metabolic acidosis
- Metabolic acidosis, high lactate
- Treatment: antidote (early) + supportive Rx

Follow up Case 1

- Lab แรกรับ Na=144 K=4.1 Cl=100 CO2=13 AG =31
- แพทย์ให้ 3% Na nitrite 10 ml + 25% Na thiosulfate 50 ml
- หลังให้ vital sign: BP= 100/60 mmHg, PR=90/min RR 20/min

  on respirator FiO2 0.6 CMV mode RR 16/min

  F/U ABG pH = 7.5 pCO2= 25 pO2= 172 O_2SAt 99%

  ผู้ป่วยรู้สึกตัวดีตลอด
- blood CYANIDE level = 0.71 mcg/ml.

Follow up case 2

- NaHCO3
- Cyanide antidote
- CN level ในน้ำดื่ม, gastric content +ve
- Blood CN: 3.59 mcg/ml (< 1 mcg/ml)

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iCAPS Project

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Thank you for your attention

Question?