

Target Audience: Emergency Medicine Residents, Medical Students

Primary Learning Objectives:

1. Recognize signs and symptoms of symptomatic bradycardia from toxicologic etiologies such as Beta Blocker and Calcium Channel Blocker Overdoses
2. Perform appropriate gastric decontamination/enhanced elimination
3. Describe techniques for treating bradycardia
4. Discuss potential complications of mechanical ventilation
5. Describe the role and evidence-basis for pharmacologic interventions used in the management of patients with symptomatic bradycardia from toxicologic etiologies
6. Order appropriate diagnostic (laboratory, radiology, etc.) studies patients with symptomatic bradycardia from toxicologic etiologies

Secondary Learning Objectives: detailed technical/behavioral goals, didactic points

1. Obtain psychiatric evaluation for suicidal patients
2. Develop independent differential diagnosis in setting of leading information from RN
3. Describe importance of obtaining POC blood glucose in setting of BB/CCB overdose
4. Describe role of High Dose Insulin Euglycemia vs. pressors in BB/CCB overdose
5. Describe role of WBI and MDAC in gastric decontamination of BB/CCB overdose

Critical actions checklist:

1. Intubate patient and consider potential problems with mechanical ventilation
2. Perform gastric decontamination with AC – (May consider multi-dose activated charcoal. WBI is optional.)
3. Order ASA/APAP level, POC glucose and basic metabolic panel
4. Volume resuscitate with NS or LR at least 3L
5. Give High Dose Insulin & glucose, Atropine, Glucagon, Calcium, and pressors
6. Consult Poison Center

Environment:

1. Room Set Up – ED non-critical care area
 - a. Manikin Set Up – Mid or high fidelity simulator, simulated sweat
 - b. Props – Standard ED equipment

For Examiner Only

CASE SUMMARY

SYNOPSIS OF HISTORY/ Scenario Background

The setting is an urban emergency department.

Patient is a 22-year-old female with a history of migraine, depression/anxiety, and ADHD brought to the emergency department by EMS for altered mental status, seizure, and rapid respirations. The patient's father said she is always anxious, has recently been depressed, but is not aware of any suicidal ideations.

PMHx: Migraine, depression/anxiety, and ADHD

PSHx: Tonsillectomy

Medications: Alprazolam, Verapamil, Adderall, Sertraline

Allergies: NKDA

SocHx: Binge alcohol use; tobacco, marijuana; lives alone in own apartment

[Patient has a verapamil overdose, is lethargic, and has seized/may seize again. She is triaged to the critical care area.]

SYNOPSIS OF PHYSICAL

Patient is initially obtunded, bradycardic.

Airway is intact.

Lips are blue.

Breath sounds are present, even and unlabored.

Cardiac pulses are bradycardic, weak and thready.

Neurologic exam is non focal. She is obtunded. Mental status is altered – moaning.

Skin is diaphoretic.

CRITICAL ACTIONS

1. Perform GI Decontamination

Perform gastric decontamination with activated charcoal if she takes it voluntarily, or wait until she is intubated (Lavage or whole bowel irrigation are optional and may help in severe overdoses involving extended-release preparations)

Cueing Guideline: The nurse asks if the doctor would like to place an NG tube.

2. Order Appropriate¹ Labs

Order appropriate labs. At a minimum, this must include a salicylate level, acetaminophen level, a point-of-care glucose, and a comprehensive metabolic panel.

Cueing Guideline: The nurse asks if the doctor would like any labs or any levels on the patient.

3. Initiate Volume Resuscitation

Give at least 3 liters of NS or LR for volume resuscitation.

Cueing Guideline: The nurse may say, “We have a line in place. Would you like any fluids?” Alternatively, the nurse can mention the hypotension. If not done the patient will become more hypotensive (BP drops to 65/33 and even lower).

4. Provide at least Two Pharmacologic Interventions for Symptomatic Bradycardia/Hypotension

Provide at least 2 pharmacologic interventions for symptomatic bradycardia. These “rescue medications” should include 2 or more of the following: high-dose insulin/glucose (HIE² therapy), atropine, glucagon, calcium, pressors, intravenous lipid emulsion (ILE) therapy. Patient will have continued bradycardia and hypotension. If the patient is not treated, she will desaturate, become acidotic, apneic, seize, and die. If the patient is treated she will require repeated doses.

Cueing Guideline: Patient will have worsening bradycardia, hypotension, and the other symptoms (as noted above) if not treated. Nurse should provide additional prompts based on the above consequences.

5. Consult Poison Center (PC)

Consult PC. This may be important for learners discussing the need for pressors, HIE, and ILE.

Cueing Guideline: The nurse asks if the PC has been called yet **or** if the doctor wants the PC called. The nurse may also ask if there is anything more that can be done to optimize the patient’s vital signs or eliminate presumed toxins as the patient is so symptomatic.

6. Perform endotracheal intubation

Perform endotracheal intubation. Consider potential problems associated with endotracheal intubation in the toxicology/overdose patient, and specifically, in the patient with a calcium channel blocker overdose.

7. Admit to the intensive care unit

¹ See definition below for “appropriate”

² HIE, High-dose insulin euglycemia

Critical Actions Checklist³

Resident Name								
Case Description								
Skills measured <small>Core competencies: PC Patient care, MK Medical knowledge, IC Interpersonal and communication skills, P Professionalism, PB Practice-based learning and improvement, SB Systems-based practice</small>	Very Unacceptable		Unacceptable		Acceptable		Very Acceptable	
Data Acquisition (D) PC MK I	1	2	3	4	5	6	7	8
Problem Solving (S) PC MK PB	1	2	3	4	5	6	7	8
Patient Management (M) PC MK IC P PB SB	1	2	3	4	5	6	7	8
Resource Utilization (R) PC PB SB	1	2	3	4	5	6	7	8
Health Care Provided (H) PC SB	1	2	3	4	5	6	7	8
Interpersonal Relations (I) IC P	1	2	3	4	5	6	7	8
Comprehension of Pathophysiology (P) MK PB	1	2	3	4	5	6	7	8
Clinical Competence (C) PC MK IC P PB SB	1	2	3	4	5	6	7	8
Critical Actions								
Yes	No				Comments:			
		Perform GI decontamination						
		Order appropriate labs						
		Initiate volume resuscitation						
		Provide at least 2 pharmacologic interventions for symptomatic bradycardia/hypotension						
		Consult poison center						
		Perform endotracheal intubation			Yes	No		
		Admit to the intensive care unit					Dangerous actions	

³ Modified ABEM Oral Certification Examination checklist and scoresheet

For Examiner Only

HISTORY

You are called to see a new patient (22-year-old female) in the Critical Care area of the emergency department. You see a pale, diaphoretic female who is obtunded.

Onset of Symptoms: Today

Background Info: 22-year-old female is obtunded and not answering questions. The patient's father said he found her seizing and called EMS (seizure stopped just prior to EMS arrival).

Additional History

From EMS: If asked about the scene in the apartment they will describe a cluttered, small apartment. There were a few empty beer cans and a large empty bottle of verapamil. She vomited during transport.

From Father: He states that the patient has been anxious and depressed. She recently broke up with her boyfriend and has been under stress.

Chief Complaint: Altered mental status

Past Medical Hx: Migraine, depression/anxiety, and ADHD

Past Surgical Hx: Tonsillectomy

Habits: Smoking: Occasional
ETOH: Binge drinking
Drugs: Marijuana

Family Med Hx: Hypertension, diabetes

Social Hx: Marital Status: Single
Children: None
Education: Some college
Employment: Unemployed

ROS: Patient is unable to answer.

CASE CONTINUATION

Shortly after patient is triaged into the ED behavioral unit, the nurse requests a physician to bedside.

Vital Signs: BP: 63/33 mmHg P: 48/minute R: 20/minute T: 37C (98.6F) POx: 94%

Primary Survey

Airway – Patent

Breathing – Rapid and shallow, 94% POx

Circulation – Bradycardia (40's), SBP 60's

Disability – Patient is obtunded. Not answering questions. Airway is intact with preserved gag and cough reflex.

Exposure – No trauma, rash, drug patches. Patient is diaphoretic

Required Actions

- Establish safety net (IV, oxygen, cardiac monitor, two large bore IVs, draw blood for labs)
- A/B – Oxygen, prepare for endotracheal intubation
- C – cardiac monitor; 2L NS IV bolus for hypotension; ECG
- D – Point-of-care serum glucose = 289mg/dL; labs are sent

Branch Point

- **IF NO INTERVENTION OCCURS**, systolic BP drops to 40 (palp), patient remains unresponsive, but begins to seize again.

PHYSICAL EXAM

General Appearance: Pale, diaphoretic female. Unresponsive.

Vital Signs: BP: 63/33 mmHg P: 48/minute R: 20/minute T: 37C (98.6F) POx: 94%
(adjust vital signs if endotracheal intubation has occurred)

Head: Normal

Eyes: PERRL, pupils 2 mm bilaterally

Ears: TM's normal.

Mouth: Smells of alcohol, no trauma, cyanotic lips

Neck: No tenderness or deformity on exam, full range of motion

Skin: Moist skin/sweaty, no rashes, warm

Chest: Normal respiratory rate without any signs of distress (no retractions)

Lungs: Clear, equal bilaterally with rapid, shallow sounds

Heart: Bradycardic, S1 S2, no murmurs

Back: Normal

Abdomen: Soft, non-tender, no signs of trauma, no rebound/guarding, absent bowel sounds

Extremities: No signs of trauma, no edema, pulses are present

| **Genital:** _Digital vaginal exam negative for retained foreign body

| **Rectal:** _Normal tone, guaiac negative

Neurological: Non-focal exam, no clonus

Mental Status: Unable to assess due to AMS

Required Actions

- Further resuscitation with IV crystalloid fluids (target: 3 liters)
- May order portable CXR and KUB (to exclude signs of pulmonary edema or other acute pathology)
- May order non-contrast head CT but cannot obtain until patient is stabilized
- May place a Foley catheter (drain 300 mL of urine)
- May consider central-line, pressors, HIE, or ILE, but initial stabilization measures require completion first

CASE CONTINUATION

- SBP will progress toward stabilization (90+ mmHg) with interventions and

Branch Point

- **IF GOAL OF ADMINISTRATION OF 3L CRYSTALLOID FLUIDS IS NOT ACHIEVED, BP drops to 60's, and patient seizes.**

Required Actions

- Administer 2-3 50-mL ampules of 10% calcium gluconate or chloride
- Mix/order a pressor (norepinephrine preferred)
- Add 20-40 mEq/L KCl
- Patient continues to be obtunded, bradycardic, and hypotensive. Discussion of impending cardiac failure.
- **Order HIE. At faculty discretion, insert need for consultation/discussion with pharmacist.**
- ABG at that time shows **pH 7.39, pCO₂ 30 mm Hg, paO₂ 88 mm Hg, base deficit 11**

Branch Point

- **IF TEAM PROCEEDS WITH INTUBATION WITH ONLY PRESSORS FOR HYPOTENSION AND SYMPTOMATIC BRADYCARDIA**, nurse should provide prompt asking if other interventions should be considered
- **IF PATIENT DOES NOT RECEIVE HIGH-DOSE INSULIN AND GLUCOSE (HIE)**, patient seizes and dies.
- **IF PATIENT RECEIVES HIE**, the patient stabilizes. BP 90/60 mmHg, HR 70/minute.
- **IF SERIAL GLUCOSE LEVELS ARE NOT CHECKED**, patient seizes and dies.

Required Actions

- Intubate the patient using RSI.
- Call the Poison Center
- Consult Medical Toxicology
- Order HIE (**insulin IV bolus:** start at 1 unit/kg, then **insulin IV infusion:** 0.5-1 unit/kg/hour infusion; IV bolus of dextrose 50% (25 grams) with frequent point-of-care serum glucose checks

Branch Point

- **IF PATIENT DOES NOT RECEIVE HIGH-DOSE INSULIN AND GLUCOSE (HIE),** patient seizes and dies.
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- **IF SERIAL GLUCOSE LEVELS ARE NOT CHECKED,** patient seizes and dies.

Required Actions

- Need for additional central venous lines and for norepinephrine IV infusion as indicated
- Call ICU for admission

For Examiner Only

STIMULUS INVENTORY

- #1 Complete blood count
- #2 Basic metabolic panel
- #3 Liver function tests
- #4 Urinalysis
- #5 Arterial blood gas
- #6 Cardiac enzymes
- #7 Toxicology
- #8 CXR
- #9 CT Head
- #10 Abdominal X-ray
- #11 Initial point-of-care glucose
- #12 Repeat point-of-care glucose
- #13 ECG

LAB DATA & IMAGING RESULTS

Stimulus #1	
Complete Blood Count (CBC)	
WBC	14,500/mm ³
Hemoglobin	13.2 g/dL
Hematocrit	40%
Platelets	239,000/mm ³
Differential	
PMNLs	45%
Lymphocytes	55%
Monocytes	2%
Eosinophils	1%
Bands	1%

Stimulus #2	
Basic Metabolic Profile (BMP)	
Sodium	145 mEq/L
Potassium	3.6 mEq/L
Chloride	109 mEq/L
Bicarbonate	16 mEq/L
Glucose	277 mg/dL
BUN	17 mg/dL
Creatinine	1.1 mg/dL

Stimulus #3	
Liver Function Tests	
AST	49 U/L
ALT	32 U/L
Alk Phos	110 U/L
Total Bilirubin	1.2 mg/dL
Direct Bilirubin	0.2 mg/dL
Albumin	4.3 mg/dL

Stimulus #4	
Urinalysis	
Color	Yellow
Specific gravity	1.017
Glucose	Negative
Protein	Negative
Ketones	Negative
Leuk. esterase	Negative
Nitrite	Negative
WBC	3/hpf
RBC	2/hpf

Stimulus #5	
Arterial Blood Gas	
pH	7.39
pCO ₂	30 mm Hg
pO ₂	88 mm Hg
HCO ₃	16 mEq/L Base deficit: 11
SaO ₂	94%

Stimulus #6	
Cardiac enzymes	
Troponin	0.025 ng/mL

Stimulus #7	
Toxicology	
Salicylate	Undetectable
Acetaminophen	Undetectable
Ethanol	112 mg/dL

Stimulus #8	
CXR: normal	

Stimulus #9	
CT head: normal	

Stimulus #10	
AXR: normal	

Stimulus #11	
Initial point-of-care glucose	
Glucose	289 mg/dL

Stimulus #12	
Repeat point-of-care glucose	
Glucose	150 mg/dL

Stimulus #13	
ECG	
Sinus bradycardia. No T-wave or ST-segment elevation; no strain pattern	

Stimulus #1**Complete Blood Count (CBC)**

WBC	14,500/mm ³
Hemoglobin	13.2 g/dL
Hematocrit	40%
Platelets	239,000/mm ³

Differential

PMNLs	45%
Lymphocytes	55%
Monocytes	2%
Eosinophils	1%
Bands	1%

Stimulus #2**Basic Metabolic Profile (BMP)**

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Potassium	3.6 mEq/L
Chloride	109 mEq/L
Bicarbonate	16 mEq/L
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Stimulus #3**Liver Function Tests**

AST	49 U/L
ALT	32 U/L
Alk Phos	110 U/L
Total Bilirubin	1.2 mg/dL
Direct Bilirubin	0.2 mg/dL
Albumin	4 mg/dL
Protein	7 mg/dL

Stimulus #4**Urinalysis**

Color	Yellow
Specific gravity	1.017
Glucose	Negative
Protein	Negative
Ketones	Trace
Leuk. esterase	Negative
Nitrite	Negative
WBC	3/hpf
RBC	2/hpf

Stimulus #5

Cardiac enzymes

Troponin	0.025 ng/mL
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Stimulus #6

Toxicology

Salicylate	Undetectable
Acetaminophen	Undetectable
Ethanol	112 mg/dL

Stimulus #7

CXR: normal

Stimulus #8

Head CT: normal

Stimulus #9

AXR: normal

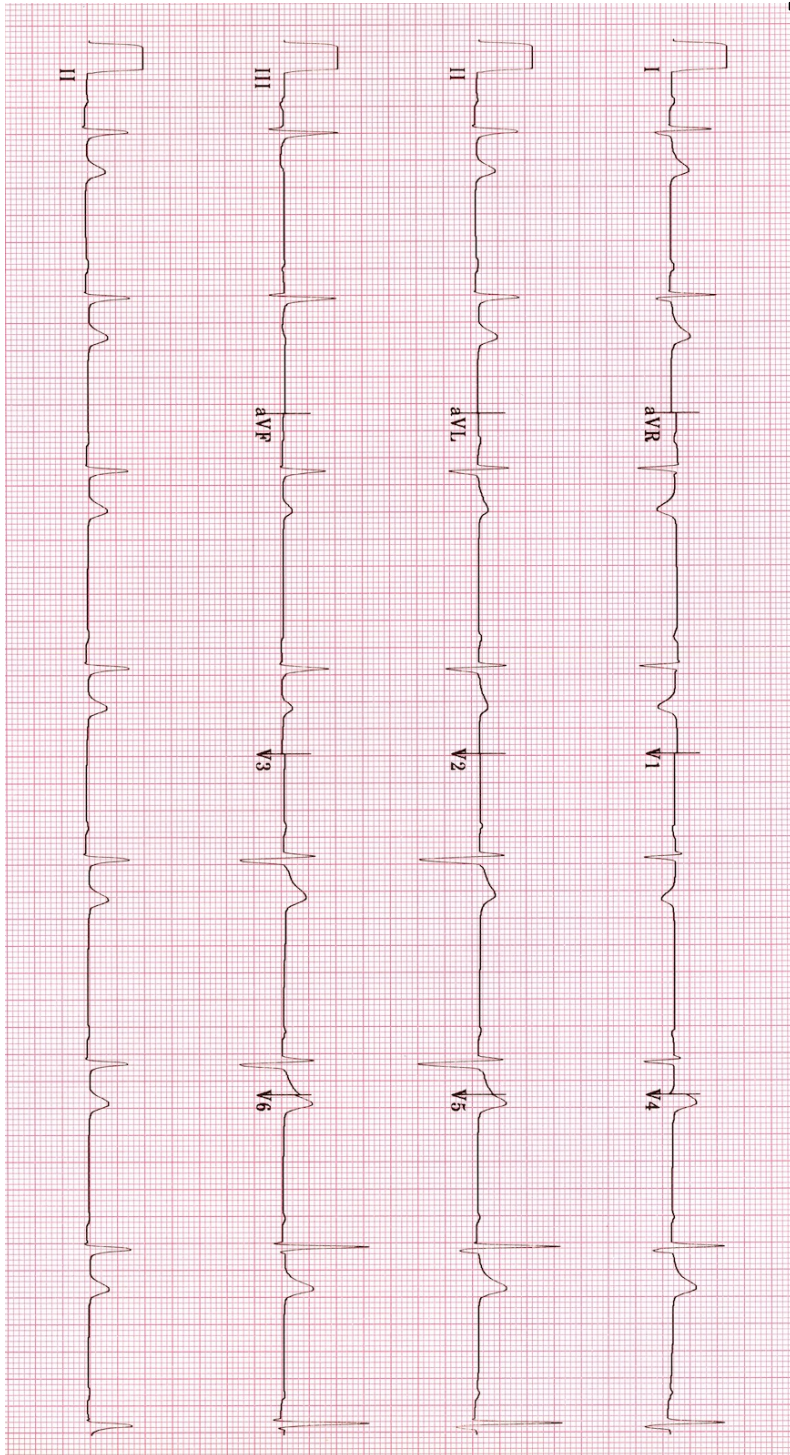
Stimulus #10

Initial point-of-care glucose	
Glucose	289 mg/dL

Stimulus #11

Repeat point-of-care glucose	
Glucose	150 mg/dL

Stimulus #12
ECG



Debriefing Materials – Calcium Channel Blocker Toxicity

Sources of Exposure:

- Calcium channel blockers are commonly prescribed antidysrhythmic medications. They have several off-label uses including migraine prophylaxis.

Pathophysiology:

- Calcium Channel Blockers decrease calcium entry through L-type cellular calcium channels, acting primarily on vascular smooth muscle and the heart.
- They cause coronary artery and peripheral vasodilation, reduced cardiac contractility, slowed atrioventricular nodal conduction, and depressed sinus node activity.
- These agents are metabolic poisons causing increased dependence of the heart on carbohydrate metabolism rather than the usual free fatty acids.

Severity of Ingestion:

- In acute overdose, mortality rate is high.
- Prognosis is worse for extended release preparations.

Organ System Effects:

- Cardiac:
 - The primary features of CCB intoxication are hypotension and bradycardia. Hypotension may be caused by peripheral vasodilation, reduced cardiac contractility, slowed heart rate, or a combination of all three. Bradycardia may result from sinus bradycardia, second- or third-degree AV block, or sinus arrest with junctional rhythm. Most CCB do not affect intraventricular conduction, so the QRS is usually not affected
- Neurologic:
 - Altered Mental Status: Stupor, confusion, and coma.
- Gastrointestinal:
 - Nausea and vomiting are the most common toxic effects.

Diagnostic Testing:

- Chemistry panel
 - Repeat as needed
- Blood Glucose Level
 - Every 30 minutes
- Urinalysis: Diltiazem and Verapamil may be detected on comprehensive urine drug screens.
- Monitor glucose levels closely. Initial hyperglycemia may give way to hypoglycemia.
- Obtain hepatic, hematologic, and coagulation profiles for patients with clinical evidence of moderate-to-severe toxicity.
- Chest x-ray is indicated if evidence of severe intoxication, pulmonary edema, or hypoxemia is present.
- Consider an abdominal x-ray if a CCB concretion/bezoar or SBO is suspected.

Treatment:

- Decontamination
 - Gastric lavage may be beneficial in severe, large volume overdose.
 - Oral activated charcoal, especially if the patient presents within one hour of ingestion.
 - Repeated doses of charcoal may enhance extended release preparation elimination and may shorten the serum half-life. However, calcium channel blockers can slow GI motility increasing the risk of obstruction and charcoal bezoar.
- Administer lactated Ringer or isotonic sodium chloride solution for volume expansion at 10-20 cc/kg/hr until a 1-1.5-cc/kg/h urine flow is established.
- Calcium reverses the depression of cardiac contractility in some patients, but it does not affect sinus node depression or peripheral vasodilation and has variable effects on AV nodal conduction. Administer calcium chloride 10%, 10 mL (0.1-0.2 mL/kg) IV, or calcium gluconate 10%, 20-30 mL (0.3-0.4 mL/kg) IV. Repeat every 5-10 minutes as needed. In case reports, doses as high as 10-15g over 1-2 hours and 30g over 12 hours have been administered without apparent calcium toxicity. Calcium chloride should be given only via central line or secure peripheral IV line owing to the potential for skin necrosis.
- Hyperinsulinemia/euglycemia (HIE) therapy is effective in animal models of severe intoxication and has been successful in multiple human case reports. The putative mechanism is correction of calcium antagonist-induced hypoinsulinemia, leading to improved cell carbohydrate metabolism, which in turn increases myocardial contractility. Like calcium, HIE treatment is not likely to reverse calcium antagonist-induced vasodilation, conduction block, or bradycardia.
 - A bolus of insulin, 0.5-1 U/kg, is followed by an infusion of 0.5-1 U/kg/h. To avoid hypoglycemia, the patient is given an initial bolus of glucose (25 or 50mL of D50) followed by additional boluses and infusion to maintain the serum glucose between 100 and 200 mg/dL.
 - Blood sugar levels should be checked every 30-60 minutes and hypokalemia might need correction.
- Intravenous lipid emulsion (ILE) therapy has shown promise in recent animal studies and a few case reports of severe verapamil poisoning. The usual dose is an IV bolus of 100mL (1.5 mL/kg) of ILE 20%, which can be repeated every 5-10 minutes for at least three doses. The bolus can be accompanied by a continuous infusion of the drug at 0.25 to 0.5 mL/kg/min for an hour.
- Epinephrine has both alpha-adrenergic and beta-adrenergic effects and may relieve hypotension and bradycardia. It can be started at 0.5 mg/h IV in adults.
- Glucagon is reported to increase blood pressure in patients with refractory hypotension and may also help with bradydysrhythmias. It can be started as a bolus in adults at 5mg, repeated in 10 minutes if no response, with caution for vomiting that may ensue.

Consultations:

- Consult the regional poison center or a local medical toxicologist for additional information and patient care recommendations.

Disposition:

- Admit patients with major signs and symptoms to an ICU.
- Consult psychiatric service personnel for stabilized patients with intentional overdose.
- Patients with accidental ingestions of less than 3 times their usual dose and no signs of toxicity can be discharged after 6 hours post ingestion. Extended relief preparations require 24hr observations.