Target Audience: Emergency Medicine Residents, Medical Students

Primary Learning Objectives:

1. Recognize signs and symptoms of hydrocarbon ingestions
2. Discuss the organ systems most affected by hydrocarbon ingestions
3. Describe role of decontamination after a hydrocarbon ingestion
4. Discuss the potential of a delayed pneumonitis after a hydrocarbon exposure
5. Recognize subtle worsening pediatric respiratory symptoms with serial exams
6. Consult with Poison Center/Toxicologist regarding specific product concerns
7. Support oxygenation and ventilation as necessary
8. Order appropriate imaging and laboratory studies
9. Discuss ED management of hydrocarbon ingestions

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

1. Discuss examples of common household products that contain potentially harmful hydrocarbons
2. Describe the chemical properties of a hydrocarbon that may predispose to pulmonary injury
3. Discuss how GI decontamination may be more harmful than beneficial
4. Identify limitations of radiographic imaging as a predictor of a clinical pneumonitis
5. Describe the differences in presentation and management for unintentional hydrocarbon ingestions compared to intentional hydrocarbon inhalation abuse
6. Describe the role of corticosteroids and antibiotics for a hydrocarbon pneumonitis

Critical actions checklist:

1. Order continuous cardiac monitor
2. Order continuous pulse oximetry
3. Avoid gastrointestinal decontamination
4. Consult Poison Center/Toxicologist
5. Administer supplemental oxygen
6. Obtain serial chest radiographs
7. Admit/transfer to the PICU for observation
8. Perform endotracheal intubation

Environment:

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

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CASE SUMMARY

SYNOPSIS OF HISTORY/ Scenario Background

This takes place in a community emergency department.

The patient is a 2-year-old male with a history of bronchiolitis who presents to the ED with his mother after ingesting “TIKI® torch fuel.” The patient’s mother reports they were having a birthday pool party in their backyard this afternoon when the patient was found drinking from a bottle of “TIKI® torch fuel.” She notes the patient gagged and was coughing for several minutes. She immediately drove him to the ED. He was napping peacefully in the car, and she feels he has now improved.

PMHx: Bronchiolitis at 11 months of age
PSHx: None
Medications: none
Allergies: NKDA
SocHx: Lives with both parents and a 5-year-old sister; No tobacco in the home

SYNOPSIS OF PHYSICAL

- Patient is initially well appearing. His vitals are significant for a high normal respiratory rate.
- He smells like gasoline.
- He is initially sleeping, but arouses with ease and is acting typical for age.
- His anterior or posterior oropharynx is clear; his lungs are clear.
- Skin is normal and without evidence of dermal exposure or burns.

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CRITICAL ACTIONS

1. **Order continuous cardiac monitoring**

   Order continuous cardiac monitoring, even for a seemingly asymptomatic patient.
   Cueing Guideline: The nurse can ask if the doctor would like to do anything to "keep an eye on the patient's status."

2. **Order continuous pulse oximetry**

   Order continuous pulse oximetry, even for a seemingly asymptomatic patient, and even if an initial CXR is normal.
   Cueing Guideline: The nurse can ask if the doctor would like to do anything to "keep an eye on the patient's status."

3. **Avoid gastrointestinal decontamination**

   Avoid gastrointestinal decontamination (may increase risk of aspiration). To meet this critical action, no induction of emesis, gastric lavage, or activated charcoal administration should be ordered or performed.
   Cueing Guideline: If the doctor orders one or more of these decontamination interventions, the nurse will ask "are you sure that this is safe?"

4. **Consult Poison Center/Toxicologist**

   Consult Poison Center/Toxicologist for specific product information and management considerations.
   Cueing Guideline: The nurse can ask if the doctor would like to consult the Poison Center or Toxicologist.

5. **Administer supplemental oxygen**

   Cueing Guideline: Nurse asks if the doctor would like to provide any interventions to this otherwise stable-appearing patient.

6. **Obtain a 6-hour chest radiograph**

   Obtain a 6-hour chest radiograph. One may be performed at the time of initial evaluation (although this is not critical), but another should be ordered six hours after exposure, even if the patient remains asymptomatic, and even if an initial chest radiograph has already been obtained.
   Cueing Guideline: The nurse can ask the doctor if there are any specific tests that should be repeated if the patient is to remain under observation or is admitted, and at what time these should be performed.

7. Admit/transfer to the PICU for observation

Admit/transfer to the PICU for observation, in adherence with institutional capabilities, policies, and procedures.
Cueing Guideline: The nurse can ask the doctor if the patient will be admitted, and to what service.

8. Perform endotracheal intubation

Perform endotracheal intubation. This may be needed if dangerous commissions are performed or ordered (e.g., discharge, attempts at gastrointestinal decontamination; see guidelines for case play).
Cueing Guideline: Nurse asks the doctor if he is concerned about this patient's airway given the patient's mental status.

Critical Actions Checklist[1]

Resident Name	
Case Description	

Skills measured **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	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:
		Order continuous cardiac monitoring	
		Order continuous pulse oximetry	
		Avoid gastrointestinal decontamination	
		Consult Poison Center/Toxicologist	
		Administer supplemental oxygen	
		Obtain a 6-hour chest radiograph	
		Admit/transfer to the PICU for observation	
		Protect the airway (perform endotracheal intubation)	

Yes	No	
		Dangerous actions

[1] Modified ABEM Oral Certification Examination checklist and scoresheet

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HISTORY

You are called to see a new patient (2-year-old male) in the pediatric area of the emergency department. You see a sleeping child on the gurney with his mother texting on her phone.

Onset of Symptoms: <1 hour ago

Background Info: The patient is a 2-year-old male with a history of bronchiolitis who presents to the ED with his mother after ingesting "TIKI® torch fuel." The patient's mother reports they were having a birthday pool party in their backyard this afternoon when the patient was found drinking from a bottle of "TIKI® torch fuel." She notes the patient gagged and was coughing for several minutes.

Additional History
From Mother: She immediately drove him to the ED. He was napping peacefully in the car, and she feels he has now improved and would like to take him home.

Chief Complaint: Chemical ingestion

Past Medical Hx: Bronchiolitis at 11 months of age

Past Surgical Hx: None

Family Hx: No pertinent history

Social Hx: Lives with both parents and a 5-year-old sister
No tobacco in the home

ROS: Gagging and coughing immediately after exposure, none since.

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INITIAL PHYSICAL EXAM

Vital Signs: BP: 100/65 mmHg P: 120/minute R: 40/minute T: 36.9C (98.4F)
POx: 97% (FiO_2=0.21) Weight: 14.9 kg

Primary Survey	
Airway:	Normal anterior and posterior oropharynx, no stridor.
Breathing:	Mild tachypnea, equal bilateral chest sounds.
Circulation:	Normal heart rate, 2+ peripheral pulses.
Disability:	Patient is initially sleeping, but awakens easily.
Exposure:	No dermal burns, rashes, or evidence of trauma.

General Appearance: Sleeping, well-developed and well-nourished toddler.

Head: Normal

Eyes: PERRL, pupils 3 mm

Ears: TM's normal.

Mouth: Lips, tongue and posterior oropharynx clear without lesions or foreign bodies; the faint smell of gas/petroleum is on the patient's breath.

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

Skin: Dry skin, no rashes, warm

Chest: Increased respiratory rate without any accessory muscle use

Lungs: Clear, equal bilaterally

Heart: Regular rate and rhythm, S1 S2, no murmurs

Back: Normal

Abdomen: Soft, non-tender, no rebound/guarding, normal BS

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

Genital: normal genitalia

Rectal: normal

Neurological: Non-focal exam

Mental Status: Easily awakens from sleep; guarded, but appropriately regards mother

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PLAY OF CASE GUIDELINES

The patient is a 2-year-old boy with a history of bronchiolitis who presents to the ED with his mother after ingesting "TIKI® torch fuel." The patient's mother reports they were having a birthday pool party in their backyard this afternoon when the patient was found drinking from a bottle of "TIKI® torch fuel." She notes the patient gagged and was coughing for several minutes.

1. The patient will arrive looking well (asymptomatic but sleeping). Mother will be insistent on wanting to leave as soon as possible.

2. Despite the patient's initial well-appearing appearance, the patient should be observed for several hours.

3. During the period of observation, the patient will deteriorate, warranting admission to the PICU or transfer. At faculty discretion, this deterioration could be severe (requiring endotracheal intubation) or mild-to-moderate (requiring supplemental oxygen).

4. The patient will deteriorate and require endotracheal intubation if interventions as noted in the critical actions are not performed or if dangerous commissions (e.g., discharge home, attempts at gastrointestinal decontamination) are performed.

Required Actions within the First Two Minutes

- Initial assessment and stabilization measures should be performed during this time
- Place on continuous pulse oximetry and cardiac monitor
- No gastrointestinal decontamination should be performed at this time
- A discussion with the mother explaining why she cannot yet take her child home may be required within this time period
- Consultation with the Poison Center or Toxicologist should be considered early in this case

Branch Points

- **IF ATTEMPTS AT GASTROINTESTINAL DECONTAMINATION ARE PERFORMED,** then the patient vomits and rapidly develops respiratory distress, requiring endotracheal intubation.
- **IF THE PATIENT IS DISCHARGED,** then the physician is notified that the patient developed respiratory distress several hours later at home and is returning to the ED by ambulance.
- **IF THE POISON CENTER OR TOXICOLOGIST IS CONSULTED,** the participant should receive the following information: "Tiki torch fuel/oil" is typically a distilled petroleum *hydrocarbon* product with fairly low viscosity and moderate volatility, similar to or sometimes including kerosene. It may also contain a benign mosquito repellent, such as citronella.

Required Actions over the Next Four Minutes

- Patient should be placed on continuous cardiac and respiratory monitoring by this time
- Diagnostics should be returned as ordered
- Toxicology consultation should have been considered by this time
- The treating team should decide to observe the patient for at least six hours post-ingestion.
- An initial CXR may have been ordered; if so, the results should be provided during this time period
- All other initial ED diagnostics, if ordered, should be provided at this time

Branch Points

- **IF THE PATIENT IS PLACED UNDER CONTINUOUS ED OBSERVATION,** then the patient will be noted to worsen over the period of observation, requiring admission or transfer (as per local institutional capabilities).

Required Actions over the Remainder of the Case
Branch Points

- During the observation period (or if the child is returning to the ED), the patient's respiratory
- **IF THE EVOLVING HYDROCARBON PNEUMONITIS IS NOT DETECTED BY THE TREATING TEAM,** then the patient will develop respiratory distress with hypoxia, requiring endotracheal intubation.
  - mild abdominal retractions
- The mother continues to request discharge paperwork.

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STIMULUS INVENTORY

#1	Complete blood count
#2	Basic metabolic panel
#3	Urinalysis
#4	Liver function tests
#5	Venous blood gas
#6	Point-of-care glucose
#7	Toxicology
#8	Initial CXR
#9	Repeat CXR
#10	ECG
#11	Lactate
#12	“TIKI® torch fuel” bottle or picture

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LAB DATA & IMAGING RESULTS

Stimulus #1	
Complete Blood Count (CBC)	
WBC	18,500/mm^3
Hemoglobin	13.2 g/dL
Hematocrit	40%
Platelets	219,000/mm^3
Differential	
PMNLs	70%
Lymphocytes	26%
Monocytes	2%
Eosinophils	1%

Stimulus #2	
Basic Metabolic Profile (BMP)	
Sodium	145mEq/L
Potassium	3.6mEq/L
Chloride	110 mEq/L
Bicarbonate	20 mEq/L
Glucose	129 mg/dL
BUN	8 mg/dL
Creatinine	0.4 mg/dL

Stimulus #3	
Urinalysis	
Color	Yellow
Specific gravity	1.030
Glucose	Negative
Protein	Negative
Ketones	Negative
Leuk. Esterase	Negative
Nitrites	Negative
WBC	0/hpf
RBC	0/hpf

Stimulus #4	
Liver Function Tests	
AST	23 U/L
ALT	21 U/L
Alk Phos	110 U/L
Total Bilirubin	1.2 mg/dL
Direct Bilirubin	0.2 mg/dL
Albumin	4.3 mg/dL
Protein	8 g/dL

Stimulus #5	
Venous Blood Gas	
pH	7.30
pCO_2	27 mm Hg
pO_2	40 mm Hg
HCO_3 base deficit	16 mEq/L 9

Stimulus #6	
Point-of-care glucose	
Value	129 mg/dL

Stimulus #7	
Toxicology	
Salicylate	< 2.5 mg/dL
Acetaminophen	< 10 mcg/mL
Ethanol	< 10 mg/dL
Urine drug screen	
Amphetamines	Negative
Benzodiazepines	Negative
Cocaine	Negative
Opiates	Negative
TCAs	Negative
THC	Negative

Stimulus #8
CXR
Normal

Stimulus #9
Repeat CXR
Bilateral infiltrates

Stimulus #10	
ECG	NSR

Stimulus #11	
Lactate	1.8 mmol/L

Stimulus #12
Visual stimulus of torch fuel

Stimulus #1

Complete Blood Count (CBC)

WBC	18,500/mm^3
Hemoglobin	13.2 g/dL
Hematocrit	40%
Platelets	219,000/mm^3
Differential	
PMNLs	70%
Lymphocytes	26%
Monocytes	2%
Eosinophils	1%

Stimulus #2

Basic Metabolic Profile (BMP)

Sodium	145mEq/L
Potassium	3.6mEq/L
Chloride	110 mEq/L
Bicarbonate	20 mEq/L
Glucose	129 mg/dL
BUN	8 mg/dL
Creatinine	0.4 mg/dL

Stimulus #3

Urinalysis

Color	Yellow
Specific gravity	1.030
Glucose	Negative
Protein	Negative
Ketones	Negative
Leuk. Esterase	Negative
Nitrites	Negative
WBC	0/hpf
RBC	0/hpf

Stimulus #4

Liver Function Tests

AST	23 U/L
ALT	21 U/L
Alk Phos	110 U/L
Total Bilirubin	1.2 mg/dL
Direct Bilirubin	0.2 mg/dL
Albumin	4.3 mg/dL
Protein	8 g/dL

Stimulus #5

Venous Blood Gas

pH	7.30
pCO_2	27 mm Hg
pO_2	40 mm Hg
HCO_3 base deficit	16 mEq/L 9

Stimulus #6

Point-of-care glucose

Value	129 mg/dL

Stimulus #7

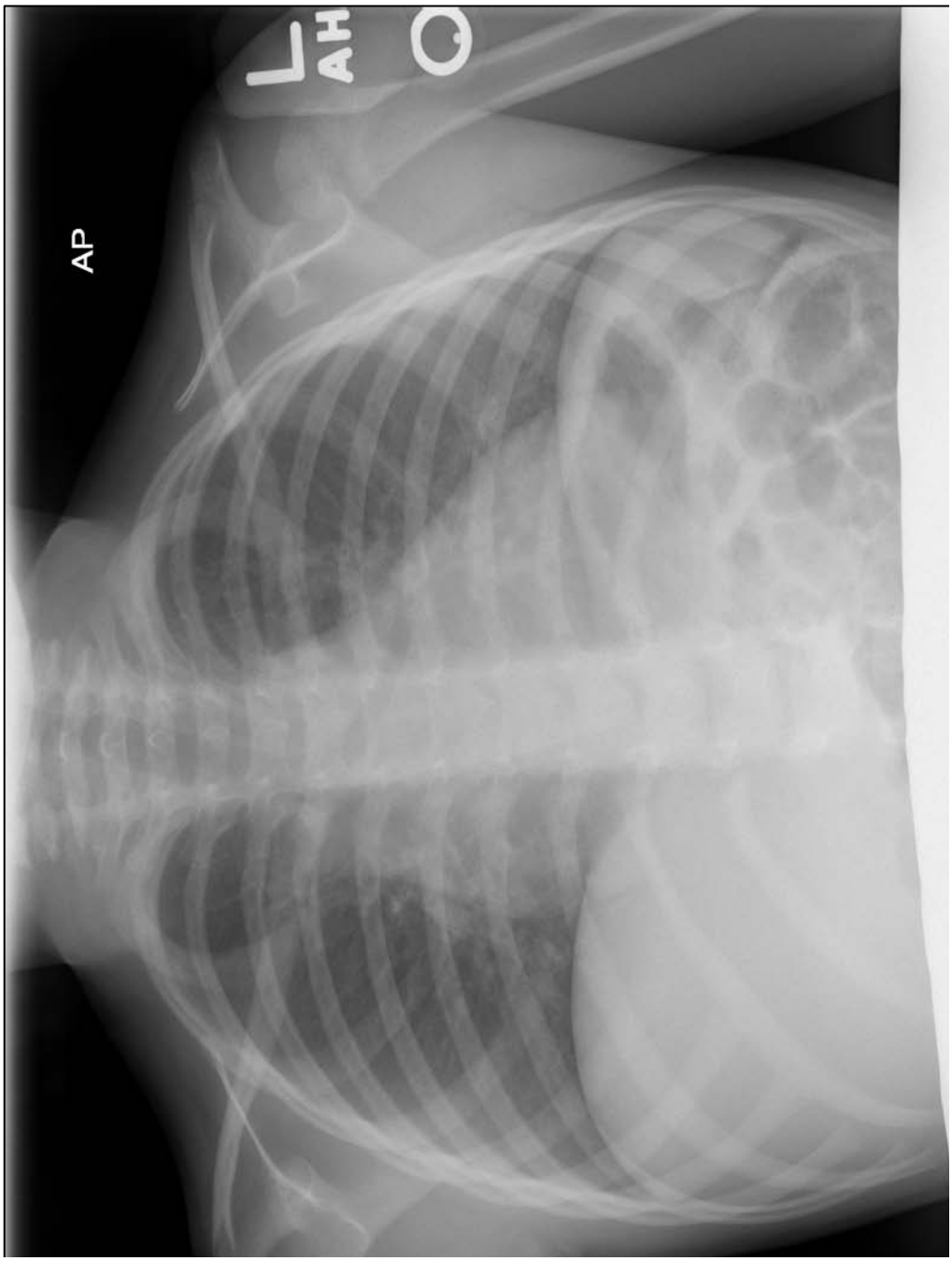
Toxicology

Salicylate	< 4 mg/dL
Acetaminophen	< 10 mcg/mL
Ethanol	< 10 mg/dL

Urine drug screen

Amphetamines	Negative
Benzodiazepines	Negative
Cocaine	Negative
Opiates	Negative
TCAs	Negative
THC	Negative

Stimulus #8



Stimulus #9

Stimulus #10
Source: *http://dontforgetthebubbles.com/ecg-quiz/*

Stimulus #11

Lactate	1.8 mmol/L

Stimulus #12


AMERICA'S #1
TORCH FUEL
TIKI
Paradise In Your Backyard
CITRONELLA SCENTED
TORCH FUEL
With Lemongrass Oil
DANGER
HARMFUL OR FATAL IF SWALLOWED. COMBUSTIBLE.
Read back panel carefully.
PELIGRO
ES NOCIVO O LETAL SI SE INGIERE. INFLAMABLE.
Lea detenidamente el panel posterior.

Debriefing Materials: Hydrocarbon ingestion

Sources of Exposure:

- Hydrocarbons are ubiquitous in both the home and in industrial settings. They are used as fuels, solvents, degreasers, propellants, and refrigerants.
- There is significant chemical diversity within the category of hydrocarbons. Even common products, such as gasoline and lamp oil, are actually a mixture of several petroleum-derived chemicals. As a result, general features of most hydrocarbon products are used to predict toxicity with a few specific exceptions.
- Children under the age of 6 years are especially vulnerable to accidental household hydrocarbon ingestions. Teenagers and adults are more likely to encounter hydrocarbons via accidental inhalational or dermal exposure in an occupational setting or intentionally via abuse (huffing, bagging, etc.).
- The packaging and presentation of hydrocarbon products may appear similar to juice or other tempting items to children. Even the ingestion of a small volume of these products can result in significant pulmonary toxicity if the hydrocarbon has risky physical properties (low viscosity, high volatility) or if the patient gags or vomits after ingestion.

Pathophysiology:

- Hydrocarbons are directly toxic to type II pneumocytes and disrupt surfactant, leading to pulmonary toxicity in the form of a chemical pneumonitis.
- All hydrocarbons, but especially halogenated hydrocarbons (found in propellants and refrigerants [e.g., Freon]), can cause cardiac dysrhythmias via myocardial sensitization.
- Hydrocarbons may cause CNS depression via a simple asphyxiant effect (displacing oxygen).

Severity of Toxicity:

- Depends on:
    - the amount ingested
    - if the patient coughed, gagged, or vomited after ingestion
    - the physical properties of the hydrocarbon product
- Hydrocarbons with low viscosity, high volatility, and low surface tension have a higher tendency for aspiration and therefore are more likely to result in pulmonary toxicity.
- The initial physical exam may be falsely reassuring with only mild tachypnea or cough.
- Imaging is often not reliable in excluding the development of a hydrocarbon pneumonitis. Chest radiographs immediately after ingestion are not useful, as they do not correlate with the risk or severity of a hydrocarbon pneumonitis even in symptomatic patients.
- Hydrocarbon pneumonitis ranges from mild dyspnea to fulminant ARDS and death. Patients typically recover within several days to weeks.
- Radiographs do not correlate well with clinical recovery, and infiltrates may persist on CXR even after symptoms resolve.

Diagnostic Testing:

- A thorough respiratory system exam and pulse oximetry evaluation.
- Serial exams to monitor for the development of delayed symptoms.
- Chest x-rays:
    - An initial CXR may be falsely reassuring, and thus is not necessary in asymptomatic patients.

    - A CXR after 6 hours of observation is more likely to detect subtle abnormalities that would suggest the patient is at risk for a delayed hydrocarbon pneumonitis.
- Laboratory tests and an ECG can be performed depending on the situation and severity of patient illness.

Treatment:

- Respiratory support with supplemental oxygen or endotracheal intubation.
- Inducing emesis, performing gastric lavage, or placing nasopharyngeal tubes can contribute to increased pulmonary exposure via aspiration or by facilitating hydrocarbon "creep" from the esophagus into the lungs.
- Activated charcoal does not adsorb hydrocarbons and may increase the risk of vomiting and aspiration.
- Steroids and antibiotics have not been clearly shown to be beneficial.
- Cardiac dysrhythmias due to myocardial sensitization should be treated with beta-blockers (e.g., esmolol) and/or Class Ib antidysrhythmics (lidocaine). Epinephrine and defibrillation or electrical pacing should be avoided if possible.

Consultations:

- Consult the regional poison center or a local medical toxicologist for additional information and patient care recommendations.
- Consult a PICU or pediatric hospital for admission/transfer and assistance with airway management.

Disposition:

- Patients who develop respiratory symptoms or who have radiographic abnormalities on their 6-hour CXR should be admitted.
- Mildly symptomatic patients or asymptomatic patients with abnormal radiographic findings can be admitted to a medical/surgical floor bed with pulse oximetry. Patients with moderate or severe symptoms should be admitted to a PICU.

Take-Home Points:

- Hydrocarbons are found throughout the home and occupational settings.
- Ingestions may be accidental or intentional. Unintentional ingestions are more common in patients < 6 years of age.
- Hydrocarbons with low viscosity, high volatility, and low surface tension have a higher tendency for aspiration and pulmonary toxicity.
- Radiographic imaging does not correlate with the severity of pulmonary toxicity.
- Asymptomatic patients should be monitored for a minimum of 6 hours after ingestion.
- Consult the Poison Control Center or Toxicologist for guidance on properties of the specific chemical ingested and appropriate management.

References:

Jolliff HA, Fletcher E, Roberts KJ, Baker SD, McKenzie LB. Pediatric Hydrocarbon-Related Injuries in the United States: 2000-2009. Pediatrics. 2013;131;1139-1148; originally published online May 6, 2013; DOI: 10.1542/peds.2012-3913

Goldfrank, Lewis R. *Goldfrank's Toxicologic Emergencies*. New York: McGraw-Hill Medical Pub. Division, 2002. Tenth Edition. 106.5747-5786. Print.