Down on the Farm: Agricultural Illnesses and Injuries

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Objectives

Describe illnesses and injuries among farm workers who may present to the emergency department.

Discuss the incidence, diagnosis, and management of environmental exposures, vector-borne illnesses, toxicologic poisoning, and mechanical injuries that may occur among farm workers.

Identify social determinants of health that may affect the care and health of farm workers.

Patient demographics

Most commonly-injured individuals are white males (Damroth et al., 2019).

In a North Dakota study, 91.2% of tractor injuries were experienced by male patients (Gilblom et al., 2023).

53% of tractor injuries are patients aged 65 and older (Gilblom et al., 2023).

24.5% of all farm machinery injuries are related to maintenance (Gilblom et al., 2023).

50% of female patients were injured by machinery in the “other machinery” category (Gilblom et al., 2023).

Insecticides

Organophosphates

Non-organophosphates

Clinical diagnosis based on toxidrome and exposure history.

12-lead ECG to detect QT prolongation.

Decontamination of the patient.

Avoid bringing containers into the emergency department or transport vehicle.

Consult poison control.

Organophosphates

Organophosphates (e.g. diazinon, acephate, malathion, parathion, chlorpyrifos) may be absorbed by inhalation, ingestion, or dermal exposure.

Binding and inhibition of acetylcholinesterase, which causes excess accumulation of acetylcholine and stimulation of muscarinic and nicotine cholinergic receptors.

Serum cholinesterase can help in the confirmation of diagnosis.

Organophosphates

S - salivation

L - lacrimation

U – urinary incontinence

D - defecation

G – GI pain

E - emesis

D - defecation

U - urination

M – muscle weakness, miosis

B – bradycardia, bronchorrhea, bronchospasm

E - emesis

L - lacrimation

S - salivation

Organophosphates

Atropine 1 mg or more IV in adult patients, repeat every 5 minutes until secretions improve. 0.01 to 0.04 mg/kg (minimum 0.1 mg) in pediatric patients.

Pralidoxime 1 to 2 grams over 5 to 10 minutes with normal saline in adults. 20 to 40 mg/kg (maximum 1 gram) in pediatric patients over 5 to 10 minutes mixed in normal saline.

Treat seizures with benzodiazepines.

Non-organophosphates

Carbamates (e.g. carbaryl, pirimicarb, propoxur, trimethacarb)

- Similar presentation to organophosphates
- Cholinesterase levels may be decreased.
- Treat with atropine

Organochlorines (e.g. chlordane, heptachlor, dieldrin, aldrin)

- Presentation is neurological with excitability and possibly seizures
- Diagnosis by special lab test and history taking.
- Cool the patient and treat with benzodiazepines.

Non-organophosphates

Pyrethroids (e.g. pyrethrins)

- Presentation may include paresthesias, vomiting, oropharyngeal irritation, and allergic hypersensitivity.
- Diagnosis by history taking.
- Supportive care with administration of bronchodilators and antihistamines.

Neonicotinoids (e.g. imidacloprid)

- Presentation may include headache, nausea, and sedation.
- Diagnosis by history taking.
- Supportive treatment.

N,N-Dietyl-3-methylbenzamide (e.g. DEET)

- Seizures
- Diagnosis by history taking.
- Treat with benzodiazepines.

Herbicides

Often consist of herbicide agent with surfactants and/or solvents.

Bipyridyl herbicides (e.g. paraquat, diquat) are the most dangerous.

Nonbipyridyl herbicides (i.e.. chlorophoxy, glyphosate, urea substituted).

Bipyridyl herbicides

Have caustic properties and may cause skin ulceration, mucus membrane ulceration, and corrosion of the GI tract.

Decontamination is critical.

Shortly after ingestion, there may be benefit of GI contamination with activated charcoal, fuller's earth, or bentonite.

Paraquat has high lethality with oral ingestion of 10 to 20 mL of a 20% solution in adults and 4 to 5 mL in pediatrics.

- Cause renal, cardiac, and hepatic failure.
- Progressing pulmonary fibrosis from oxidative damage.
  - Limit oxygen administration to patients with hypoxia.

Non-bipyridyl herbicides

Chlorophenoxy (e.g. 2,4-dichlorophenoxyacetic acid)
- Irritation of mucus membranes, pulmonary edema, muscle toxicity, hyperthermia.
- Treatment with urine alkalinization and/or hemodialysis.

Glyphosate
- Irritation of mucus membranes, erosions, multi-organ failure, respiratory distress.
- Treatment is supportive. Observation for 6 hours is indicated in patients with asymptomatic exposure.

Urea-substituted (e.g. chlorimuron, diuron, fluomenturon, isoproturon)
- Methemoglobinemia
- Treatment with methylene blue

Organophosphates (e.g. butiphos)
- SLUDGE or DUMBELS toxidrome may be observed.
- Treatment with atropine and pralidoxime

N,N-Dietyl-3-methylbenzamide (e.g. DEET)
- Seizures may occur and should be treated with benzodiazepines.

Rodenticides

Most commonly are warfarins (e.g. brodifacoum, difenacoum, bromadiolone).

Coagulopathies develop within 48 hours and may last for weeks to months.

INR should be tested 24 to 48 hours after ingestion.

INR > 2, administer oral vitamin K at 20 mg/day in adults, 1 to 5 mg for children. Treatment can be provided for up to 10 months (oral administration).

Acute hemorrhage should be treated with volume replacement, plasma or four-factor PCC, IV vitamin K, and supportive care.

Rodenticides – severely toxic

Arsenic

Barium carbonate

White phosphorus

N-3-Pyridylmethyl-*N*-p-nitrophenyl urea (i.e. Vacor)

Sodium fluoracetate

Strychnine

Thallium

Metal phosphides

Rodenticides – mild to moderately tox

Alpha-Napthyl-thiourea

Cholecalciferol

Bromethalin

Norbormide

Red squill

Pulmonary histoplasmosis

Common, typically asymptomatic infection that may be more severe in those with higher exposure. Consider in those patients who may work in poultry houses or barn structures.

The most prevalent endemic mycosis in the U.S.

Histoplasma capsulatum, which proliferates in bird or bat droppings. Theorized that these droppings provide a medium in which the fungus flourishes.

Symptomatic disease develops in less than 5% who experience a low-level exposure.

Antigen testing of urine, serum, and bronchoalveolar lavage.

Fungal cultures are useful in diagnosing pulmonary histoplasmosis.

Amphotericin B should only be used as the initial treatment in patients who have more severe infection due to its potential toxicity.

Itraconazole is highly effective in treating*H. capsulatum*.

Fluconazole should be used in those patients who cannot tolerate itraconazole (Kauffman, 2024).

Black widow

Member of the *Lactrodectus* species. Systemic effects of envenomation are known as lactrodectism.

Annually, there are approximately 2600 reported envenomations.

Venom consists of active proteins, peptides, and proteases. Neurotransmitters, including acetylcholine, dopamine, norepinephrine, epinephrine, and glutamate are released and cause pain, muscle rigidity, vomiting, and diaphoresis (Williams et al., 2023).

Photo credit: Charaj, FAL, via Wikimedia Commons

Black widow

Wound site may show fang marks with surrounding erythema, pain, and edema.

Lactrodectism symptoms include muscle rigidity, muscle cramps, truncal and abdominal tenderness, nausea, and vomiting. Pain spreads contiguously from the site of envenomation.

Lab values may show elevated WBCs, hematuria, and elevated transaminases. CK elevation may be seen with rhabdomyolysis. Myoglobin in the blood and urine may be observed with the development of myocarditis.

Pain at the wound site is present in mild envenomation and may be treated with oral analgesics.

Moderate to severe envenomation is treated with opioids and benzodiazepines (Williams et al., 2023).

Black widow

Consult a medical toxicologist.

Black widow antivenom is a safe and effective treatment.

Observation is indicated after administration.

There is a risk of anaphylaxis with the administration of antivenom. Therefore, it is recommended only for those patients whose symptoms are not effectively managed with analgesics. Avoid in patients with a history of asthma or exaggerated IgE immune responses to environmental allergens.

Patients typically recover in 24 to 48 hours (William et al., 2023).

Brown recluse

Commonly found in the south, west, and Midwest.

Local tissue injury due to necrosis at the bite site.

Systemic effects are termed loxoscelism are more common in pediatric patients.

Enzyme in the venom causes hemolysis and destruction of erythrocytes.

Bite often includes two puncture wounds with surrounding erythema and pale center due to vasospasm (Anoka et al., 2023).

Photo credit: Br-recluse-guy, Public domain, via Wikimedia Commons

Brown recluse

Clinical diagnosis.

Labs are indicated when systemic complaints are present, especially in the evaluation of children.

- CBC
- BMP
- Urinalysis
- Serum calcium
- Serum phosphate
- Liver function tests
- CK/myoglobin
- Reticulocyte count
- Haptoglobin
- Lactate dehydrogenase
- PT/INR
- D-dimer
- Fibrinogen

Brown recluse

Treatment should include cleansing site with soap and water, elevation of extremity, application of ice, and treatment with acetaminophen.

Tetanus immunization.

Antihistamines for treatment of itching at the site.

Antibiotics if signs of infection are observed.

Pain medications as appropriate.

No antivenom is available.

Admission for observation and treatment if systemic findings and/or abnormal lab results are present.

Dapsone and systemic steroids have not been found to be advantageous and have serious side effects.

Death is rare but higher risk is in pediatric patients (Anoka et al., 2023).

Snake Bites

Approximately 4735 bites from native U.S. venomous snakes occur annually (Corbett & Clark, 2016).

Half of all bites are from crotalids.

The majority of bite patients are males who are older than 19 years.

Five to six deaths occur each year in the U.S. (Corbett & Clark, 2016).

- Most often pediatric patients or older adults.
- Delayed administration of antivenom treatment.
- Almost always from crotalid envenomation.

Snake Bites

Don’t bring the offending serpent into the Emergency Department, the aircraft, or the ambulance. Crotalinae family (i.e. crotalids)

- Rattlesnakes
- Cottonmouths
- Copperheads

Elapidae family

- Coral snakes

Colubridae (i.e. colubrids) are generally not considered poisonous as they are rear-fanged and are unable to deliver venom sufficiently to humans (Corbett & Clark, 2016). There are approximately 1,760 species worldwide and account for about two-thirds of the world’s snakes.

Crotalinae

Rattlesnakes, cottonmouths, and copperheads.

Venom is mostly cytotoxic and hemotoxic.

Venom includes multiple proteins, macromolecules, and metals.

Classic manifestations of envenomation include destruction of local tissue and hematologic toxicity (Corbett & Clark, 2016).

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Crotalinae

Tissue toxicity ranges from mild, localized pain and swelling to severely painful swelling that rapidly advances and causes necrosis.

- Rattlesnake envenomation is associated with more severe tissue toxicity than cottonmouths and/or copperheads.

Hematologic toxicity with coagulopathies that manifest with hypofibrinogenemia, elevated prothrombin time, and thrombocytopenia.

Neurotoxicity is not significant with crotalid envenomations, except with the Mojave rattlesnake (Corbett & Clark, 2016).

Systemic toxicity may include hypotension, tachycardia, respiratory distress, angioedema, cardiovascular collapse, confusion, third spacing of fluids due to endothelial damage, nausea, vomiting, and diaphoresis (Corbett & Clark, 2016).

- Anaphylaxis has been reported so ongoing assessment and the administration of epinephrine, antihistamines, and corticosteroids with antivenom should be considered.

Crotalinae

Assessment of airway, breathing, and circulation.

IV access with administration of analgesia and IV fluids, if needed.

Tetanus prophylaxis.

Frequent assessments to evaluate for worsening of swelling and for changes in distal pulses, capillary refill, and sensation.

Marking of swelling and erythema can aid in evaluation of the progression.

Elevation to the level of the heart to alleviate edema. **No tourniquets or overlying jewelry and/or clothing.**

No data to support the use of venom extraction devices (Corbett & Clark, 2016).

Crotalinae

Lab studies

- CBC
- INR
- PT
- Fibrinogen
- Fibrinogen degradation products (may detect early coagulopathies)
- Consider CK (if there is concern for rhabdomyolysis)

Admission for observation even when antivenom is not indicated if signs of envenomation (i.e. physical signs, patient symptoms, or laboratory abnormalities) are identified.

Antibiotics are generally not indicated (Corbett & Clark, 2016).

Crotalinae

Antivenom treatment is indicated when:

- Progressive local effects
- Significant hematologic toxicity
- Systemic or neurotoxic signs of envenomation (Corbett & Clark, 2016).

Crotalidae polyvalent immune Fab (CPIF)

- Can stop worsening of local tissue damage.
- Improves hematologic, neurotoxic, and systemic toxicity.
- Pregnancy class C
- Safe in pediatric patients

Crotalidae immune $F(ab')_2$ (CIF)

- More recently approved by the FDA
- Pregnancy class C
- Safe in pediatric patients (Corbett & Clark, 2016).

Crotalinae

CroFab dosing

- Pain, swelling, hemotoxicity, neurotoxicity, or other systemic symptoms
- Fibrin < 100 mg/dL, platelets < 100/high power field, or DIC/bleeding.
- 4 to 6 vials in 100 mL normal saline over 1 hour (initiate slowly)
- Reassess swelling over the next 1 hour and redraw labs 1 hour after infusion is complete.
- Redose in 4 to 6 vial increments until swelling stabilizes and lab values stabilize or improve.
- Add PRBCs, cryoprecipitate, and plasma if patient is in DIC/bleeding (Corbett & Clark, 2016).

Elapidae family

Coral snakes. Red, yellow, and black banding with red bands touching the yellow bands.

Approximately 2% of all venomous snake bites in the U.S. each year.

Deaths are very rare.

Eastern coral snake bites are typically more severe than bites from the Texas coral snake. Arizona coral snake bites are “not medically significant” (Corbett & Clark, 2016, p. 343).

Elapidae

Neurotoxicity with post-synaptic acetylcholine blockage at the neuromuscular junction (Corbett & Clark, 2016).

Symptoms may include ptosis, cranial nerve palsies, dysarthria, and dysphagia and can worsen to include respiratory paralysis and death.

Symptoms typically develop within 6 hours but can be delayed to up to 12 hours.

Admission is typically indicated for close monitoring (Corbett & Clark, 2016).

Elapidae

North American Coral Snake Antivenom (whole IgG)

Assess for known horse allergy or perform intradermal injection with provided horse serum prior to IV administration.

- Relative contraindication with need to evaluate risks and benefits.

Empiric administration of the antivenom is not recommended due to risk of acute hypersensitivity reactions.

Proceed with administration at first note of neuromuscular toxicity.

Treat hypersensitivity reactions with epinephrine, corticosteroids, and antihistamines.

Not categorized for use in pregnant patients.

Generally safe for use in children (Corbett & Clark, 2016).

Anaphylaxis in adults

Epinephrine 1 mg/mL, 0.3 to 0.5 mg IM in the mid-outer thigh. May repeat every 5 to 15 minutes.

Albuterol 2.5 to 5 mg in 3 mL normal saline nebulized in the patient who is experiencing bronchospasm.

Normal saline 1 to 2 liter bolus IV.

Diphenhydramine 25 to 50 mg IV (over 5 minutes) OR cetirizine 10 mg IV (over 2 minutes).

Consider famotidine 20 mg IV (over 2 minutes).

Consider methylprednisolone 125 mg IV.

Initiate epinephrine infusion at 0.1 mcg/kg/minute via pump and titrate up.

Patients who take beta-blockers may have a limited response to epinephrine and may benefit from 1 to 5 mg of glucagon IV over 5 minutes. Follow with infusion of 5 to 15 mcg/minute (Campbell & Kelso, 2023).

Anaphylaxis in pediatrics

Epinephrine 1 mg/mL, 0.1 mg/kg to a maximum of 0.5 mg IM in the mid-outer thigh. May repeat every 5 to 15 minutes.

Albuterol 2.5 mg in 3 mL normal saline nebulized in the patient who is experiencing bronchospasm.

Normal saline 20 ml/kg bolus IV.

Diphenhydramine 1 mg/kg to a maximum of 50 mg IV (over 5 minutes) OR cetirizine 2.5 mg IV (over 2 minutes) in patients 6 months to 5 years or 5 or 10 mg IV (over 2 minutes) in patients ages 6 to 11 years of age.

Consider famotidine 0.25 mg/kg to a maximum of 20 mg IV (over 2 minutes).

Consider methylprednisolone 1 mg/kg to a maximum of 125 mg IV.

Initiate epinephrine infusion at 0.1 mcg/kg/minute via pump and titrate to effect (maximum of 1 mcg/kg/minute) (Campbell & Kelso, 2023).

Tickborne illnesses

Lyme disease

Southern Tick-associated Rash Illness (STARI)

Rocky Mountain Spotted Fever

Anaplasmosis

Ehrlichiosis

Babesiosis

Tularemia

Powassan Virus D

Borrelia miyamotoi disease

Tickborne illness treatment for MOST (CDC, 2022).

Age category	Medication	Dosing	Maximum dose	Duration in days
Adults	Doxycycline	100 mg PO or IV BID	100 mg/dose	Treat for at least 3 days after the resolution of fever and evidence of clinical improvement. The minimum course of treatment is 5 to 7 days.
Pediatrics (< 45.5 kg/100 lbs.)	Doxycycline	2.2 mg/kg/dose PO or IV BID	100 mg/dose	
With treatment with doxycycline at the recommended dose and duration, there is no evidence to show staining of permanent teeth, even in those younger than 8 years of age.				

Tularemia treatment (CDC,2022).

Age category	Medication	Dosing	Maximum dose	Duration in days
Adult	Gentamicin*	5 mg/kg IV or IM daily	Monitor serum levels	Minimum 10 days
	Ciprofloxacin	400 mg IV or 500 mg PO BID	N/A	10 to 14 days
	Doxycycline	100 mg IV or PO BID	N/A	14 to 21 days
Pediatric	Gentamicin*	2.5 mg/kg IM or IV TID	Monitor serum levels; consult peds ID	Minimum 10
	Ciprofloxacin	15 mg/kg IV or PO BID	800 mg/day	10
	Doxycycline	2.2 mg/kg IV or PO BID	100 mg IV or PO BID	14 to 21 days

*Gentamicin is recommended for the treatment of severe tularemia.

Alpha gal syndrome

Alpha-Gal syndrome “is a complex allergic disease characterized by the development of specific IgE antibodies against the carbohydrate galactose-α-1,3-galactose (α-Gal), an oligosaccharide present in cells and tissues of non-primate mammals” (Roman-Carrasco, 2021, p. 1).

Patients develop delayed allergic reactions (2 to 6 hours) after consuming mammalian meat.

110,000 cases were diagnosed in the U.S. between 2010 and 2022 (Mollah, Zacharek, & Benjamin, 2024).

Most frequently diagnosed in the central, southern, and eastern U.S.

Alpha gal syndrome

Mild reactions should be treated with antihistamines.

Severe reactions should be treated with epinephrine injection.

Cutaneous allergy testing is of limited value as extracts of meat produce limited reactions.

Oral food challenges are reliable but carry the risk of anaphylaxis.

Testing algorithms that include IgE immunoassays may be performed by specialists.

Patients should be prescribed an epinephrine auto-injector.

Animal injuries

The most common type of farm-related injury (Damroth et al., 2019).

Injuries may include bites, blunt trauma (e.g. kicks, pinning, trampling), and penetrating trauma (e.g. goring).

Consider that open injuries are likely to have high bacterial introduction.

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Vehicle injuries

The type of farm-related injury with the highest injury severity score (Damroth et al., 2019).

The most lethal type of farm-related trauma (Damroth et al., 2019).

In a North Dakota Level I trauma facility, farm machinery admissions were associated with higher injury severity score, longer length of stay in intensive care, and higher mortality than admissions not associated with farm machinery (Gilblom et al., 2023).

Photo credit: Gary Halvorson, Oregon State Archives, Attribution, via Wikimedia Commons

Tractor

Combine

Grain auger

Drilling auger

Bush hog

Photo credit: Acroterion, CC BY-SA 4.0 <https://creativecommons.org/licenses/by-sa/4.0>, via Wikimedia Commons

Disc

Photo credit: Evelyn Simak / Disc harrow in field north of Illington Road

Seed drill

Grain silo

Traumatic injury treatment

Consider the need for patient decontamination.

Control any external hemorrhage.

Maintain cervical immobilization.

Intubate and ventilate as indicated.

Support blood pressure with blood products (e.g. plasma, PRBCs, and/or whole blood). Assume shock is hemorrhagic. Consider spinal shock if unresponsive to blood product administration and/or imaging reveals spinal injury.

Tetanus prophylaxis.

Analgesia.

Antibiotics for open injuries.

Transfer to definitive care if not available in your facility.

Antibiotics with open MSK injury

Gustilo-Anderson Classification of Open Fractures

- I – Open fracture with wound < 1 cm long, low energy, no gross contamination
- II – Open fracture with wound 1 to 10 cm long, low energy, no gross contamination, without extensive soft-tissue damage, flaps, or avulsions
- IIIA - Open fracture with wound > 10 cm with adequate soft-tissue coverage or any open fracture due to high-energy trauma or with gross contamination, size of wound is not a variable.
- IIIB – Open fracture with extensive soft-tissue injury or loss, with periosteal stripping and bone exposure that requires soft-tissue coverage in the form of muscle rotation or transfer.
- IIIC – Open fracture associated with arterial injury requiring repair.

Antibiotics with open MSK injury

Patients are likely to require operative management to perform adequate irrigation.

Give antibiotics early in patients with open musculoskeletal injury and continue for 24 hours.

Gustilo-Anderson I & II – Cefazolin 2 grams IV early. If PCN allergic, clindamycin 900 mg IV.

Gustilo-Anderson III – Ceftriaxone 2 grams IV and Vancomycin 1 gram IV immediately. If PCN allergic, aztreonam 2 grams IV and vancomycin 1 gram IV early (Garner et al., 2020).

Agricultural open musculoskeletal injuries have a higher likelihood of infection with anaerobes than non-agricultural open musculoskeletal injuries. (Wynn et al., 2022). Add penicillins with farm or fecal contamination (Garner et al., 2020).

Burn injuries

Consider the need for patient decontamination.

Identify and treat any concomitant trauma.

Inhalation injuries in open environments are rare but intubate and ventilate as needed.

For burns greater than 20% TBSA in adults, initiate Lactated Ringer's solution at 500 mL until a formula can be used to calculate the necessary infusion rate and urine output can be monitored.

Be liberal with analgesia administration.

Tetanus prophylaxis.

Consult a burn specialist. Transfer to definitive care if not available in your facility.

Social Determinants of Health

Rural residence is likely to delay presentation to the Emergency Department and may impact follow-up.

Patient may be self-employed and, possibly, uninsured.

Patient may have limited financial resources.

The patient may be a member of a community where one aged member decides the transport modality and/or provides approval for care.

References

Anoka, I. A., Robb, E. L., & Baker, M. B. (2023). Brown Recluse Spider Toxicity. In *StatPearls*. StatPearls Publishing.

Campbell, R. L. & Kelso, J. M. (2023). Anaphylaxis: Emergency Treatment. UpToDate. https://www-uptodate-com.ckmproxy.vumc.org/contents/anaphylaxis-emergency-treatment?search=anaphylaxis%20treatment&source=search_result&selectedTitle=1%7E150&usage_type=default&display_rank=1

Centers for Disease Control and Prevention (CDC). 2022. *Tickborne Diseases of the United States: A Reference Manual for Healthcare Providers* (6th ed.).

Corbett, B., & Clark, R. F. (2017). North American Snake Envenomation. *Emergency medicine clinics of North America*, *35*(2), 339–354. https://doi-org.proxy.library.vanderbilt.edu/10.1016/j.emc.2016.1

Damroth, K., Damroth, R., Chaudhary, A., Erickson, A., Heneghan, L., Hellenthal, N., Monie, D., Cooper, S., Anderson, M., & Kaufman, T. (2019). Farm Injuries: Animal Most Common, Machinery Most Lethal: An NTDB Study. *The American surgeon*, *85*(7), 752–756.

Garner, M. R., Sethuraman, S. A., Schade, M. A., & Boateng, H. (2020). Antibiotic Prophylaxis in Open Fractures: Evidence, Evolving Issues, and Recommendations. *The Journal of the American Academy of Orthopaedic Surgeons*, *28*(8), 309–315. https://doi-org.proxy.library.vanderbilt.edu/10.5435/JAAOS-D-18-00193

Gilblom, E. A., Sang, H. I., Johnson, A. B., Sahr, S., Misialek, M., Syverson, D., & Staskywicz, Z. (2023). Farm Machinery Injuries: A Retrospective Analysis of Admissions at a Level I Trauma Center in North Dakota. *Journal of agromedicine*, *28*(3), 587–594. https://doi-org.proxy.library.vanderbilt.edu/10.1080/1059924X.2022.2158151

References

Kauffman, C.A. (2024). *Diagnosis and treatment of pulmonary histoplasmosis.* UpToDate. https://www-uptodate-com.ckmproxy.vumc.org/contents/diagnosis-and-treatment-of-pulmonary-histoplasmosis?search=farm%20injuries&topicRef=2450&source=see_link

Kauffman, C. A. (2024). *Pathogenesis and clinical features of pulmonary histoplasmosis*. UpToDate. https://www-uptodate-com.ckmproxy.vumc.org/contents/pathogenesis-and-clinical-features-of-pulmonary-histoplasmosis?search=farm%20injuries&source=search_result&selectedTitle=6%7E66&usage_type=default&display_rank=6

Mollah, F., Zacharek, M. A., & Benjamin, M. R. (2024). What Is Alpha -Gal Syndrome? *JAMA*, *331*(1), 86. https://doi-org.proxy.library.vanderbilt.edu/10.1001/jama.2023.23097

O'Connell, C. W. (2018). Pesticides. In Cydulka et al. (Eds), *Tintinalli's Emergency Medicine Manual*, 8th ed. McGraw-Hill Education.

Román-Carrasco, P., Hemmer, W., Cabezas-Cruz, A., Hodžić, A., de la Fuente, J., & Swoboda, I. (2021). The α-Gal Syndrome and Potential Mechanisms. *Frontiers in allergy*, *2*, 783279. https://doi-org.proxy.library.vanderbilt.edu/10.3389/falgy.2021.783279

Williams, M., Sehgal, N., & Nappe, T. M. (2023). Black Widow Spider Toxicity. In *StatPearls*. StatPearls Publishing.

Wynn, M., Kesler, K., Morellato, J., Higginbotham, R., Robertson, M., Marsh, J. L., & Hogue, M. (2022). Agricultural Trauma Causing Open Fractures: Is Antibiotic Coverage Against Anaerobic Organisms Indicated?. *Journal of orthopaedic trauma*, *36*(2), e51–e55. https://doi-org.proxy.library.vanderbilt.edu/10.1097/BOT.0000000000002192