Cimex lectularius ("Bed Bugs")
Recognition, Management, and Eradication

Kathryn S. McMenaman, DO and Marianne Gausche-Hill, MD†‡§*

Abstract: Reports of bed bug infestations in major cities in the United States and abroad have been in the public press. Physicians and other clinicians who care for children need to be able to recognize bed bug bites and understand the social, psychological, and medical implications that this diagnosis will have on patients and their families. In this article, a case presentation serves to guide discussion regarding establishing the diagnosis, differential diagnosis, and the management of bed bug bites and their complications. Integrated pest management programs involving housing managers, residents, and professional pest exterminators provide both chemical and nonchemical solutions for eradication of bed bug infestations.

Key Words: bed bugs, *Cimex lectularius*, pruritus, eradication

(*Pediatr Emer Care* 2016;32: 801–806)

TARGET AUDIENCE

This CME activity is intended for physicians who care for children. Pediatricians, emergency physicians, pediatric emergency physicians, nurse practitioners, and other allied health professionals will find this information especially helpful.

LEARNING OBJECTIVES

After completion of this CME article, the reader should be able to:

1. Diagnose a bed bug bite and its clinical consequences by integrating presentation, appropriate environmental history, and careful dermatologic examination.
2. Discuss treatment options for the patient, patient's family, and cohabitators.
3. Outline patient education on prevention of reinfestation, hygiene practices for prevention of spread of bed bugs, and public health guidelines for decontamination of the source.

CASE: 6-YEAR-OLD GIRL WITH A PRURITIC RASH

A 6-year-old girl is brought to the pediatric emergency department by her mother, who describes a history of *itchy* rash that started 3 weeks ago. The rash is located on her arms and legs. It has not spread to her trunk. The girl had a similar episode that self-resolved several weeks prior, and then this rash started to flare again. She is otherwise healthy-appearing and interactive with staff. Other family members have had a similar rash.

Medical History

Asthma treated with beclomethasone dipropionate HFA daily and albuterol when necessary.

Review of Symptoms

The patient has not had fever, chills, nausea, vomiting, or joint pain.

Vital Signs

The patient's heart rate was 106 beats per minute; blood pressure, 94/68 mm Hg; respiration rate, 16 breaths per minute; temperature, 37.5°C; oxygen saturation, 99% on room air; and her numeric pain scale was 4 of 10.

Physical Examination

The patient is well-appearing and interactive. Her cardiovascular examination result is normal. She has no hepatosplenomegaly. The lesions do not blanch when pressed and have distinct spots of dark red centers with swollen erythema surrounding. The rash is not confluent, nor are there areas of weeping or sloughing (Fig. 1).

Questions

1. What factors predispose children to dermatologic infestations with bed bugs?
2. What conditions are in the differential diagnosis and how do you differentiate them?
3. How will you treat this patient and her family?
4. What can be done to prevent future recurrences?

THE BED BUG LIFE

Cimex lectularius, the common bed bug, is a parasitic insect well known for the fact that it feeds exclusively on blood (Fig. 2). Bed bugs have been documented as far back as the Ice Age, when they were living in caves feeding off both humans and bats.[1,2] Resurgence in the population has given rise to a renewed interest in this age-old pest.[3,4] Today, there are numerous reported cases in large cities, and the first bed bug conference took place in Philadelphia PA in 2009.[3] Public health experts are attributing the recent resurgence of *C lectularius* infestations to increased international travel, immigration, and insecticide overuse and resistance.[3]

Cimex is derived from the Roman word for bug and *lectularius* from the Latin name for couch or bed.[5] The nocturnal bloodsucking ectoparasite feeds on humans, birds, bats, pets, and other mammals.[5,6] Their ideal environment is warm, dark areas, and are often detected in the seams of mattresses, furniture, flooring, wallpaper, and other household items. They are flat, 5-mm ovoid wingless insects with 6 legs. They are easily visible to the untrained eye.[5] Although incapable of flight or jumping, these

*Senior Resident (McMenaman), Department of Pediatrics, Harbor-UCLA Medical Center, Torrance; †Medical Director (Gausche-Hill), Los Angeles County EMS Agency, Santa Fe Springs; ‡Professor of Clinical Medicine and Pediatrics (Gausche-Hill), David Geffen School of Medicine at UCLA, Los Angeles; and §EMS Fellowship Director (Gausche-Hill), Harbor-UCLA Medical Center, Department of Emergency Medicine, Torrance, CA.

The authors and staff in a position to control the content of this CME activity and their spouses/life partners (if any) have disclosed that they have no financial relationships with, or financial interest in, any commercial organizations pertaining to this educational activity.

Reprints: Marianne Gausche-Hill, MD, FACEP, FAAP, 10100 Pioneer Blvd, Suite 200, Santa Fe Springs, CA 90670
(e-mail: Mgausche-hill@dhs.lacounty.gov).

ISSN: 0749-5161

FIGURE 1. Typical rash from bed bug bites (www.bedbugs.com; accessed March 13, 2016).

insects can run rapidly when ambient temperatures are warm.[4] They generally are found within 1 to 2 m of a suitable host to facilitate feedings.[5] They also can stow in travelers' luggage, making long treks as hitchhikers to a new host's home. Each female can lay approximately 3 to 5 eggs, and each nymph will consume 5 blood meals before each molt through 6 weeks to reach adulthood. The adult bedbug can survive for 12 months without a blood meal and up to 24 months in cooler environments. Males starved longer than 2 weeks will cease to mate, however.[3] Bedbugs emerge at night and are attracted by a host's body temperature and carbon dioxide production. The host receives a painless bite from a pair of maxillary stylets. A second pair of stylets contains anticoagulant, vasodilator, and proteolytic enzymes that are injected into the skin wound.[2] Blood is then consumed by the bed bug for 10 to 30 minutes for a full meal. The bugs can increase in length by 30% to 50% and weight by 150% to 200% after a meal.[5]

Transmission of Other Diseases

The role of *C lectularius* as a vector for blood-borne pathogen transmission is under ongoing investigation. Controlled studies in vivo have demonstrated 20 different human illnesses including leishmaniasis, American trypanosomiasis, and tularemia, which can incubate in the bed bug. Various sources suggest the possible transmission of these diseases to the human host, but no definitive article has been published confirming a case to date.

Viral Transmission

Hepatitis B and hepatitis E were detected in bed bugs in the 1970s, but the bed bug was found to lack the required proteins to allow for replication of these viruses.[6–8] The absence of T4 antigen on the insect's cell surface has been postulated to prohibit human immunodeficiency virus replication in a similar manner.[3,9] An alternative study did show, however, that *Cimex* was capable of transmitting hepatitis B virus from infected bed bugs to laboratory rabbits and guinea pigs.[7,8] Hepatitis B virus can be detected in bed bugs up to 8 days after ingestion of highly concentrated virus in experimental blood meals. Studies show conflicting results as to viral replication within the insects and presence of virus detected in the bug feces.[8,10,11] Despite these controversial findings, one experiment in Gambia of bed bug eradication had no effect on hepatitis B virus rates of infection despite 100% reduction of bed bug numbers.[12]

Clinical Presentation

These obligate hematophagous ectoparasites usually cause no reaction to the bites; sometimes, a barely visible punctate mark can be seen at the bite site. Reactions that present for medical attention are usually 2- to 5-mm pruritic maculopapular erythematous lesions, which resolve within a week. Often, in a linear pattern as the bed bug feeds. These are reactions to proteins in the bug's saliva. Bites are often in a set of 3 distinct small round bite marks colloquially known as "breakfast, lunch, and dinner" classically on the face, arms, and neck.[13] Papular urticaria is a hypersensitivity reaction characterized by autoeczematization and diffuse pruritus and is a manifestation of bed bug bites in children, especially those with atopy. Bullous lesions have also been reported, resembling erythema multiforme.[5,13,14] Scratching and local skin breakdown can predispose to secondary bacterial infection and scar formation. Chronic *Cimex* infestation can cause nervousness, depression, lethargy, pallor, diarrhea, and even iron deficiency anemia.[12,13,15]

Diagnosing the Home

Bed bugs leave behind telltale signs of their infestation of a home. Patients should be instructed to search for reddish brown blood stains on their sheets and mattresses, especially in the creases of the mattress. Flecks of excrement can often be found as well. With high insect load, a sweet malodor can be detected because the amount of parasite oil secretion would be very high in populations with many members mating. Often, experts recommend setting an alarm for 4 A.M. to do a flashlight search of the mattress to make the diagnosis because this is when the bedbugs are frequently motile and searching for a feed.

MANAGEMENT

Patient

Reactions to most bites resolve in 3 to 10 days without treatment. Symptom control with oral antihistamines, topical steroids, and wound care are usually adequate.[13] Antibiotics are indicated for secondary bacterial superinfection, and blistering skin infections can be treated with the addition of short-course oral corticosteroids. After treatment of the patient and the home, patients should be referred to primary care for follow-up because patients sometimes develop signs and symptoms of depression, anxiety, and stress related to the incident. Delusions of parasitosis, or formication, is a rare disorder that presents as tactile hallucinations of being infested by a parasite.[16] Self-injurious behavior due to scratching ensues, and patients often present containers of skin

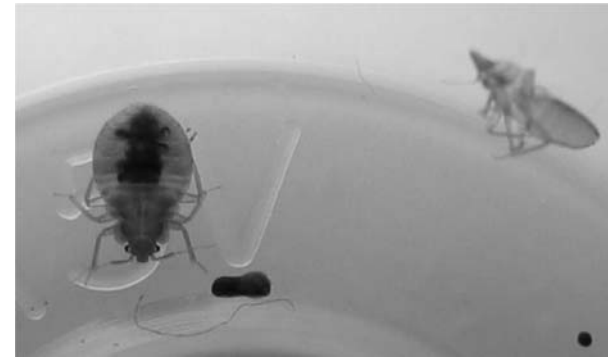

FIGURE 2. *C lectularius* (bed bugs) (www.bedbugs.com; accessed March 13, 2016) adult and nymph.

TABLE 1. Chemical and Nonchemical Eradication Systems

Nonchemical
- Manual removal by hand or with vacuum cleaner
- Mattress encasements
- Enclosing infested furniture or other items in plastic and discard
- Exposure to increased temperatures:
  - Temperatures between 45°C and 48°C
    - a clothes dryer;
    - hot steam applicators;
    - portable heat chambers;
    - portable whole-room heaters;
    - heating trucks.

Chemical
- dust and spray formulations of pyrethroids
- neonicotinoids (dinotefuran)
- pyrethroid + neonicotinoid mixtures
- pyrroles (chlorfenapyr)
- silicates (diatomaceous earth)
- essential oil and detergent products
- dichlorvos (DDVP)

Adapted from Bennett GW, Gondhalekar AD, Wang C, et al. Using research and education to implement practical bed bug control programs in multifamily housing. *Pest Management Science*. 2016;72(1):8–14.

DDVP indicates 2,2-dichlorovinyl dimethyl phosphate.

debris as evidence to clinicians. Treatment requires psychiatrist expertise because patients are often aggressively opposed to taking antipsychotic medications.[13,17]

Eradication

The treating emergency clinician should question patients to determine source of exposure so that eradication steps can be targeted to prevent reinfection, such as any travel history, new furniture, hotel stays, new visitors in the home, or rodents in the home.[13] Patients' families must be instructed to inspect and later treat infested rooms and adjoining areas in the home. Bed bug detection and monitoring devices or methods are beyond the scope of this review but include active monitors (using carbon dioxide attractants), passive monitors (using sticky pads for trapping), visual inspection, and use of canines. Homemade traps using a source of carbon dioxide such as dry ice or a sugar, yeast, and water mixture have been used to detect bed bugs.[18]

Chemical and nonchemical methods for eradication are outlined in Table 1.

A professional exterminator is often required, although homeowners can attempt a combination of vacuuming, caulking wall holes, discarding old furniture, or spraying mattresses and plush furniture with insecticides. Soft items must be washed at a hot setting for 30 minutes, or bedding can be frozen in bags in a freezer. Heat treating furniture to 49°C has been shown to be effective.[17,19] Use of insecticides such as malathion, pyrethrin, dichlorovos, permethrin, and diethyltoluamide are appropriate choices and must make direct contact with affected surfaces. Patients' families should use these agents with caution to prevent overexposure and potential toxicity, especially to exposed young children with relatively large body surface area-to-volume ratios.[13] If the *Cimex* are discovered to be alive 2 weeks after attempted eradication, professional exterminators must be called because this is indicative of continued infestation. Professional exterminators even have trained dogs to sniff for bed bugs. Using white sheets can make it easier to identify the blood spots from the bugs. Applying permethrin 5% cream or DEET 40% before going to bed is a reasonable approach to deterring the bed bugs while waiting for complete deinfestation.[13]

There is evidence that pyrethroid-impregnated bed nets used for malaria control may be helping to eliminate bed bugs but also may be contributing to bed bug resistance to insecticides.[20]

Given the obvious health concerns from spraying mattresses with insecticides, research has turned to more natural ways to eliminate bed bugs. Entomopathogenic fungi are species of fungus that can parasitize insects and kill them. Currently, *Beauveria bassiana* is a fungi species being tested to effectively parasitize *C lectularius* as an alternative to pesticide use.[21] Further research is ongoing to develop this biopesticide and its possible delivery system to be used as a mainstream treatment for bed bug infestation.

Novel Programs for Infestation Control

In multifamily dwellings, which are common in many parts of the United States, integrated pest management (IPM) has been shown to be the best method for infestation control.[19] The IPM programs elicit cooperation from housing managers, residents, and professional pest exterminators to provide both chemical and nonchemical solutions to bed bug infestation.

DIFFERENTIAL DIAGNOSIS

Table 2 outlines the differential diagnosis and highlights historical and physical findings including the nature and distribution of the rash, which may assist the emergency practitioner in distinguishing among possible etiologies. Fortunately, bed bug bites are exceedingly rare as compared with flea bites and scabies.[22]

TABLE 2. Insect Bite Differential and Associated History and Physical Findings

Many Bites?
- Yes → Fleas, bedbugs
- No → Ticks, mosquito

Where are the bites?
- Exposed skin only: mosquitos
- Feet/ankles: fleas
- Interdigitary: scabies

Pattern?
- Rows: bed bugs, spiders
- No pattern: mosquitos, fleas

Pain at time of bite?
- Yes: fire ants, spiders
- No/delayed pain: mosquitos, bedbugs

Rash?
- Target rash → Lyme disease, tick bite
- Extremities → Rocky Mountain spotted fever, tick bite

Fever?
- Yes: tick → Lyme disease, Rocky Mountain spotted fever
- Mosquito → malaria

Swelling/bruising/abdominal pain?
- Black widow spider
- Brown recluse spider

SUMMARY OF CLINICAL COURSE

Our patient was treated with antihistamines (diphenhydramine) and topical steroids for pruritus. The family was counseled on eradication in the home and social services was consulted to assist the family with local resources.

Information on local helplines were given to the family: Vector Management Program (626) 430–5450 and Environmental Health Emergency Hot Line (888)700–9995.

CONCLUSIONS

Bed bug infestation in the United States is a well-documented problem, and patients may present to the emergency department with evidence of bug bites consistent with bed bug infestation. Usually, multiple family members are involved and often in multifamily living situations. Identification of the infestation and initiation of an IPM program is a proven way to eliminate the infestation. In most cases, treatment consists of local wound management and medications to control pruritus. Rarely are antibiotics or systemic steroids needed.

REFERENCES

1. Lavery M, Parish LC. Bed bugs revisited. *Skinmed*. 2011;9:6–8.
2. Paul J, Bates J. Is infestation with the common bedbug increasing? *BMJ*. 2000;320:1141.
3. Ter Poorten MC, Prose NS. The return of the common bedbug. *Pediatr Dermatol*. 2005;22:183–187.
4. Steen CJ, Carbonaro PA, Schwartz RA. Arthropods in dermatology. *J Am Acad Dermatol*. 2004;50:819–842.
5. Goddard J, deShazo R. Bed bugs (*Cimex lectularius*) and clinical consequences of their bites. *JAMA*. 2009;301:1358–1366.
6. Vall Mayans M, Hall AJ, Inskip HM, et al. Do bedbugs transmit hepatitis B? *Lancet*. 1994;343:761–763.
7. Blow JA, Turell MJ, Silverman AL, et al. Stercorarial shedding and transtadial transmission of hepatitis B virus by common bed bugs (Hemiptera: Cimicidae). *J Med Entomol*. 2001;38:694–700.
8. Silverman AL, Qu LH, Blow J. Assessment of hepatitis B virus DNA and hepatitis C virus RNA in the common bedbug (*Cimex lectularius* L.) and kissing bug (*Rodnius prolixus*). *Am J Gastroenterol*. 2001;96:2194–2198.
9. Bed bugs, insects, and hepatitis B. *Br Med J*. 1979;2:752.
10. Jupp PG, Lyons SF. Experimental assessment of bedbugs (*Cimex lectularius* and *Cimex hemipterus*) and mosquitoes (*Aedes aegypti formosus*) as vectors of human immunodeficiency virus. *AIDS*. 1987;1:171–174.
11. Webb PA, Happ CM, Maupin GO. Potential for insect transmission of HIV: experimental exposure of *Cimex hemipterus* and *Toxorhynchites amboinensis* to human immunodeficiency virus. *J Infect Dis*. 1989;160:970–977.
12. El-Mofty MM, Sakat SA, Younis MWF. Induction of skin papillomas in the rabbit, *Oryctologus cuniculus*, by bites of a blood-sucking insect *Cimex lectularius* irradiated by gamma rays. *J Invest Dermatol*. 1989;93:630–632.
13. Shmidt E, Levitt J. Dermatologic infestations. *Int J Dermatol*. 2012;51:131–141.
14. deShazo R, Feldlaufer M, Mihm M, et al. Bullous reactions to bedbug bites reflect cutaneous vasculitis. *Am J Med*. 2012;125:688–694.
15. Leininger-Hogan S. Bedbugs in the intensive care unit. A risk you cannot afford. *Crit Care Nurs Q*. 2011;34:150–153.
16. Reichenberg JS, Magid M, Jesser CA, et al. Patients labeled with delusions of parasitosis compose a heterogenous group: a retrospective study from a referral center. *J Am Acad Dermatol*. 2013;68:41–46.
17. Heller MM, Wong JW, Lee ES, et al. Delusional infestations: clinical presentation, diagnosis and treatment. *Int J Dermatol*. 2013;52:775–783.
18. Vaidyanathan R, Feldlaufer MF. Bed bug detection: current technologies and future directions. *Am J Trop Med Hyg*. 2013;88:619–625.
19. Bennett GW, Gondhalekar AD, Wang C, et al. Using research and education to implement practical bed bug control programs in multifamily housing. *Pest Manag Sci*. 2016;72:8–14.
20. Alaii JA, Van Den Borne HW, Kachur S, et al. Perceptions of bed nets and malaria prevention before and after a randomized controlled trial of permethrin-treated bed nets in western Kenya. *Am J Trop Med Hyg*. 2003;68(Suppl 4):142–148.
21. Barbarin A, Jenkins N, Rajotte E, et al. A preliminary evaluation of the potential of Beauveria bassiana for bed bug control. *J Invertebr Pathol*. 2012;111:82–85.
22. Cestari T, Martignago BF. Scabies, pediculosis, bedbugs, and stinkbugs: uncommon presentations. *Clin Dermatol*. 2005;23:545–554.