

Nancy M. Dunbar,<sup>1</sup> M.D. and Richard C. Harruff,<sup>1</sup> M.D., Ph.D.

## Necrotizing Fasciitis: Manifestations, Microbiology and Connection with Black Tar Heroin\*

**ABSTRACT:** A 10-year review of records of the King County Medical Examiner's Office found 87 deaths due to necrotizing fasciitis and related necrotizing soft tissue infections. In 64 of these cases there were sufficient details to provide an analysis of the manifestations, microbiology, and source of infection. One half (32) of the cases were due to injection of black tar heroin, the nearly exclusive form of heroin in the Northwest United States. Of those due to black tar injection, 24 were clostridial infections with various species represented, eight of which were *Clostridium sordellii*. Of the 32 cases not associated with drug injection, streptococcal species predominated, with *Streptococcus pyogenes* isolated in 14 cases. Only three of 32 cases not associated with injection drug use were clostridial infections. These differences were statistically significant. *Staphylococcus aureus* was isolated from 14 cases; two were methicillin-resistant strains. Overall, 28 of the 64 cases were polymicrobial infections, 15 due to black tar injection and 13 not associated with drug injection. This study supports the conclusion that necrotizing fasciitis due to black tar heroin injection is predominantly a clostridial disease, and in this way differs significantly from necrotizing fasciitis due to other causes.

**KEYWORDS:** forensic science, forensic pathology, death investigation, black tar heroin, necrotizing fasciitis, injection drug abuse

Black tar heroin is a crude, unpurified derivative of the opium poppy smuggled from Mexico into the United States, where it is transported and distributed along the Interstate 5 corridor (King County Sheriff's Office, personal communication). Black tar is essentially the exclusive form of heroin encountered in the Northwest United States. In the Seattle, Washington, area most users administer the drug by intravenous (IV) injection using insulin syringes. The repeated IV injection of black tar heroin eventually leads to vascular sclerosis and causes heavy users to resort to subcutaneous (SC) and intramuscular (IM) injection routes as their IV sites become exhausted (1). Complicating these routes of administration, SC and IM injection promotes infection by introducing contaminated material into the SC tissue. Consequently, infections such as skin and SC abscesses are frequent among injection drug users. More serious necrotizing soft tissue infections due to SC and IM injection of black tar heroin are less common but have a high mortality. These potentially lethal infections, typically grouped as necrotizing fasciitis, also include cellulitis and clostridial myonecrosis. As these infections represent a potential cause of death in drug users and other individuals coming under the jurisdiction of medical examiners and coroners, it is important for death investigators and forensic pathologists to be aware of necrotizing fasciitis and its association with black tar heroin injection. For this reason, the present study was initiated to better understand the manifestations and microbiology of the disease and its association with injection drug abuse.

### Materials and Methods

King County Medical Examiner's Office (KCMEO), part of Public Health - Seattle & King County, assumes jurisdiction in all reported deaths due to drug abuse and deaths due to infections that may represent a public health hazard, including necrotizing fasciitis. For this study, a records review over 10 years, from 1995 to June of 2005, yielded 87 total deaths due to necrotizing fasciitis, cellulitis, or clostridial myonecrosis. The majority of these cases received treatment prior to their death at Harborview Medical Center (HMC) in Seattle, the designated Level I trauma center for Washington state and the trauma and burn referral center for Washington, Alaska, Montana, and Idaho. Medical records from HMC and death investigation and postmortem examination reports from KCMEO were reviewed to determine the age, gender, race, source and site of infection, other coexisting medical conditions, and treatment received prior to death in each case. In addition, results of all premortem hospital wound and blood cultures were reviewed. Autopsy cultures were rarely performed because of antibiotic therapy, and were not included in this study. Cases were categorized according to the microorganisms identified in the first positive cultures following admission to the hospital. Eliminating 22 cases in which no microorganism was identified and one case of necrotizing fasciitis due to methicillin-resistant *Staphylococcus aureus* with no information regarding source of infection left 64 cases that were analyzed in the present study. For these 64 cases, the microbiology was correlated with the source of infection according to details gathered from the death investigation report and the clinical history. From these details, the 64 cases were categorized into one of four groups indicating the most likely source of infection. Cases were categorized as injection drug use if there was history and/or physical signs of chronic SC or IM injection at the site of infection; trauma if there were history and/or signs of injury at the site of infection; skin breakdown if the decedent suffered from a chronic interruption of the integument or a vascular condition that would

<sup>1</sup>King County Medical Examiner's Office, 325 Ninth Avenue, HMC Box 359792, Seattle, WA.

\*Presented as a poster at the 56th Annual Meeting of the American Academy of Forensic Sciences in Seattle, WA, February 2006.

Received 18 Aug. 2006; and in revised form 24 Dec. 2006; accepted 29 Dec. 2006; published 24 May 2007.

predispose to infection; and spontaneous if the decedent was previously healthy and had no history or physical signs of drug injection, injury, or chronic predisposing local condition. Statistical test for significance was performed by chi-squared analysis.

## Results

Samples of black tar heroin frequently accompanying overdose fatalities consisted of lumps of firm, gummy, dark brown to black material (Fig. 1). Manifestations of SC or IM black tar injection were usually evident from postmortem examination of the body or from examination of debrided tissue excised surgically, appearing as dark, raised nodules up to 2–3 cm in diameter on the skin surface. Incision of the nodules revealed black deposits surrounded by variable suppuration and scar tissue (Fig. 2). Microscopic examination of the SC nodules showed central deposits of extracellular, dark brown pigment also present within macrophages, accompanied by variable components of acute and chronic inflammation, foreign body reaction, fibrosis and old and recent hemorrhages (Fig. 3).



FIG. 1—Black tar heroin samples typically accompanying drug overdose fatalities. The heroin consists of dark brown to black gummy lumps wrapped in plastic or similar material. Insulin syringes are employed for injection of the drug. Black tar is heated in a spoon or a “cooker” with a small amount of water until it becomes liquid enough to draw through the syringe needle. As an attempt to filter out insoluble material, the suspension is drawn through a fibrous wad, in this case fashioned from a commercial cigarette filter.

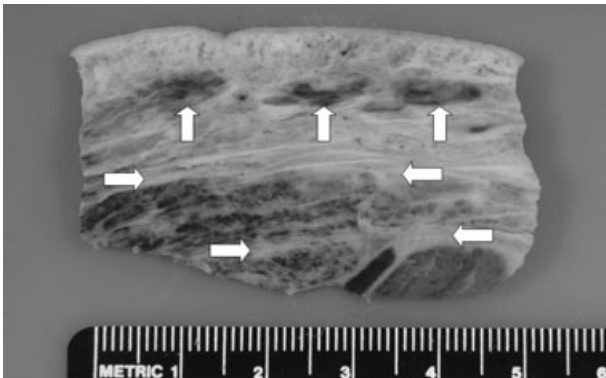


FIG. 2—Skin and subcutaneous (SC) tissue from a case of necrotizing fasciitis. The section is oriented perpendicular to the skin surface facing upward in the photograph. Nodules of dark brown deposits in the SC tissue (vertical arrows) represent collections of black tar surrounded by acute inflammation. Bands of white scar tissue (horizontal arrows) obliterate the SC tissue and extend into the skeletal muscle towards the bottom of the photograph.

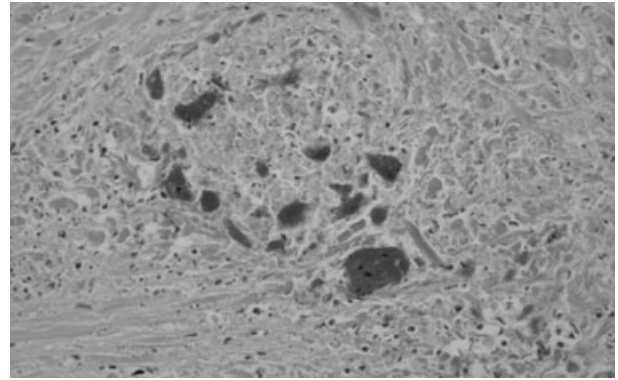


FIG. 3—Microscopic section from a case of necrotizing fasciitis showing deposits of black tar heroin that had been injected under the skin. The dark material represents insoluble residue that remains in the tissue, associated with necrosis, acute inflammation, and fibrosis. Original magnification 100x, hematoxylin and eosin stain.

Table 1 correlates the microbiology of 64 cases of necrotizing fasciitis with respect to the source of infection. Thirty-two cases, categorized as injection drug use, were all associated with black tar heroin injection with infection presenting at or around the injection sites. Of these, 17 grew cultures isolating a single organism; the remaining 15 were polymicrobial. Of the 17 single isolates, 13 cultures were positive for clostridial species including four isolates of *Clostridium sordellii* and two isolates of *Clostridium perfringens*. Table 2 lists the various organisms from the 15 cases in which there were two or more different species of bacteria isolated from the same case. Of these 15 polymicrobial cultures, clostridia were present in 11, with two different clostridial species present in three cases and *C. sordellii* present in four. Overall, clostridia were present in 24 of 32 deaths due to necrotizing fasciitis resulting from black tar heroin injection.

Of the remaining 32 cases occurring among noninjection drug users, 13 were classified as trauma in Table 1. These were infections developing at the site of injury, including minor falls or other known blunt trauma (10 cases), motor vehicle collision (one case), lower extremity prosthesis site (one case), and suppurative hidradenitis that had been manually traumatized by the decedent (one case). All of these wounds grew cultures containing at least one species of streptococci or staphylococci. In six of these 13 cases, cultures yielded a single isolate, four of *Streptococcus pyogenes* and two of *Staphylococcus aureus*, one of which was methicillin-resistant *S. aureus* (MRSA). The remaining seven cases were polymicrobial with various streptococcal species present in five, as shown in Table 2. In the seven cases classified as skin breakdown, infection started in vulnerable skin sites due to chronic conditions, including chronic skin ulcers (four cases), percutaneous feeding tube site (one case), chronic lymphedema (one case), and chronic venous stasis (one case). All were infected by streptococci; two had single isolates of *S. pyogenes* and four were polymicrobial (Table 2). One polymicrobial case was also infected with MRSA. In the 12 cases classified as spontaneous, there were no known trauma or preexisting skin conditions near the infection site. Of these spontaneous infection cases, three had single isolates of clostridia identified, two of which were *Clostridium septicum*. Another six grew single isolates of streptococci, five of which were *S. pyogenes*. One infection was due to *S. aureus*, and the remaining two were polymicrobial (Table 2).

In summary, 32 of the 64 cases of necrotizing fasciitis were associated with IV drug use. Of these 32 cases, 24 were clostridial

TABLE 1—Correlation of microbiology with source of infections in 64 deaths due to necrotizing fasciitis.

	Source of infection							
	Injection drug use		Trauma		Skin breakdown		Spontaneous	
Total cases	32		13		7		12	
Microbiology	Monomicrobial	Polymicrobial	Monomicrobial	Polymicrobial	Monomicrobial	Polymicrobial	Monomicrobial	Polymicrobial
Number of cases:	17	15	6	7	3	4	10	2
Number of isolates*								
Clostridial species	13	14†	0	0	0	0	3	0
<i>C. bifermentans</i>	1	0	0	0	0	0	0	0
<i>C. perfringens</i>	2	3	0	0	0	0	0	0
<i>C. septicum</i>	0	0	0	0	0	0	2	0
<i>C. sordellii</i>	4	4	0	0	0	0	0	0
<i>C. subterminale</i>	1	0	0	0	0	0	0	0
<i>C. tertium</i>	1	1	0	0	0	0	0	0
Not specified	4	6	0	0	0	0	1	0
<i>Streptococcus pyogenes</i>	0	2	4	3	2	0	5	0
Other streptococcal species	0	5	0	5	1	3	0	0
<i>Staphylococcus aureus</i> ‡	1	7	2	2	0	1	1	0
Other bacterial species§	3	15	0	19	0	6	1	6

\*The total number of isolates in the polymicrobial columns exceeds the total number of cases.

†Two different clostridial species were isolated from each of three cases.

‡Two isolates of *S. aureus* were methicillin-resistant strains.

§See Table 2 for a listing of bacterial species isolated in polymicrobial infections.

infections, eight of which included *C. sordellii*. Of the 32 cases of necrotizing fasciitis not associated with injection drug use, 20 were monomicrobial with 13 involving streptococcal species (11 *S. pyogenes*), four involving *S. aureus* (two MRSA), and three involving clostridia (two *C. septicum*). This association of clostridial infection with black tar heroin injection is statistically significant ( $p < 0.001$ ).

## Discussion

This study shows convincingly that necrotizing fasciitis due to clostridial infection is a potential consequence of IM or SC injection of black tar heroin. This unrefined form of heroin is accurately

described by its name, and considering its crude preparation and potential for adulteration, bacterial contamination of black tar is not surprising. Most bacteria are killed by brief heating to temperatures of 72°C, for example, in the process of pasteurization. However, the spores of clostridia are more resistant to heat. It has been shown that either the raw drug or adulterants found in black tar heroin contain clostridial spores that are difficult to kill by the brief heating drug users employ (2). When the spores are introduced intramuscularly via SC or IM injection, the focus of insoluble material, hemorrhage, and devitalized tissue at the injection site provides the anaerobic microenvironment that promotes clostridial growth. Clostridial infections, including wound botulism, tetanus, and necrotizing fasciitis, have been reported previously among black tar heroin injection drug users (1–6) and clusters of infections have been associated with a single batch of heroin (3). The present study demonstrates that necrotizing clostridial infections of skin and soft tissues are highly associated with black tar injection. Although it is clear that the black tar was the source of infection, it was not possible to determine whether clostridial spores were introduced during collection or preparation of the drug or whether they were introduced by subsequent adulteration or injection techniques. Although this study as well as previous studies demonstrate the strong association of black tar with clostridial infections (1,5,6), clusters of clostridial infections in regions where black tar is not the predominate form of heroin (2,4) indicate that clostridial spores may be introduced through a variety of means.

In general, necrotizing fasciitis caused by any of the several species of clostridia has a high mortality rate. A large proportion of the cases reported here were due to *C. sordellii*. Of the 14 isolates in which the microbiology laboratory identified the species, eight were confirmed as *C. sordellii*. Previous studies have isolated *C. sordellii* from black tar heroin samples (2). In a reported outbreak of necrotizing fasciitis among black tar heroin users infected with *C. sordellii*, the disease was especially severe (6). In clinical medicine, this organism is an uncommon infectious agent primarily associated with fulminant obstetric infections (7,8). In the present series, *C. sordellii* appeared to be a common contaminant of black tar heroin, as evidenced by the relative frequency in which it was isolated. Another clostridial species reported as

TABLE 2—Miscellaneous bacterial species isolated from polymicrobial infections.

Bacterial species	Number of isolates	
	Injection drug users	others
<i>Staphylococcus</i> , coagulase negative	7	6
<i>Diphtheroides</i>	1	1
<i>Lactobacillus</i>	0	1
<i>Corynebacterium striatum</i>	1	0
<i>Bacillus</i> , not otherwise specified	1	0
Gram-negative rods, lactose fermenting, including <i>Escherichia coli</i> , <i>Klebsiella pneumoniae</i> , and <i>Proteus</i> species	2	4
<i>Haemophilus</i> species	0	1
<i>Arcanobacterium haemolyticum</i>	0	1
<i>Acinetobacter</i>	1	1
<i>Stenotrophomonas multophila</i>	0	1
<i>Eikenella</i>	0	1
<i>Prevotella</i>	0	1
<i>Chryseobacterium indologenes</i>	1	0
<i>Pseudomonas</i>	2	0
Other non-lactose fermenting gram negative rods	0	1
Various and mixed anaerobic species	1	11
<i>Enterococcus</i>	1	1
Non-spore-forming gram-positive rods, not otherwise specified	0	1

causing fulminant systemic disease is *Clostridium novyi*. This organism has been reported in multiple deaths of injection drug users in the United Kingdom and Ireland (4,9) but was not encountered in the current study. It is possible that *C. novyi* was overlooked because in 10 of the 27 isolates the microbiology laboratory did not identify the clostridial species.

Compared with the disease associated with black tar injection, the microbiology of necrotizing fasciitis not associated with drug injection was significantly different. In those categories associated with minor trauma, local skin conditions, and occurring spontaneously, streptococcal species predominated. *Streptococcus pyogenes* (Lancefield group A Streptococcus) was highly represented, occurring in 14 of the 32 cases not associated with drug injection. *S. pyogenes* is considered a virulent organism, capable of causing disease in healthy, uncompromised individuals (10,11).

*Staphylococcus aureus* represents another potentially virulent organism that has been reported in necrotizing fasciitis due to needle punctures (12) and injection drug use (13). In the present study, *S. aureus* was isolated from 14 cases, eight due to black tar injection and six not associated with drug injection. Two isolates were methicillin resistant (MRSA). A recent report from California concluded that MRSA infections were becoming increasingly more common in cases of necrotizing fasciitis due to injection drug use (13).

Polymicrobial infections accounted for 28 cases in the current study, in 15 of the 32 cases due to black tar injection and in 13 of the 32 cases not associated with injection drug use. These results coincide with a previous report that emphasized the polymicrobial nature of necrotizing fasciitis, which is more likely to be recognized when more refined methods are used for specimen collection, transportation, and cultivation (14). The same study also showed how the microbiology of necrotizing fasciitis correlated with sources of infection and predisposing conditions. Other infections associated with heroin injection have been noted in the past. In one outbreak, disseminated candidiasis was traced to fresh lemon juice, which is sometimes used as an acidification method to dissolve heroin (15,16). Despite earlier reports suggesting that nonsteroidal anti-inflammatory drugs (NSAIDs) increase the risk of streptococcal necrotizing fasciitis, a systematic literature review of prospective studies (17) concluded otherwise, showing that NSAID therapy neither promoted the development of streptococcal necrotizing fasciitis nor worsened established streptococcal infections.

Altogether this study supports the conclusion that necrotizing fasciitis caused by injection of black tar heroin is substantially different from the same disease resulting from other causes. Necrotizing fasciitis associated with heroin injection is predominantly a clostridial infection, while the others are predominantly streptococcal infections. While all cases of necrotizing fasciitis are potentially fatal, this conclusion indicates that different prevention and treatment strategies are necessary depending on the underlying source of infection. This conclusion also has relevance for death investigation in that clostridial infection is a likely indicator of injection drug abuse. Furthermore, clusters of infections due to the same organism may indicate a common source of the drug, and it cannot be overlooked that deliberate contamination of a drug would constitute homicide. Finally, to better understand the microbiology of

injection drug abuse, and because the sources of drugs vary greatly from region to region, it would be important that future reports include descriptions of the physical state and likely source of drugs common to the region where the infections originate.

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Additional information and reprint requests:

Richard C. Harruff, M.D., Ph.D.  
King County Medical Examiner's Office  
325 Ninth Avenue  
HMC Box 359792  
Seattle, WA 98104-2499  
E-mail: richard.harruff@metrokc.gov