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Culture-Proven Thorn-Associated Infections in Arizona: 10-Year Experience at Mayo Clinic

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Background. Thorn injuries are common in the desert Southwest; however, the frequency and microbiology of thorn-associated infections have not been systematically described. Most information comes from case reports describing infections from atypical or environmental microorganisms. Our aim was to summarize the spectrum of thorn-associated infections.

Methods. We conducted a retrospective review of electronic health records for patients presenting to our institution from January 1, 2005 to December 31, 2014 for treatment of thorn-associated injuries and then focused on the patients with cultures.

Results. Of 2758 records reviewed, 1327 patients had thorn-associated injuries; however, only 58 (4.4%) had cultures. Of these patients, 37 (64%) had positive findings; 5 had polymicrobial infection. The most commonly identified organisms were *Staphylococcus aureus* (n = 22, 59.0%) and coagulase-negative *Staphylococcus* species (n = 8, 21.6%). Other pathogens included *Nocardia* species (n = 3, 8.1%), *Streptococcus* species (n = 2, 5.4%), Gram-negative bacteria (n = 2, 5.4%), *Aspergillus* species (n = 2, 5.4%), *Paecilomyces lilacinus* (n = 1, 2.7%), and *Candida* species (n = 1, 2.7%). There were no infections caused by *Pantoea agglomerans*, *Sporothrix schenckii*, or *Coccidioides* spp.

Conclusions. In contrast to most published case reports, we found that typical cutaneous microorganisms, such as *Staphylococcus* species, caused the majority of culture-positive, thorn-related infections.

Keywords. arthritis; cactus; infection; tenosynovitis; thorn.

Cactus and other plant-related thorn injuries are common in the desert Southwestern United States and often prompt patients to seek medical attention. However, few reports in the medical literature describe the frequency and causes of thorn-associated infections [1–3]. Most published information about such infections consists of case reports detailing atypical organisms such as *Pantoea agglomerans* [4–10] (formerly *Enterobacter agglomerans*) [11], *Clostridium tetani* [12], *Serratia fonticola* [13], *Yersinia enterocolitica* [14], *Curtobacterium flaccumfaciens* [15], *Cellulosimicrobium cellulans* [16], *Alternaria* [17], *Sporothrix* [18], *Apophysomyces elegans* [19], and *Coccidioides* [20, 21]. In addition, most of these case reports describe deeper infections [22], such as osteomyelitis, tenosynovitis, and septic arthritis rather than the cellulitis that is more commonly seen in clinical practice. We

contacted the Maricopa County Department of Public Health in Arizona to ask whether a larger database of thorn-related infections existed, and there was none. Therefore, the aim of this retrospective study was to review a 10-year experience with thorn injury and to report the pathogens cultured from such lesions.

METHODS

This retrospective, descriptive study was approved by the Mayo Clinic Institutional Review Board. We included patients who were seen at Mayo Clinic in Arizona from January 1, 2005 to December 31, 2014 for wounds caused by thorn injuries. Clinical text from charts during this time period was electronically searched for the key words "thorn," "cactus," "needle," "Saguaro," and "spines." Records of the identified cohort were then reexamined in a second search for the term "culture" within 1 year of being seen at our institution. Individual records were then reviewed to determine which patients sustained thorn injuries that were ultimately cultured.

Cases were included when an adult patient (age ≥18 years) provided a history of an observed thorn puncture (any plant type) with no other suspected cause of the injury. Patients were included if a culture was performed at the site of injury or if blood cultures were obtained as part of the evaluation. Cases of "possible" thorn injuries (the patient was suspicious, but a thorn injury was not confirmed) were rejected.

The data were analyzed using simple descriptive statistics of frequencies, means, and medians. Two sample t tests were used to compare both the culture-positive and -negative groups and the cultured and uncultured groups, unless categorical variables were present, and in those cases, comparisons were performed using χ^2 and Fisher exact tests when appropriate. Time intervals were compared using a Wilcoxon 2-sample test. A P value of <.05 was considered statistically significant.

RESULTS

We identified 2758 potential cases, 1327 of which were identified as thorn-related injuries (including but not limited to cactus, agave, rose, bougainvillea, palm, and mesquite thorns) (Figure 1). Among the 1431 excluded cases, 184 suspected (but did not witness) thorn injury. Of these, 57 had cultures performed but were still excluded. Of the 1327 patients with thorn injuries, 58 (4.4%) had both a witnessed thorn penetration and cultures performed. Only this group of 58 patients was further analyzed.

Table 1 describes demographic characteristics, location of thorn injury, imaging tests done, and procedures performed for the 58 study patients and compares the group with positive-culture results (n = 37, 64%) with those with negative-culture results (n = 21, 36%). There was no difference in demographic characteristics or the presence of comorbidities between the culture-positive and culture-negative groups. Twenty-two of the patients (38%) were seen initially at an outside facility, and the initial presentations of 2 were unknown. The remaining patients (n = 34, 59%) were initially seen in the following clinics at Mayo Clinic in Arizona: emergency department (n = 12, 35%), family medicine (n = 7, 21%), general internal medicine (n = 9, 26%), dermatology (n = 4, 12%), hand surgery (n = 1, 3%), and orthopedics (n = 1, 3%).

Table 2 describes the times from the thorn injury to medical attention. Most of the 58 patients sought medical attention within 1 month of their thorn injury, but 3 patients were first seen more than 1 year after the initial injury. The time to resolution of infection was abstracted from the records when

available, but because this information was frequently absent, we did not analyze it further.

Of the 58 patients with cultures, 37 (64%) had positive-culture results. Five patients had positive cultures from more than 1 specimen. Of the 37 patients with positive results, 32 (86%) positive results were detected from samples of skin or soft tissues, 3 (8%) from blood culture, 5 (14%) from tissue biopsies, and 2 (5%) from joint aspirates. Thirty (52%) patients had fungal cultures done, 3 of which had positive results. One of the cultures grew *Candida* species, another grew *Aspergillus niger*, and the third grew *A niger* and *Paecilomyces lilacinus*. Twenty-three patients (40%) had cultures performed for mycobacteria, none of which had positive results.

Most of the 58 cultured, thorn-associated infections were clinically consistent with cellulitis and abscess (Table 3). Most positive cultures grew *Staphylococcus aureus* (n = 22) (Table 4), 6 of which were methicillin-resistant *S aureus*, and 16 were methicillin-susceptible *S aureus*. Coagulase-negative *Staphylococcus* species (CoNS) (n = 8) were the second most commonly identified microorganism, but they often accompanied other pathogens (n = 4). One culture result was positive for *Staphylococcus lugdunensis*, thought to be a pathogen, and 3 others (not speciated) were isolated in low levels and may have been skin contaminants. The 3 *Nocardia* species were detected in surgical soft-tissue specimens and included *Nocardia abscessus*, *Nocardia brasiliensis*, and *Nocardia* not otherwise specified. All 3 of the patients with *Nocardia* reported incurring their injuries while working in the yard (from an agave or rose thorn, a rose thorn, and a lime-tree thorn). One of these patients had a history of cancer, another had a history of osteomyelitis, and the third had no targeted comorbidities. Other pathogens included *Streptococcus* species (n = 2, 5%), *Aspergillus* (n = 2, 5%), *Candida* species (n = 1, 3%), and *P lilacinus* (n = 1, 3%). There were no infections due to *P agglomerans*, *Sporothrix schenckii*, or *Coccidioides* species.

DISCUSSION

In the present study, we aimed to comprehensively describe the range of culture-positive thorn-associated infections at our facility and the relative frequency of unusual organisms for similar injuries occurring in the desert Southwestern United States to give guidance to healthcare providers who treat patients with probable thorn-associated infection. Although thorn-related injuries were relatively common (1327 injuries in 10 years), only a small fraction of our patients with certain thorn injury (4%) had cultures performed, resulting in only 37 (3%) patients with positive results from which to describe the microbiology.

Most published case reports of thorn-associated infections describe environmental pathogens such as *P agglomerans* [4–10], *Nocardia* [23, 24], or fungal [17–21] organisms. In particular, *P agglomerans*, a plant-associated, Gram-negative aerobic bacillus, has been cultured from numerous patients
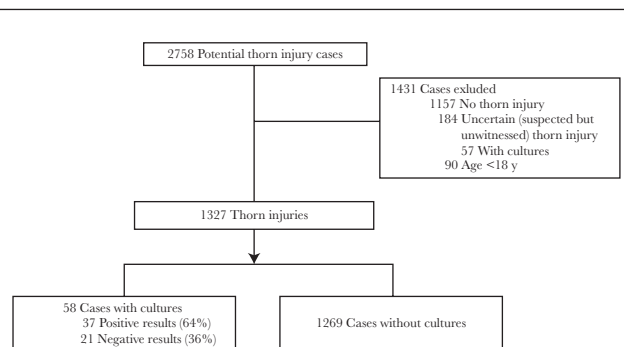
Figure 1. Flow diagram for the cohort of patients with potential thorn injuries for the 10-year study period (January 1, 2005 through December 31, 2014).

Flow diagram contents:
- 2758 Potential thorn injury cases
- 1431 Cases exluded
  - 1157 No thorn injury
  - 184 Uncertain (suspected but unwitnessed) thorn injury
  - 57 With cultures
  - 90 Age <18 y
- 1327 Thorn injuries
- 58 Cases with cultures
  - 37 Positive results (64%)
  - 21 Negative results (36%)
- 1269 Cases without cultures

Table 1. Demographic Characteristics of Patients With Positive- and Negative-Culture Results[a]

Characteristic	Positive Culture Results (n = 37)	Negative Culture Results (n = 21)	Total (N = 58)	P Value[b]
Age				.25
Median	63.0	57.0	60.5	
Range	(39.0–83.0)	(24.0–82.0)	(24.0–83.0)	
Sex				.28
Female	14 (37.8)	11 (52.4)	25 (43.1)	
Male	23 (62.2)	10 (47.6)	33 (56.9)	
Comorbidity				.41
≥1	19 (51.4)	8 (38.1)	27 (46.6)	
Activity				.94
Gardening	13 (35.1)	8 (38.1)	21 (36.2)	
Mountain biking	1 (2.7)	1 (4.8)	2 (3.4)	
Other	13 (35.1)	8 (38.1)	21 (36.2)	
Location of wound[c]				
Upper extremity	26 (70.3)	17 (81.0)	43 (74.1)	.37
Lower extremity	12 (32.4)	5 (23.8)	17 (29.3)	.49
Number of organisms				<.001
1	32 (86.5)	0	32 (55.2)	
≥2	5 (13.5)	0	5 (8.6)	
Foreign body found	21 (56.8)	11 (52.4)	32 (55.2)	.79
Surgical debridement	9 (24.3)	11 (52.4)	20 (34.5)	.04
Bedside incision and drainage	17 (45.9)	3 (14.3)	20 (34.5)	.02
Imaging studies				
Radiographs	15 (40.5)	10 (47.6)	25 (43.1)	.80
Magnetic resonance imaging	6 (16.2)	7 (33.3)	13 (22.4)	.19
Computed tomography scan	1 (2.7)	1 (4.8)	2 (3.4)	>.99
Hospitalization	17 (45.9)	9 (42.9)	26 (44.8)	>.99
Seen at outside facility first	16 (43.2)	6 (28.6)	22 (37.9)	.40

[a]Results are presented as no. (%) unless specified otherwise.

[b]Ages were compared using the 2-sample t test. For other categorical variables, the comparisons between the 2 groups were done using the χ^2 test or Fisher exact test, as appropriate.

[c]Two patients had both upper and lower extremity wounds.

with thorn-induced septic arthritis [4, 5, 8–10]. The recent, successful detection of these atypical pathogens may reflect improved diagnostic techniques, such as the use of special media, incubation at organism-specific temperatures, polymerase chain reaction and other molecular techniques, or histologic evaluation [25, 26]. In our cohort with culture-positive, confirmed thorn infection, we did not detect any *P agglomerans,* nor did we identify any thorn-associated infections related to *S schenckii,* or *Coccidioides* species despite *Coccidioides* being endemic in the Phoenix, Arizona, area. Perhaps we would have identified more of these environmental organisms had more of the thorn injuries been cultured, although this seems unlikely because the common empiric antimicrobial agents used for skin infections would not have had activity against environmental fungi, mycobacteria, or Gram-negative bacteria.

Table 2. Time From Thorn Injury to Medical Attention for Patients With Positive and Negative Culture Results

Time	Positive Culture Results (n = 37)	Negative Culture Results (n = 21)	Total (N = 58)	P Value[a]
Time from injury to first evaluation				.19
No.	33	15	48	
Missing data, patients	4	6	10	
Median (range), days	7.0 (1.0–240.0)	10.0 (1.0–1461.0)	10.0 (1.0–1461.0)	
Time from injury to culture				.68
No.	31	10	41	
Missing data, patients	6	11	17	
Median (range), days	10.0 (1.0–386.0)	10.5 (2.0–275.0)	10.0 (1.0–386.0)	

[a]Wilcoxon 2-sample test.

Table 3. Common Clinical Manifestations of Cultured Thorn-Associated Infections[a]

Clinical Manifestation	Positive Culture Results (n = 37)	Negative Culture Results (n = 21)	Total (N = 58)	P Value
Skin and/or soft tissue infection	24 (64.9)	6 (28.6)	30 (51.7)	.01
Felon abscess	11 (29.7)	4 (19.0)	15 (25.9)	.53
Osteomyelitis	3 (8.1)	1 (4.8)	4 (6.9)	>.99
Septic bursitis	1 (2.7)	0	1 (1.7)	>.99
Flexor tenosynovitis	0	5 (23.8)	5 (8.6)	.004
Septic arthritis	3 (8.1)	1 (4.8)	4 (6.9)	>.99

[a]All data are presented as No. (%).

In contrast, our study showed that the most common pathogen in cultured thorn-associated infections was *S aureus*, which was identified in 22 (59%) of the 37 patients with positive-culture results. The 8 cultures with CoNS also tested positive for other pathogens or were isolated alone in low levels, making the significance uncertain. Although the type of plant thorn responsible for each injury was frequently documented, we were unable to correlate any specific microorganism with a particular plant. It has been suggested that a localized allergic reaction to a foreign body (thorn) may result in aseptic inflammation [27–29], but because we did not focus on histopathology, we could not address this possibility.

Of the 1327 patients with suspected thorn injuries, we excluded 57 who had cultures performed at the site of the wound because, although the patients were suspicious of a thorn injury, they were unable to confirm with certainty that a thorn injury had preceded the wound. Thirty-four of these 57 patients had positive-culture results, and the spectrum of organisms was similar to the 37 confirmed thorn infections presented in the current study and included *S aureus* (n = 15, 44%), fungal infection (n = 7, 21%; primarily various *Aspergillus* species), coagulase-negative *Staphylococcus* (n = 6, 18%), mycobacteria species (n = 2, 6%; including 1 each of *Mycobacterium avium* complex and *Mycobacterium kubicae*), and Gram-negative bacilli (n = 4, 12%; including 1 *P agglomerans*). Although exclusion of the "possible" thorn injuries likely eliminated some true thorn-related infections, we considered it important to keep this study free from injuries that potentially occurred as a result of another mechanism.

Both time to presentation (sometimes delayed) and diagnostic tools used influenced the diagnosis of thorn injury. The more time that elapses after an injury, the greater the potential for a diagnostic dilemma. We observed a wide time range from injury to medical attention, including several years in some cases. Such examples show that chronic complications, such as skin changes, bony destruction, and late (secondary) infections, are not uncommon. Case reports have documented pseudotumors, vascular abnormalities, and cysts on imaging that were ultimately from thorn-related changes [7, 30, 31]. Given the delayed and unusual presentations often cited in the literature, penetrating vegetation should be considered for the differential diagnosis in cases of persistent or recurrent abnormalities or when infections are found with no known source. This knowledge can provide a caregiver an opportunity to explore relevant details of the history for clues that may influence management. Timely wound culture, sensitive imaging modalities, empiric antibiotics, and a thorough search for the thorn can be crucial in treating such an injury.

The number of radiographs ordered for this cohort suggests that healthcare providers were searching for foreign bodies and soft tissue or bony changes in the area of injury. However, radiographs are less sensitive than other imaging techniques (ultrasound, computed tomography, magnetic resonance imaging) for detecting thorns [2, 3, 32]. Within our cohort, 2 patients had thorns detected on magnetic resonance imaging, 1 of which was successfully removed.

The activity related to the thorn-associated injury was often a valuable part of the history. Gardening is already recognized in

Table 4. Selected Clinical Manifestations of Selected Microorganisms Isolated in Culture[a,b]

Clinical Manifestation	*Staphylococcus aureus*	CoNS	*Streptococcus* Species	*Nocardia* Species	Fungi	Gram- Negative Bacteria
Cellulitis (n = 14)	10 (71.4)	2 (14.3)	1 (7.1)	1 (7.1)	0	0
Felon abscess (n = 13)	8 (61.5)	1 (7.7)	0	2 (15.4)	0	2 (15.4)
Osteomyelitis (n = 4)	2 (50.0)	2 (50.0)	0	0	0	0
Septic arthritis (n = 4)	1 (25.0)	2 (50.0)	0	0	1 (25.0)	0
Septic bursitis (n = 1)	1 (100.0)	0	0	0	0	0

Abbreviations: CoNS, coagulase-negative *Staphylococccus* species.
[a]All data are presented as No. (%).
[b]Patients may have had more than 1 microorganism per clinical manifestation and more than 1 clinical manifestation per patient.

the literature as a risk factor for thorn injury, and our findings supported this [8, 22–24]. Fewer biking- and hiking-related injuries occurred than expected, even though a strong culture of hiking and mountain biking exists in the Phoenix area. It is noteworthy to mention that there were 5 medical practitioners in the study cohort. We conjecture that this group may have been more likely to seek help for severe infection.

Twenty of the 58 patients (34%) (Table 1) were treated with surgical debridement, which often, but not always, identified embedded vegetative material. It also must be noted that more patients who had a surgical debridement had negative cultures than those who did not have a surgical procedure. The data we collected did not offer an explanation for this finding; however, we hypothesize the possibility that preprocedure antibiotics may have rendered cultures negative.

This study had several potential limitations. The search methodology to identify the study population proved to be difficult, and no prior studies in the literature provided precedent. We initially used *International Classification of Diseases, Ninth Revision* (ICD-9) codes that included "cellulitis," "abscess," "foreign body," and "wounds," which produced tens of thousands of potential cases, a small proportion of which were our target population. Another ICD-9 code search for penetrating injury (E920.8) was insensitive and identified too few cases. Therefore, we identified the potential study candidates by using an electronic text-word search of electronic health records. This search method was more specific and more sensitive than our previous searches of diagnosis codes. Despite this laborious search method, we were aware of a few missed cases of patients with plant-injury-related infections that were described in the record without the use of our search terms; an example was a patient who sustained an injury from an agave plant and who developed a subsequent infection with *Nocardia* species. Additional organisms identified from other plant-related injuries included *Streptococcus agalactiae* and *Enterobacter cloacae*.

The small proportion of patients with positive cultures is potentially concerning as a true representation of all thorn-related infections. When we compared the demographic characteristics (sex and age) of the cohorts with cultured (n = 58) versus uncultured (n = 1269) wounds, there was no statistical difference between the groups for sex ($P = .68$) and age ($P = .40$). However, the lack of difference in the 2 demographic characteristics between these groups does not guarantee that the smaller sample is perfectly representative of the larger group.

There are other potential limitations to the data. Selection bias may have occurred against someone presenting with systemic (rather than localized) symptoms or years after a thorn injury; in these cases, establishing a cause is more difficult. Many patients presented with infected wounds, were treated empirically, and improved without having a wound culture. In addition, only a minority of patients had fungal and mycobacterial cultures performed, and it is possible that our findings were

biased as a result. However, when injuries resolved without need for a culture, it is hard to argue that we missed many fungal or mycobacterial infections. Finally, the use of empiric antibiotics may have rendered many cultures negative. A prospective study will be required to more fully describe the full spectrum of microorganisms complicating thorn-associated infections.

CONCLUSIONS

In conclusion, thorn injuries are common in the desert, but few lead to detection of a microorganism near the site of injury. In the current study of culture-positive, thorn-associated infections, *Staphylococcus* species were the most commonly isolated pathogens. These results suggest that after localization and removal of the thorn and obtaining cultures, empiric therapy for thorn-associated infections should initially target typical skin flora.

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