

FIXATION ON HISTOLOGY

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Aftermath of the Joplin tornado

At 5.17pm on the evening of Sunday 22nd May 2011, the National Weather Service issued a tornado warning for an area near the Missouri - Kansas state line. In response, the civil defence sirens were activated and at 5.34pm, the tornado touched down gently at an EF0 level of intensity (Figure 1). By the time it dissipated some 38 minutes later, it had reached speeds of more than 200 miles per hour (EF5 level) and devastated the city of Joplin, Missouri. With a total track length of more than 20 miles and a width of almost one mile, this tornado was unusual in that it intensified very quickly.







	Damage: Incredible EF5 Windspeeds: Greater than 322km/h (200mph)
	Damage: Devastating EF4 Windspeeds: 267-322km/h (166-200mph)
	Damage: Severe EF3 Windspeeds: 218-266km/h (136-165mph)
	Damage: Considerable EF2 Windspeeds: 178-217km/h (111-135mph)
	Damage: Moderate EF1 Windspeeds: 138-177km/h (86-110 mph)
	Damage: Light EF0 Windspeeds: 105-137km/h (65-85mph)

Figure 1. Tornado levels on the Enhanced Fujita scale

Within a short time, entire neighbourhoods were destroyed, and the residents of Joplin had endured showers of debris hurled at them at unbelievable speeds. With 158 deaths and damage amounting to 2.8 billion American dollars, it ranked as the costliest single tornado in the history of the United States (Figure 2). In the weeks that followed, medical staff began noticing something very strange among the injured.



Figure 2. Combined images showing the damage in Joplin following the tornado

Flesh wounds began turning black with a white, fuzzy mould emerging from them. Samples were taken for culture and medical staff were shocked when they examined the laboratory results. Thirteen of the injured had become infected with a fungus that is seldom seen in humans. Belonging to one of the major groups of fungi, *Apophysomyces trapeziformis* is a parasitic fungus of the order Mucorales (Figure 3). By definition, these fungi survive on decaying and rotten vegetation and very rarely infect humans. When they do, they cause mucormycosis, a rare and devastating infection that can sometimes prove fatal. Although the disease can affect the skin following traumatic inoculation, it can also involve the brain and lungs and spread throughout the body.

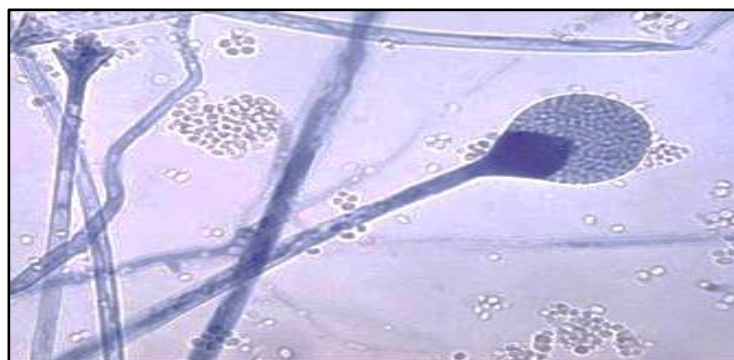


Figure 3. The *Apophysomyces trapeziformis* fungus

Under tornado conditions, infected debris injects the fungus at excessive speeds directly into human flesh. Once inside the body, the fungus infiltrates blood vessels where its filaments create clots that prevent the blood from flowing (Figure 4). As the tissue dies it blackens and often sprouts a white, fuzzy coat of mould. These fungal infections are generally treated with antifungal drugs and debridement (regular surgical removal of dead flesh). All thirteen of those infected had been in the zone of greatest destruction and had a high number of wounds and lacerations which correlates well with the rate of *Apophysomyces* infection. Of those infected, five patients died although it was uncertain whether the fungus was the primary cause of death as no autopsies were carried out. Cutaneous mucormycosis has been documented previously in the wake of other natural disasters. Following the volcanic eruption in Colombia in 1985 and the Indonesian tsunami in 2004, this fungus reared its ugly head by causing infections through penetrating trauma. The injuries associated with this fungus have been compared to those resulting from combat where increased rates of fungal-related traumas were reported by military personnel.

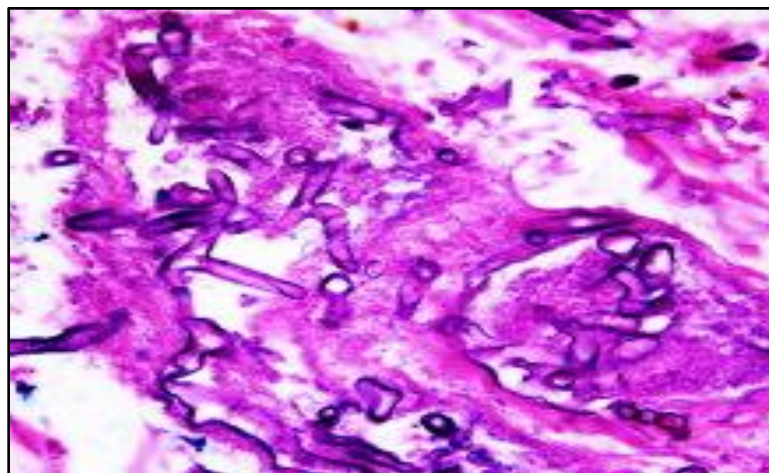


Figure 4. Mucormycosis with blood vessel involvement

Natural disasters are complex events although outbreaks of infectious disease are relatively uncommon as immediate consequences of them. However, the risk for soft tissue infections following any disaster is greatly increased when wounds become contaminated with soil, water, and debris. Most recognized infections associated with disaster are bacterial although fungal infections in wounds can also occur. As these infections often appear clinically similar to those contaminated by bacteria, awareness by the medical fraternity is paramount when treating survivors of such disasters. As the discovery following the Joplin tornado revealed, the identification

of drug resistant Gram-negative bacteria in the wounds of patients already infected with the *Apophysomyces* fungus indicates that different organisms often work in tandem. In this instance, it was elucidated that as the tornado initially touched down on farmland during its approach, agrarian factors may have played their role in exposing residents of Joplin to further deadly threats.

Further reading

1. Biotic environments supporting the persistence of clinically relevant Mucormycetes. Richardson MD & Rautemaa-Richardson R. *Journal of Fungi* 2020;6(1):4
2. Fungal diseases as neglected pathogens: A wake-up call to public health officials. Rodrigues ML & Nosanchuk JD. *PLoS Neglected Tropical Diseases* 2020; 14(2):e0007964
3. Invasive fungal infections after natural disasters. Benedict K & Park BJ. *Emerging Infectious Diseases* 2014;20(3):349-355
4. Mucormycosis due to *Apophysomyces* species complex - 25 years' experience at a tertiary care hospital in southern India. Pamidimukkala U, Sudhaharan S et al. *Medical Mycology* 2020;58(4):425-433
5. Necrotizing cutaneous mucormycosis after a tornado in Joplin, Missouri, in 2011. Neblett Fanfair R, Benedict K et al. *New England Journal of Medicine* 2012; 367(23):2214-2225

Phil Bryant

February 2021