Hyperthermia mediated by 'magnetotactic bacteria' could kill S. aureus

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As Staphylococcus aureus becomes increasingly resistant to antibiotics, new methods of killing these pathogens are urgently needed. Now a team of investigators has demonstrated in laboratory rodents that a form of hyperthermia using magnetic nanocrystals, and targeted to the pathogens, can kill S. aureus. The research is published ahead of print February 12 in *Applied and Environmental Microbiology*, a journal of the American Society for Microbiology.

Certain bacteria, including the species, Magnetooliva massalia strain MO-1, synthesize intracellular magnetic nanocrystals—"magnetosomes"—that can create heat when placed in an alternating magnetic field. Applying a magnetic field, the researchers hypothesized, could also be used to guide the bacteria into the depths of an infected wound. Of course, the heat generated by the magnetic crystals would kill not only S. aureus, but also the bacteria containing the nanoparticles. Thus, they posited, these "magnetotactic bacteria" could be used in the manner of suicide bombers, to kill S. aureus.

In the study, the investigators first demonstrated that magnetotactic bacteria in a suspension of S. aureus, interacting with an alternating magnetic field, could raise the temperature of that suspension to 43oC. (109.4oF.). That temperature is sufficient to kill the bacteria.

More importantly, the researchers write, applying the magnetotactic bacterium-mediated hyperthermia to a S. aureus-infected wound in mouse tails, resulted in faster healing than in mice that did not receive

hyperthermia.

The investigators have also engineered polyclonal antibodies onto the surfaces of the magnetotactic bacteria. These bind to S. aureus like stickle burrs, but with the precision of a key into a lock, so that the magnetotactic bacteria do not stick to other species of bacteria, including beneficial bacteria. With the magnetotactic bacteria thus bound to these pathogens, the hyperthermia from the magnetic particles would be more likely to kill the pathogens, and less likely to damage healthy tissue, said coauthor Tao Song, PhD, professor of bioelectromagnetics at Beijing Key Laboratory of Bioelectromagnetism, Institute of Electrical Engineering, Chinese Academy of Sciences, Beijing, China.

Currently, the team is also investigating the mechanism of magnetotaxis. They want to find out how the bacteria interact with the magnetic torque, and how the magnetic torque converted to biochemical signals that steer the bacterial swimming, said coauthor Long-Fei Wu, PhD, research director of the Laboratoire de Chimie Bactérienne, Institut de Microbiologie de la Mediterranée, CNRS, Aix-Marseille University, Marseille, France. (The CNRS is France's largest governmental research organization, and is headquartered in Paris.)

"Targeting magnetic nanoparticles to tumors or infected tissues can significantly improve the effectiveness of magnetic hyperthermia and reduce unacceptable coincident heating of healthy tissue," said Song. These principles outlined in this research could be generalized to kill other types of pathogens.

More information: Changyou Chen et al. Evaluation of the anti-activity of magnetotactic bacteria-mediated magnetic hyperthermia , *Applied and Environmental Microbiology* (2016). DOI: 10.1128/AEM.04103-15

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