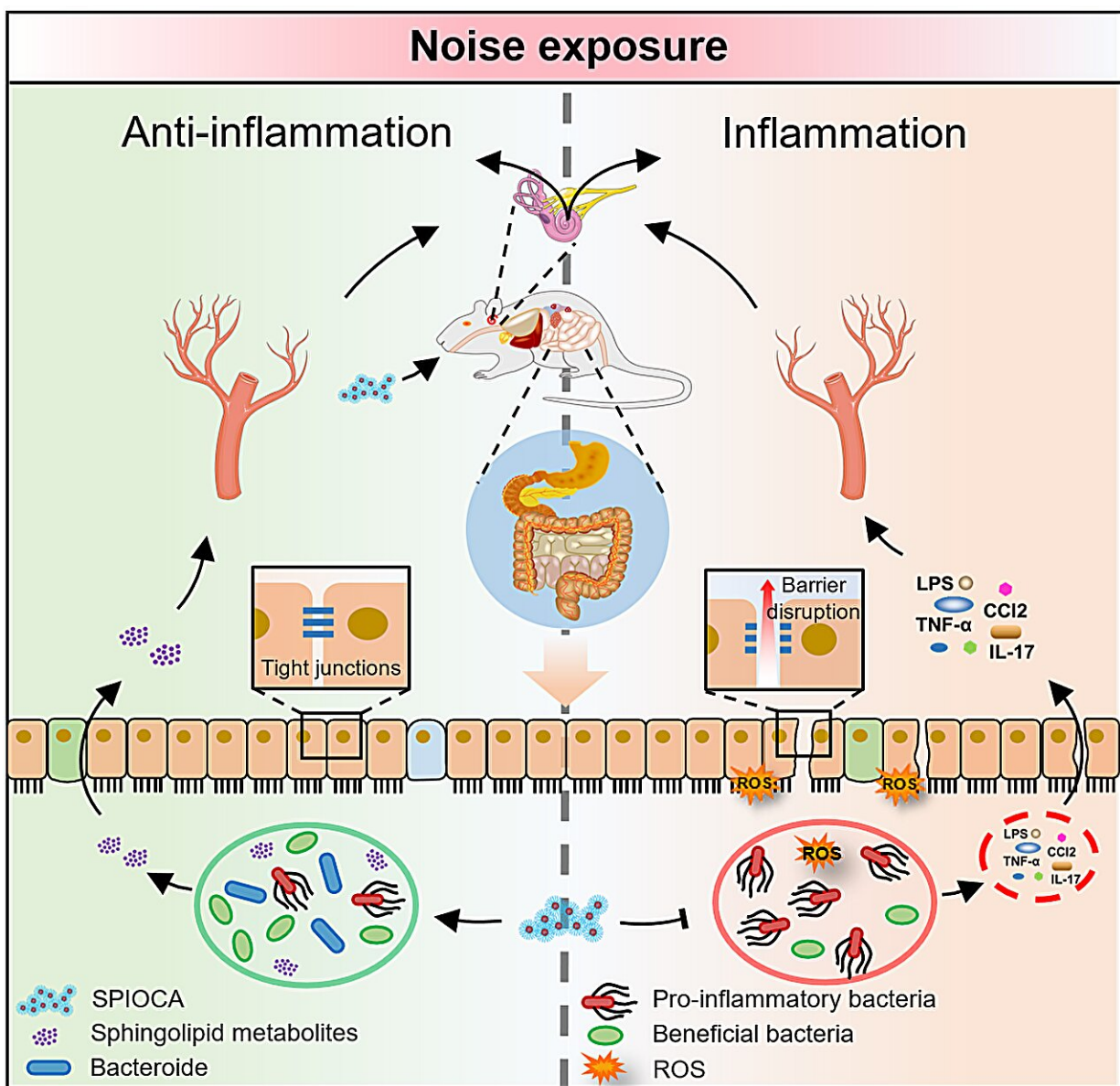


Superparamagnetic iron oxide nanoparticle regulates microbiota–gut–inner ear axis for hearing protection

June 25 2024



Noise can lead to gut microbiota dysbiosis, resulting in an increase in various harmful bacteria and oxidative stress levels within the gut. Pro-inflammatory factors produced by harmful bacteria are transported to the cochlea via the bloodstream, causing elevated inflammation levels in the cochlea and leading to hearing loss. SPIOCA inhibits noise-induced gut microbiota dysbiosis, helps maintain the integrity of the gut barrier, and thus prevents the transport of pro-inflammatory factors to the cochlea. Additionally, SPIOCA specifically induces an increase in sphingolipid-producing Bacteroides, thereby regulating sphingolipid metabolism within the gut-ear axis, further enhancing its protective effect on hearing. Credit: Science China Press

As industrialization and urbanization accelerate, noise-induced hearing loss (NIHL) has become an increasingly prevalent sensorineural hearing disorder. Despite the widespread use of hearing aids and cochlear implants to alleviate some of the challenges posed by hearing loss, these devices offer limited treatment efficacy and cannot reverse or cure damage to the auditory nerves and inner ear structures. Consequently, there is an urgent need to develop novel treatments for NIHL to effectively prevent and repair hearing loss, thereby improving patients' quality of life.

In traditional Chinese medicine, magnetite (Magnetitum) and hematite (Hematitum) have been used for centuries to treat various neurological disorders, including [hearing](#) loss. Magnetite is known for its calming, sedative, and hearing restoration effects, while hematite is renowned for its ability to soothe the liver, anchor the spirit, and provide a calming effect. These mineral medicines have been widely applied in [clinical practice](#), accumulating a wealth of experience and [case studies](#).

Inspired by traditional Chinese medicine, modern scientists have begun to explore how to combine the active ingredients of these traditional

medicines with modern technology to develop more targeted and effective treatments. The research team used FDA-approved carboxymethyl cellulose (CMC) as a coating agent to develop a pH-responsive superparamagnetic iron oxide nanoparticle assembly (SPIOCA). SPIOCA exhibits excellent biocompatibility and can effectively resist degradation by stomach acid.

The study found that oral administration of SPIOCA can significantly inhibit immune-inflammatory responses in the cochlea, effectively protecting against noise-induced hearing loss and cochlear hair cell loss. This discovery provides new possibilities for treating NIHL.

In their research, the team found that SPIOCA exerts its protective effects by regulating the composition of the gut microbiota. Noise exposure often leads to the proliferation of harmful bacteria, disrupting the balance of the gut microbiota. Oral administration of SPIOCA not only reduces the proliferation of harmful bacteria but also maintains the number of beneficial bacteria, thereby stabilizing the gut microenvironment.

The stability of the gut microbiota is crucial for suppressing intestinal inflammation and oxidative stress responses. SPIOCA protects the integrity of the gut barrier by inhibiting intestinal inflammation and oxidative stress. This process reduces the transport of pro-inflammatory factors into the bloodstream, thereby lowering the risk of systemic inflammatory responses. This protective effect extends to the inner ear, effectively safeguarding auditory function.

Sphingolipids are a class of lipids that play a crucial role in [cell signaling](#) and [structural stability](#), and their metabolic pathways are essential for hearing protection. The study also found that SPIOCA can specifically increase the abundance of Bacteroides, a beneficial bacterium in the gut that can produce sphingolipids. By regulating sphingolipid metabolism in

the gut-inner ear axis, SPIOCA further enhances its protective effect on hearing.

The findings of this study not only provide a new method for hearing protection but also offer new ideas for treating other microbiota dysbiosis-related diseases. The research was [published](#) in the journal *National Science Review* under the title "Superparamagnetic iron oxide nanoparticle regulates microbiota–gut–inner ear axis for hearing protection."

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More information: Zhanhang Guo et al, Superparamagnetic iron oxide nanoparticle regulates microbiota–gut–inner ear axis for hearing protection, *National Science Review* (2024). [DOI: 10.1093/nsr/nwae100](https://doi.org/10.1093/nsr/nwae100)

Provided by Science China Press

Citation: Superparamagnetic iron oxide nanoparticle regulates microbiota–gut–inner ear axis for hearing protection (2024, June 25) retrieved 29 June 2024 from <https://medicalxpress.com/news/2024-06-superparamagnetic-iron-oxide-nanoparticle-microbiotagutinner.html>

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