Proof-of-concept study shows fossil fuels responsible for heart arrhythmias in mammals

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One of the most common byproducts of the burning of fossil fuels, phenanthrene, causes heart arrhythmias in mice, proving for the first

time it is toxic to mammals.

The study, led by Professor Holly Shiels from The University of Manchester was published in the journal *Environmental Health Perspectives* on 1 Nov. 2023.

Thanks to earlier work by Professor Shiels in conjunction with scientists at Stanford University, University of Bristol, Moscow State University and The National Oceanic and Atmospheric Association (NOAA), phenanthrene's toxicity to the hearts of fish and crustaceans (crayfish) has been well established.

But now the team have discovered the change also occurs in healthy mouse hearts when directly exposed to phenanthrene, mimicking what happens when we breath in pollution.

She said, "We've known that phenanthrene is causally linked to cardiotoxicity in fish for many years—scientists recognized this following the disastrous impact of the Exxon Valdez oil disaster in Alaska in 1989.

"But we now know this same effect occurs in mammals, and we are also able to show its causal mechanism."

Phenanthrene is a polycyclic aromatic hydrocarbon (PAH) that is present in crude oil and emitted into the air when fossil fuels are burnt.

"It is widely known that PAH's in general are bad for human health, but no one really studied the impact of the lower molecular weight PAH's," said professor Shiels.

Dr. Sana Yaar, a Ph.D. student at The University of Manchester who is the lead author on the study, said, "Similar effects in humans could have

serious health consequences which is why we need greater regulatory attention of this ubiquitous pollutant generated from fossil-fuel combustion."

Phenanthrene is one of the compounds produced when fossil fuel is burned; it is present in the gas phase of air pollution and also adheres to the surface of particulate matter (PM).

It can be inhaled into the lung and then translocated into the bloodstream, eventually finding its way to the heart. Epidemiological evidence has long shown a positive association between PM2.5 concentration and the incidence of arrhythmias and both PM and diesel particles have been shown to trigger arrhythmias in rodents.

"Our findings suggest phenanthrene could be involved in these pathologies," says Prof Shiels.

In the study, when phenanthrene was applied to an isolated mouse heart, it caused monophasic tachycardia, which is when the heart starts to beat too quickly.

Tachycardia is a form of arrhythmia common in people who have scarring caused by a heart attack or past heart disease.

The researchers were able isolate single heart muscle cells known as myocytes to understand how electrical dysfunction arrhythmias were achieved.

They showed that phenanthrene disrupts the contractile and electrical function of the mouse heart by blocking ion channels required for synchronous beating of the heart.

"Our study provides proof of concept that phenanthrene exposure can be

proarrhythmic," says Prof Jules Hancox, co-author from the University of Bristol. "To understand the risk this poses to humans, more information is now needed on the levels phenanthrene can reach in the heart following occupational or environmental exposure."

Co-author Ellie England, Ph.D. student from The University of Manchester said, "If the effects of phenanthrene shown here for mice extend to humans, it could be particularly dangerous to people with existing heart problems, including the elderly. Unfortunately, the authorities do not routinely measure the amount of PAHs or more specifically, phenanthrene, in the air.

"We think this is a mistake, as individuals who are vulnerable to heart disease would benefit from knowing the dangers of inhaling or ingesting phenanthrene."

She added, "If monitoring was in place there's much doctors and public health officials could do to help vulnerable people reduce the risk of cardiotoxicity resulting from phenanthrene exposure. For example, at risk groups could stay indoors when there's a spike in pollution, use air purifiers and avoid busier streets."

Professor Shiels added, "As combustion engine technology improves, PM from car exhaust is reducing in many cities and that is beneficial to human health. But what many people don't realize is that fossil fuel combustion also produces ultrafine PM, which has a greater capacity to enter the blood stream due to its small size, is rarely monitored. And even electric cars that increase tire wear particle formation to their heavy weight, also impact our health. That is why we should be routinely monitoring for phenanthrene and other PAHs in the air."

More information: *Environmental Health Perspectives* (2023). ehp.niehs.nih.gov/doi/10.1289/EHP12775

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