Rotorua, hydrogen sulphide and Parkinson’s disease—A possible beneficial link?

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ABSTRACT

AIM: Rotorua city (New Zealand) is known for its ‘rotten egg’ smell, due to high levels of hydrogen sulphide (H₂S) concentrations emitted from local geothermal vents. Studies have shown H₂S as potentially toxic if too high in concentration. However, some health benefits have been observed at lower concentrations. This article summarises what is known about effects of H₂S on health and postulates whether ambient air inhalation levels of H₂S in Rotorua might have a therapeutic role in the management of motor symptoms in Parkinson’s disease (PD).

RESULTS: Chronic H₂S inhalation has been shown to have a protective factor on dopaminergic neurons of animal models of PD. A large-scale survey of long-term Rotorua residents showed no evidence of health detriment nor impairment of cognitive functions. Intriguingly, however, participants in higher H₂S exposures showed a tendency for faster motor response times in a finger tapping test. One of the PD Motor Rating Scale examination tests for PD is finger tapping speed, as this is associated with motor performance. Might it be that relatively high, but safe, H₂S levels in Rotorua could help protect the degradation of dopaminergic neurons associated with PD?

CONCLUSION: An observed beneficial link between chronic H₂S inhalation in PD animal models and improved finger tapping scores in a sample of the Rotorua population, linked to dopaminergic nerve function, is worth investigating further.

High exposure of hydrogen sulfide (H₂S) gas is toxic to the human nervous system, and effects such as necrosis of the cerebral cortex in addition to the basal ganglia have been demonstrated. In ambient air, the respiratory system is the main path for absorption. Toxication reports underline the relationship between H₂S concentrations and related different organ system problems: 1,000,000–2,000,000ppb of H₂S exposure results in immediate respiratory paralysis, 530,000–1,000,000ppb of H₂S causes respiratory arrest, 320,000–530,000ppb of H₂S exposure includes a risk of death as a result of pulmonary oedema, 150,000–250,000ppb of H₂S blocks the olfactory sense and 50,000–100,000ppb can cause serious eye damage. Concentrations of H₂S for eye and respiratory irritation are reported in the range of 10,000–50,000ppb. Hydrogen sulfide intoxications are most often caused by occupational exposure events, up to 100,000ppb. Industrial sites with high risk for potential exposure and associated health problems include Kraft mills and viscose rayon plants, where concentrations are within the range of 3,000–20,000ppb. An accidental release of H₂S in Mexico, Poza Rica, exposed people to concentrations of 1,000,000–2,000,000ppb, and was claimed to be the cause of deaths and hospitalisations. The concentration of H₂S occurring naturally in nature is much lower. Most likely, locations for naturally occurring H₂S gas concentrations in ambient air are those near sulfur springs and lakes in geothermally active areas. In a geothermal area, mean concentrations of up to 1,400ppb have been reported. In contrast, maximum clean air concentrations in cities like London are dramatically lower at 0.1ppb.

Rotorua city is within an active geothermal region in New Zealand. Exposure analysis in a Rotorua population group demonstrated H₂S concentrations to be only 20.8ppb (mean) for residences and 27ppb...
The number of dopaminergic neurons in the brain decreases as Parkinson’s disease progresses and in PD animal models, \( \text{H}_2\text{S} \) as a gaseous neurotransmitter has been proven to have protective effects on dopaminergic neuron loss when inhaled.\(^6\) In addition, it has been demonstrated that \( \text{H}_2\text{S} \) as a neuromodulator regulates striatal neurotransmission.\(^7\) In humans, naturally low levels of \( \text{H}_2\text{S} \) gas occur in the body. This gas is synthesized by gut microbiota flora as well by enzymes in tissues where L-cysteine is metabolised, derived from alimentary sources or liberated from proteins in addition to synthesis from L-methionine.\(^8\) These enzymes are predominantly in nervous system, liver and kidney tissue.\(^8\)

Hydrogen sulphide functions as a gaseous neurotransmitter and helps maintain homeostasis of cellular energetics, vascular and anti-inflammatory processes. If certain levels of \( \text{H}_2\text{S} \) are necessary for healthy homeostasis of dopaminergic neurons, it may be that findings from a study on the abundance of a particular \( \text{H}_2\text{S} \) secreting Prevotellaceae, which showed that, relatively, abundance in gut microbiota of PD patients presents an interesting link.\(^9,10\)

It may be that the observation of a small positive association between higher \( \text{H}_2\text{S} \) exposure and improved simple reaction time, including finger tapping scores, was not due to multiple testing (which all participants were subject to) but due to a higher concentration of \( \text{H}_2\text{S} \) in dopaminergic neurons. This is a speculative but tantalising idea that is worth further examining. Presently there is no normalised report for PD diagnosis and progression in Rotorua. Detailed and normalised (including ethnicity, smoking habits, age) survey studies are needed to investigate if there is a statistically significant difference of PD rates and symptom severities of Rotorua residents in comparison to other regions of New Zealand. This research question needs to be carefully developed. Improved finger tapping reports obtained in Rotorua residents exposed to higher chronic levels of \( \text{H}_2\text{S} \) give no clarity to potential beneficial effects of \( \text{H}_2\text{S} \) exposure on Parkinson’s disease. The PD animal models studies, where eight days of \( \text{H}_2\text{S} \) inhalation showed prevention of neurodegeneration,\(^4\) showed results for acute rather
than chronic exposure, so are limited in relevance to the chronic exposure model that Rotorua provides. However, available knowledge that chronic exposure levels of \( \text{H}_2\text{S} \) inhalation in Rotorua are not harmful and possibly beneficial to motor functions is positive for any further studies that might be proposed to focus on the potential beneficial effects of \( \text{H}_2\text{S} \) on PD. In addition, the potential bottleneck of future studies is to determine the optimal inhalation dosages of \( \text{H}_2\text{S} \) for human PD studies. The \( \text{H}_2\text{S} \) levels in Rotorua (20.8–27ppb) would be the key to overcome the underlined bottleneck of the future human PD studies.

In conclusion, Rotorua with its unique, safe and relatively high concentration of ambient \( \text{H}_2\text{S} \) warrants closer examination to clarify whether there is a definite, positive correlation of inhalation of \( \text{H}_2\text{S} \) on human PD symptoms and pathophysiology.

**Competing interests:**
Nil.

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