Nitrous Oxide and Prehospital Emergency Medicine

Information Sheet for Emergency Care Providers

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Why do we care about nitrous oxide?

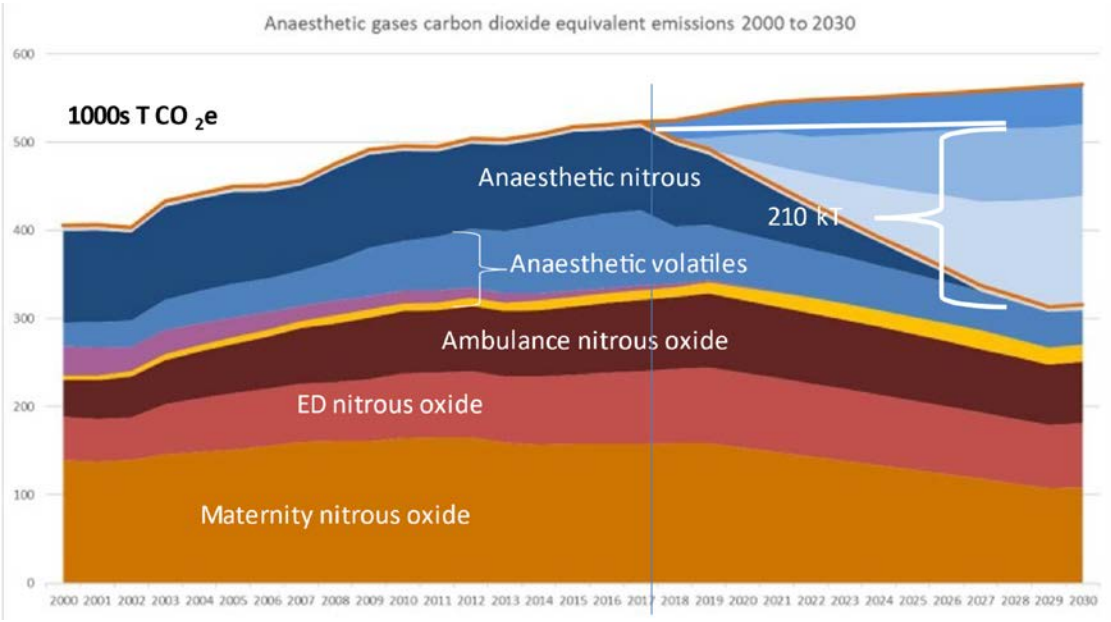
Nitrous oxide is a commonly used gas in Emergency Departments (ED), Ambulances and Prehospital Emergency Medicine Services in the form of a 50:50 mixture of oxygen and nitrous oxide, e.g. Entonox®.

Used correctly, nitrous oxide can be a very safe and effective analgesic medicine. For some patients it may be the best option. However, we must be aware of some of the broader implications of this drug:

1. The ability of nitrous oxide to trap heat in the atmosphere (known as the global warming potential or GWP) is approximately **298 times that of carbon dioxide**.(1)
2. Nitrous oxide is also an **ozone** depleting gas, and has been labeled as one of the most significant ozone depleting gases of the 21st century.(2)
3. Nitrous oxide inactivates vitamin B12 and interferes with folate metabolism. Risks of **occupational exposure** in healthcare workers such as reduced fertility have been reported following repeated exposure in inadequately ventilated rooms and spaces.(3)
4. Nitrous oxide can be used as a drug of abuse, with regular exposure leading to peripheral neuropathy, and subacute combined degeneration of the spinal cord.

What does this have to do with Prehospital Emergency Medicine?

The NHS in England has pledged to be carbon net zero by 2040.(4) The NHS is responsible for 4-5% of total UK carbon emissions,(5) and anaesthetic gases have been identified as a 'carbon hotspot'. The 2019 NHS Long Term Plan highlights these gasses as an area for action.(6) Nitrous oxide use in the acute sector leads to more greenhouse gas emissions than any other anaesthetic gas, accounting for **75% of all anaesthetic gas emissions**.(7)



Graph 1. ED and Ambulance Nitrous Oxide Use, as a proportion of total anaesthetic gas footprint. [8]

A significant proportion of these emissions originate from nitrous oxide use by **ambulance services and emergency departments** (graph 1). All of us should work together to reduce nitrous oxide wastage, and use of alternatives, where feasible and safe to do so.

- It is estimated that 30 minutes of Entonox® use produces the equivalent emissions of approximately 38 kg of CO2.[9] This is the same as driving a medium sized petrol car over 120 miles. [1]
- At present, partially empty and expired Entonox® cylinders are vented off directly to the atmosphere, further contributing to emissions.
- Some EDs may have piped Entonox® from a gas manifold. This has the potential to lead to leaks from pipework, and also wastage of large quantities of gas if the manifold is not correctly managed.

What is the ask?

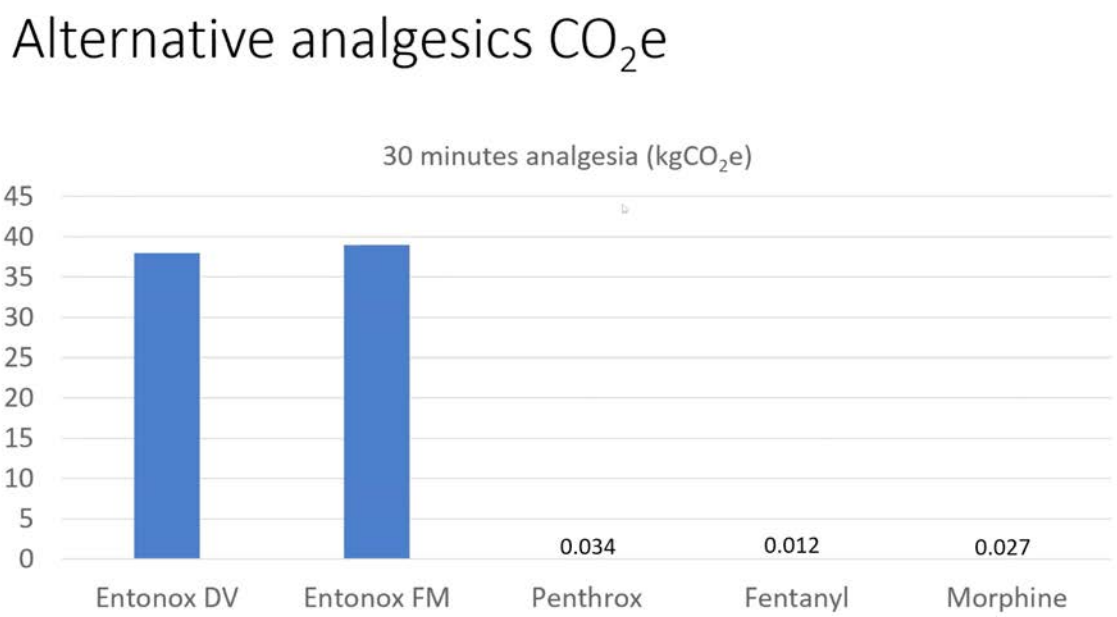
All prehospital providers review their use of nitrous oxide; addressing issues of waste, unnecessary carriage and the use of alternatives. Reducing harmful and polluting anaesthetic gasses from the environment is a shared responsibility.

In some cases, the use of nitrous oxide containing mixtures may still be the best option for analgesia. For patients and providers for whom alternatives do not exist, access to good quality

analgesia should always be the priority. **Pain relief must never be compromised**. However, efforts to reduce nitrous oxide waste, unnecessary carriage, and improving access for all staff groups to alternative agents that offer *at least* equitable analgesia should be pursued.

What are the alternatives to nitrous oxide?

1. A survey of 20 HEMS units found that just over half carry Entonox®; however all answered that it is rarely or never used, with many citing ambulance governance structures being the reason for its inclusion.[10] Entonox® use remains common in ambulance services and emergency departments.
2. Alternatives to nitrous oxide, such as methoxyflurane (marketed as Penthrox®) are now available, and may be suitable for some, but not currently all, patients. Methoxyflurane has a much lower ability than nitrous oxide to trap heat in the atmosphere (GWP of 4 vs 298)[11] although the data to compare the total environmental impact of nitrous oxide and methoxyflurane as a life cycle analysis (incorporating manufacture, use and disposal of each product) is not yet available.
3. Efficacy and safety data for methoxyflurane administered via the Penthrox® inhaler, in children and adolescents is pending (MAGPIE trial)[12]
4. Royal College of Emergency Medicine Guideline for Management of Pain in Adults[13] and Joint Royal Colleges Ambulance Liaison Committee (JRCALC) guidance[14] describe a number of alternatives, including Penthrox® and non-pharmacological interventions. Other alternatives include different routes of administration, and will vary between prescribers and non-prescribers e.g. intranasal, intravenous, intramuscular and oral
5. Although Entonox® may still have a role in some patients for acute pain, prehospital emergency medicine services, emergency departments, and NHS Ambulance Trusts have a range of other analgesic modalities which may provide more definitive and longer lasting analgesia. Analgesics other than Entonox® have the advantage of having a lower carbon footprint per half hour of analgesia delivered.



Graph 2. Scope 1 emissions for Entonox® use, compared to other analgesic modalities. [15]

The Environmental Special Interest Group of the Royal College of Emergency Medicine has produced a calculator which can be used to calculate the carbon emissions from Entonox® use in emergency care. Calculations are based on emissions factors derived from the UK Government Conversion Factors for Company Reporting[1] and are subject to change. The calculator can be accessed via the QR code or link below.

https://greened.clappia.com/app/GRE332617

Conclusion

Nitrous oxide is a **potent greenhouse gas and ozone depletor**. It has potential **harms** associated with long term and occupational exposure. Whilst there may be patients or providers for whom nitrous oxide containing products, such as Entonox®, are required, where clinically appropriate, other alternatives may provide longer lasting and more definitive analgesia.

Extensive work in NHS hospital Trusts has demonstrated large amounts of wastage of nitrous oxide, and this problem should also be examined and addressed in prehospital services. Environmental damage carries a human health cost, financial cost and ecological cost, in turn each affecting the **ability for health services to provide care**. We have a responsibility to individually and collectively understand and minimise the environmental consequences of **our actions**. Mitigating, eliminating or reducing wastage and unnecessary usage of nitrous oxide in our services can be one in a number of steps to recognise and act on this **responsibility** we share.

References

1. UK Government Conversion Factors for Company Reporting 2021. Available from: https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2021. Accessed 8/6/2021
2. Nitrous Oxide in Modern Anaesthetic Practice. BJA Education. Volume 16, Issue 3. 2016. Pp 87-91.
3. 'Entonox 'Essential Safety Information. BOC Healthcare. Available from: https://www.bochealthcare.co.uk/en/images/Entonox%20Datasheet_tcm409-507933.pdf. Accessed 18/6/21.
4. Greener NHS. NHS England and NHS Improvement. Delivering a 'Net Zero 'National Health Service. Accessed 18/6/21. Available from: https://www.england.nhs.uk/greenernhs/wp-content/uploads/sites/51/2020/10/delivering-a-net-zero-national-health-service.pdf.
5. Greener NHS. News and Updates. January 2020. Accessed 18/6/21. Available from: https://www.england.nhs.uk/greenernhs/2020/01/greener-nhs-campaign-to-tackle-climate-health-emergency/
6. The NHS Long Term Plan. January 2019. Accessed 18/6/21. Available from: https://www.longtermplan.nhs.uk/publication/nhs-long-term-plan/.
7. The Association of Anaesthetists Accessed 8/6/21. Available from: https://anaesthetists.org/Home/Resources-publications/Environment/Nitrous-oxide-project
8. SDU Presentation to Association of Anaesthetists 2019, Glasgow 2019 With Permission.
9. Personal Communication. Dr JMT Pierce. Consultant Anaesthetist. University Hospital Southampton.
10. Survey of Pre Hospital Emergency Medicine Services. Original Research. Dr Amar Mashru. (unpublished data). December 2020/January 2021.
11. Hass et al. Atmospheric chemistry of methoxyflurane (CH3 OCF2 CHCl2): Products and mechanisms. Chemical Physics Letters. Feb 2020. 740.
12. Hartshorn, S., Barrett, M.J., Lyttle, M.D. et al. Inhaled methoxyflurane (Penthrox®) versus placebo for injury-associated analgesia in children—the MAGPIE trial (MEOF-002): study protocol for a randomised controlled trial. Trials 20, 393 (2019)
13. https://rcem.ac.uk/wp-content/uploads/2021/10/RCEM_BPC_Management_of_Pain_in_Adults_300621.pdf
14. Joint Royal Colleges Ambulance Liaison Committee, Association of Ambulance Chief Executives (2021) JRCALC Clinical Guidelines 2021. Bridgwater: Class Professional Publishing.
15. Calculation of Scope 1 emissions, and process up scale for IV agents, including procurement and combustion of syringes. Original research. Dr JMT Pierce. Consultant Anaesthetist. University Hospital Southampton. With permissions.