Improving Environmental Stewardship in Paediatric Anaesthesia

Identifying hotspots and barriers

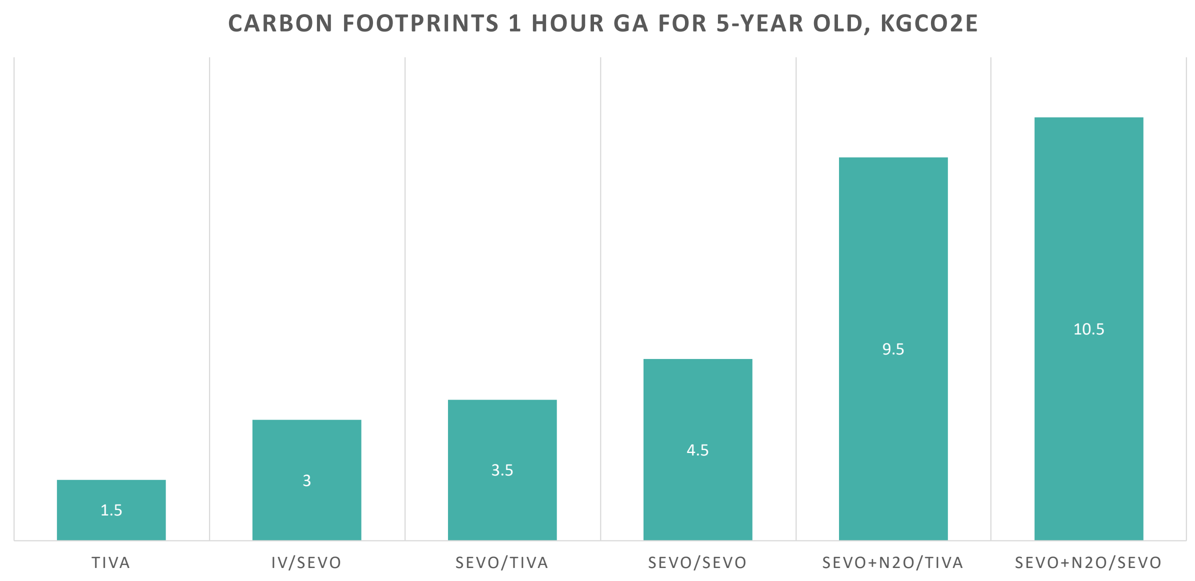
Paediatric anaesthesia has been identified as one of four sub specialty areas within anaesthesia that present unique barriers to the implementation of more sustainable practice [ref]. These barriers are ongoing reliance on *high flow inhalational inductions,* the use of *nitrous oxide* to augment inhalational induction and perceived or actual barriers to *awake intravenous cannula* insertion in children. (The other priority areas are: neuro-, obstetric and cardiac anaesthesia).

Paediatric anaesthesia hotspots

1. Nitrous oxide (even when only used at the onset of inhalational induction, using standard (6L/minute) fresh gas flows and a circle breathing system), typically contributes to more than half the entire carbon footprint of that anaesthetic [refs].
2. For an inhalational induction and ongoing volatile maintenance, approximately half of the inhalational agent is used during the induction period [refs].
3. Following an inhalational induction, switching to paediatric TIVA can result in carbon savings after 10-20 minutes if single use plastics are minimised [refs].
4. Reducing fresh gas flows into a circle system during both induction and maintenance of inhalational anaesthesia has been implemented successfully and safely and can significantly reduce anaesthetic gas wastage [refs].

Figure 1. Carbon footprint of different modes of paediatric anaesthesia – total CO_2e for induction and maintenance [induction technique/maintenance technique]

(Emissions derived from audit data [ref] which correlate well with LCA modelling studies [refs]. Note, emissions from manufacturing may significantly increase the total carbon footprint of sevoflurane [ref]. Carbon footprint of consumables extracted from LCA modelling studies [refs].



Summary

TIVA? - YES - IV awake.

Volatile? - go low flow.

Nitrous? – NO

In the next newsletters we will look further into the relative impacts of nitrous oxide, sevoflurane and paediatric TIVA.

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Nitrous oxide

Nitrous oxide is a common and relatively long lasting greenhouse gas. It also destroys atmospheric ozone adding to its warming effect. Reducing nitrous oxide use and waste is likely to be our easiest carbon reduction strategy as paediatric anaesthetists – our 'lowest hanging fruit'. Even using it briefly to augment the onset of inhalational inductions will contribute to around half the carbon emissions of that entire anaesthetic [Figure 1. ref].

Traditionally nitrous oxide has been used in the belief that it makes inhalational inductions quicker, smoother and easier. However, the evidence for the efficacy of nitrous oxide in this setting is not clear cut [refs] and the anecdotal experience of many paediatric anaesthetists is that, for the majority of patients, sevoflurane works just as well without nitrous.

In our department, we have made the simple change of having 'oxygen / air' rather than 'oxygen / nitrous' as the default gas mixture when the anaesthetic machine is turned onto paediatric settings. This, along with raising awareness of the issue, is working to drop our nitrous use in paediatric anaesthesia.

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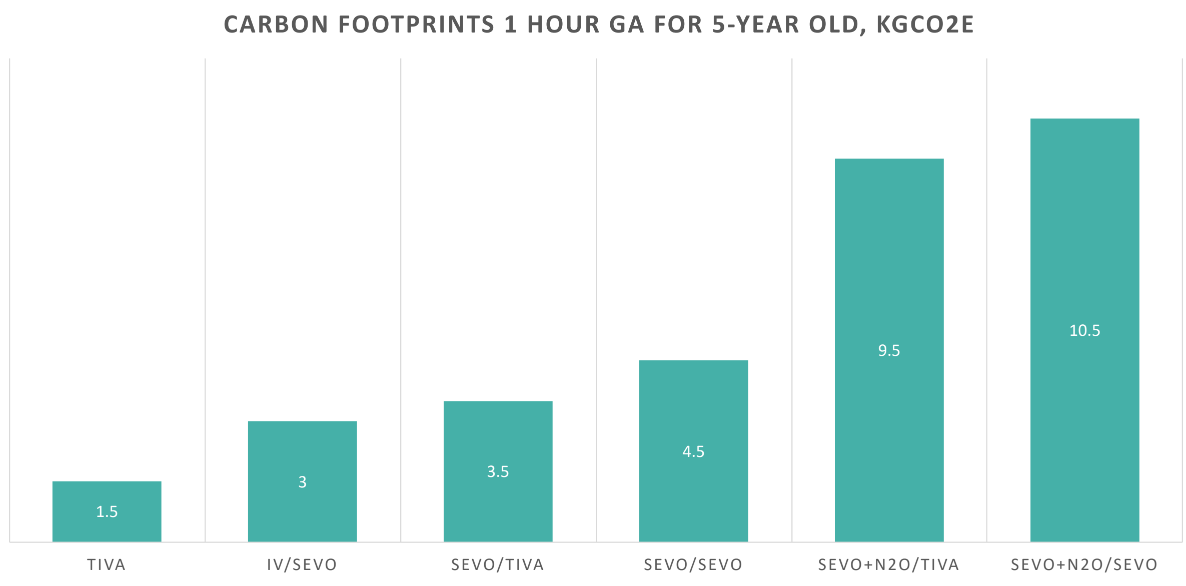

Decommissioning manifolds and reticulated nitrous oxide

The main finding from the Nitrous Project, which started in Scotland [ref], is that clinical end-use of nitrous oxide is nearly always dwarfed by fugitive losses and leaks from manifolds, reticulation systems, anaesthetic machine checks, the venting of used cylinders and diversion [ref].

Most institutions have seen huge reductions in nitrous oxide procurement by decommissioning manifolds and reticulation systems and instead suppling nitrous, on request, in small portable cylinders. This practice has also been shown to reduce clinical use by aiding systemic behavioural change.

Nitrous oxide outside the operating theatre

It may also fall within your sphere of influence to discuss nitrous oxide reduction strategies and alternatives in other sub specialties e.g. hospital dental, emergency departments and hospital wards. Maternity units, as high end users, require implementation and improvements in nitrous oxide scavenging and destruction technology [ref] and/or the provision of alternative (low carbon) forms of labour analgesia to reduce their high levels of carbon emissions [ref].

Occupational exposure to nitrous oxide

Nitrous scavenging and destruction units are used in Scandinavian birthing units. The primary drive for this was originally to reduce the risk of occupational exposure to nitrous which can cause myeloneuropathy and SACDC and is associated with reduced fertility [ref]. The risk of vitamin B12 deficiency and peripheral neuropathy is also increased in staff members with plant-based diets [ref].

Summary

Nitrous oxide even when only used at the beginning of inhalational inductions contributes significantly to the carbon footprint of paediatric anaesthesia.

Decommissioning reticulated nitrous and moving over to supplying nitrous oxide in smaller cylinders at the point of care has significantly reduced the financial and environmental costs of nitrous in many institutions.

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The Sevoflurane / TIVA debate

In the last newsletter we looked at our 'lowest hanging fruit' to reduce our carbon footprint as paediatric anaesthetists - nitrous oxide. Today we take a look at the more subtle differences between sevoflurane and TIVA.

Sevoflurane – is there a problem?

Sevoflurane's contribution to global warming and climate change has created an interesting debate with some saying that it is too short lived and in too low concentrations in the atmosphere to have a significant effect [ref]. Others maintain that it is still a potent, albeit short-lived greenhouse gas that we have the knowledge and technology to either avoid or use sparingly [ref].

Carbon footprint of sevoflurane manufacture

The precise manufacturing processes of sevoflurane are not disclosed. Modelling of the proposed chemical manufacturing shows that the entire life cycle footprint of sevoflurane may be 2-8 times the footprint of the waste gas alone ('exhaust pipe emissions') [ref].

Volatile Capture Technology (VCT)

Volatile capture technology (to destruction or reuse) requires improvement to bring clinical 'in vivo' mass transfer rates closer to those seen 'in vitro' [ref]. Note, capture efficiency is efficiency of mass transfer to the capture canister plus desorption efficiency from it.

Paediatric TIVA

The uptake of paediatric TIVA in our own institution is still on the rise. This has been driven by both a desire to reduce greenhouse gas emissions and to improve clinical outcomes.

However, awake iv access is not possible in every child which brings us to the question: when do you break even (in terms of total carbon footprint) by switching from a (nitrous free) inhalational induction over to TIVA? Depending on the age and weight of the patient, the techniques employed and the quantity of consumables used, this time ranges from zero to around 20 minutes in real life scenarios [ref] compared with over 1 hour in simulated models [refs]. There are of course additional considerations to this 'carbon-centric' approach. They include ecotoxicity and pollution from plastic and pharmaceutical waste. These impacts or 'externalities' are more difficult to assign a cost to [ref]. On the positive side, there are also improved outcomes from using a specific technique in a given clinical scenario.

Summary

TIVA? - YES - IV awake.

Volatile? - go low flow.

Nitrous? – NO

See Easy read long version for optional intro and final summary … with wider focus … but we may consider this outside our remit.

References … *lots more to add and sort*

Narayanan H, Raistrick C, Pierce JMT, Clifford Shelton C. Carbon footprint of inhalational and total intravenous anaesthesia for paediatric anaesthesia: a modelling study. Br J Anaesth 2022; Jun 18; S0007-0912(22)00224-0. doi: 10.1016/j.bja.2022.04.022. Online ahead of print.

van der Griend BFH, McGregor AL, Currant PN, Kennedy RR. An audit of inhalational anaesthetic agent usage in paediatric anaesthesia. Anaesthesia 2022 Jun 24. doi: 10.1111/anae.15795. Online ahead of print.

Kantsedikas I, Brooks P. Carbon footprint of paediatric general anaesthesia following inhalational induction: a comparison between modelling study estimates and empirical data. Anaesthesia 2023; 78, S3: 8-66. Special Issue: Abstracts of the Annual Congress 2023, Edinburgh, UK. https://associationofanaesthetists-publications.onlinelibrary.wiley.com/doi/full/10.1111/anae.16112

Singh A, Sinha R, Aravindan A, Kumar KR, Datta PK. Comparison of low-fresh gas flow technique to standard technique of sevoflurane induction in children - A randomized controlled trial. Pediatric Anesthesia 2019; 29: 304-9.