Original Article

Should pipeline nitrous oxide be discontinued in secondary care: A cost-benefit analysis

ABSTRACT

Background: Nitrous oxide (N_2O) has seen a marked decline in its usage in recent years due to its adverse clinical effects. We audited the practice in our department to evaluate the N_2O consumption and cost-effectiveness of its supply.

Methodology: Electronic anesthesia records of all patients anesthetized in our main operating rooms in a typical month were reviewed retrospectively, and utilization of N_2O was noted in addition to the patient demographics, surgical procedure, and specialty.

Results: A total of 950 patients were anesthetized, and 3.1% received N_2O. The annual usage was estimated to be 72,871 liters, with a leakage of 3,883,105 liters to the environment, posing a safety hazard and wasting 149,612.50 SAR.

Conclusion: Notable costs and environmental benefits may be achieved by substituting a piped supply of N_2O with portable E-cylinders on demand in operating rooms for rational use.

Key words: Greenhouse gases, hazardous waste, nitrous oxide

Introduction

Nitrous oxide (N_2O) is a medical gas that has traditionally been used in anesthesia for over a century due to its properties of speeding up a smoother induction,[1,2] reducing the amount of volatile anesthetic agents for maintenance of anesthesia,[3,4] rapid emergence,[5] efficient analgesia,[6] and anti-depressant effects.[7] Its adverse clinical effects may include gastrointestinal and neuropsychiatric disorders, causing nausea/vomiting, euphoria/agitation, expansion of gas-filled spaces, inadvertent hypoxia, risk of awareness, lung atelectasis predisposing to pneumonia, air pollution, drug abuse, and so on.[8] These disadvantages may outweigh advantages, and increasing recognition has resulted in a marked decline in the use of N_2O in recent years.

The N_2O contribution to greenhouse gas emissions is approximately 7%, with an overall impact on global warming of 0.1%; the portion coming from human sources is only 1%, and that from clinical practice is even smaller; since N_2O remains in the atmosphere for 150 years, its long-term damage is considerable.[9]

In major hospitals, the Medical Gas Pipeline System (MGPS) delivers pressurized gases; vulnerable to developing escapes

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of potentially hazardous waste, it is notoriously difficult to detect and curtail leaks. The MGPS in our quaternary care hospital runs several kilometers of pipeline due to the distances between the manifold bank and the operating rooms (ORs) scattered through multiple buildings. We audited the N_2O consumption to evaluate the cost-effectiveness of its supply.

Material and Methods

After obtaining approval and consent waiver from the KFSHRC Research Ethics Committee (REC #2211192, 02 September 2021), electronic anesthesia charts were reviewed for all patients anesthetized over a typical month in our main OR suite (as the bulk of anesthetic activity takes place there). Data collected included the duration of the anesthetic, the fractional concentration of N_2O and the duration of its use, the fresh gas flow (FGF) rate, and the patient demographics along with the surgical procedure and specialty. Extracted data were analyzed [Figure 1] after populating a Microsoft Excel® sheet. An upscaling factor (UF) was determined by dividing the total anesthesia time from the charts reviewed by that for all the patients anesthetized in all locations in our hospital during the audited month [Figure 2]. This was used to extrapolate the consumption of N_2O for the whole hospital and then multiplied by 12 to estimate the annual usage. The data for the actual N_2O supply for the preceding 3 years were accessed from the hospital records [Figure 3]. Comparisons were made between the average supply and consumption in our hospital, accordingly determining the wastage [Figure 4].

Results

A total of 950 patients were anesthetized in the main OR suite; all electronic anesthesia charts were available for them. N_2O was used in 3.1% (n = 29) of cases over 0.87% of the total anesthesia time, mainly in patients undergoing procedures in general surgery and ENT; 62% (n = 18) were females. Only 1% (n = 4) of the children received N_2O for a relatively short duration (during induction). One particular anesthetist administered approximately 84% of the total consumed volume of N_2O.

Only 2% (≈73,000 liters) of the supplied N_2O (3.95 million liters) was actually consumed, revealing an undetected 98% volume loss between the manifold and the patient end; to avoid this enormous wastage through the MGPS, the requisite volume could be supplied through 76 portable E-type cylinders, costing only 6,840 Saudi Arabian Riyals (SAR). An estimated saving of SAR 1,40,876 (USD 37,566) per annum was therefore possible, with a further saving on the cost of maintenance of the MGPS, in addition to the invaluable impact on the environment and patient and staff safety.

Discussion

Our audit confirmed the decline in the usage of N_2O. The enormous volume loss could only be explained by leaks in the MGPS as the J-type cylinders in the manifold bank were replaced only when empty. The pattern of N_2O usage revealed a user bias; regular education and review of anesthetic practices might help to reduce variation and improve quality of care.

This audit established that the piped supply of N_2O was grossly underutilized, resulted in leakage of hazardous waste and was financially inefficient; we recommended to discontinue N_2O supply through the MGPS and shift to portable E-type cylinders in the operating rooms according to clinical needs.

A limitation of our audit was that the anesthesia machines in the remote locations (42% of the anesthesia activity) were not connected to record the gas usage data in the e-anesthesia charts. Although, from experience, we knew that a majority of the patients in those areas were receiving only intravenous sedation without the use of inhalational agents, we extrapolated the data from our main OR suite, thereby anticipating an over-estimation of N_2O usage, and the actual numbers may be even lower.

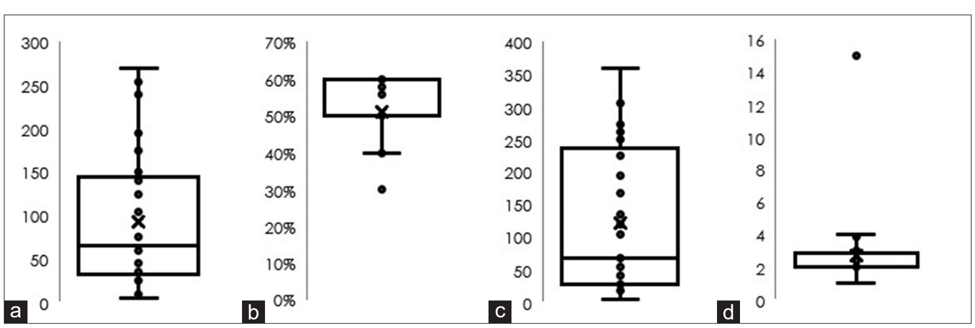

Figure 1: N_2O usage data. (a) N_2O duration (in minutes), (b) N_2O fraction (percent), (c) N_2O volume (liters), (d) Flow rate (liters per minute)

	Main ORs	Hospital wide	Upscaling factor
Anesthesia time (Minutes)	177723	306677	306677 / 177723 = **1.72**
Actual Volume of N2O usage (Liters)	3519	3519 x 1.72 = **6073**	
Volume of N2O usage (Liters)	One year	6073 x 12 = **72871**	

Figure 2: N_2O usage calculation

Hospital wide N_2O Supply				
Year	**J-type Cylinders**	**E-Type Cylinders**	**Volume supplied(Liters)**	**Amount (SAR)**
2018	278	2	3004306	SAR 118,330.00
2019	443	4	4788212	SAR 188,635.00
2020	377	4	4075412	SAR 160,585.00
		Average	**3,956,977 Liters**	**SAR 152,587.50**

Figure 3: N_2O supply

	Volume (L)	Cost (SAR)
Supply	3,956,977	152,587.50
Usage	72,871	11,711.46
Wastage	**3,883,105**	**140,876.04**

Figure 4: N_2O wastage calculation

Conclusion

Our audit proved to be an economical and effective tool, an alternative to the highly expensive engineering apparatuses, to determine the extent of the wastage of N_2O supplied through the MGPS with a potential to introduce a significant change of practice with enhanced efficiency and safety.

Data availability

The data that support the findings of this study are available from the corresponding author, [AM], upon reasonable request.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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