Original Article

A survey on the use of low flow anaesthesia and the choice of inhalational anaesthetic agents among anaesthesiologists of India

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ABSTRACT

Background and Aims: With the availability of modern workstations and heightened awareness on the environmental effects of waste anaesthesia gases, anaesthesiologists worldwide are practicing low flow anaesthesia (LFA). Although LFA is being practiced in India, hard evidence on the current practice of the same from anaesthesiologists practicing in India is lacking and hence, we conducted this survey. **Methods**: A questionnaire containing 16 questions was distributed among a subgroup of anaesthesiologists who attended the 2014 National Conference of Indian Society of Anaesthesiologists. The filled-in questionnaires were computed and analysed with SPSS version 11. **Results:** The response rate to the survey was 82%. About 73% of the respondents practiced LFA routinely, with 65% having workstations. Most of the anaesthesiologists used fresh gas flows <1.5 L/min with 45.1% using O_2 concentrations at a range of 30–40%. $ETCO_2$ monitoring was used routinely by most whereas use of agent analysers and bispectral index monitoring were restricted. The availability of scavenging system was also limited to only 33.5%. Majority preferred N_2O as carrier gas and sevoflurane as volatile agent of their choice. **Conclusion:** Our survey revealed that practice of LFA in India has numerous lacunae. Provision of better monitoring facilities, workstations as well as awareness regarding the environmental issues of waste anaesthetic gases need to be addressed.

Key words: Inhalational anaesthetic agents, low flow anaesthesia, survey

INTRODUCTION

The inhalational anaesthetic agents presently available are metabolised only to a small extent and are largely exhaled unchanged. This property can be taken advantage of, to perform successful, economic and safe "low flow anaesthesia" (LFA). The aim of our survey was to get data on the current practice of LFA in India. The economical, ecological and pulmonary benefits of LFA warrant its routine practice. The routine use of low flows can cut down anaesthesia costs up to 75%.[1] The amount of volatile anaesthetic agents extracted is directly proportional to the fresh gas flow (FGF) into the breathing circuit and system.[2] When high FGF are used, 90% of the volatile agents are unused[2] and are emitted as waste anaesthetic gases (WAG) into the operation theatre (OT) environment or to the atmosphere, exposing those in the OT to health hazards and adding on to the greenhouse effect as well as ozone depletion.

A survey[2] on LFA found that the routine use of LFA would circumvent the initial expenditure in months by saving on expenses on volatile agents and carrier gases. Another study[3] found that educating the

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anaesthesiologists was very effective in reducing the FGF rates used thereby contributing to overall cost reduction of anaesthesia.

In a geostatistical assessment of anaesthetic gases in OT and exposure to staff,[4] high average concentration of nitrous oxide (8–445 ppm with peak 1345 ppm) was detected with high occupational hazard potential for staff in OT. Gas scavenging is the most practical way to control or remove WAG from OT environment.[5] It is the responsibility of the institution to provide effective scavenging system or continuous flow fresh air ventilation systems to prevent waste gas accumulation in the OT environment, as well as to organise and document a programme of maintenance and checking of all anaesthetic equipment.[6] We present the data obtained from the survey on low flow anaesthesia.

METHODS

Questionnaires on the use of LFA and the choice of inhalational anaesthetic agents were distributed among 200 anaesthesiologists who visited a business promotion stall during the National Conference of Indian Society of Anaesthesiologists. The completed questionnaires were collected there itself. The questionnaire was validated by collecting data from anaesthesiologists working in our centre. From the same group of anaesthesiologists, the same information was collected after 1 month. The difference between the survey responses at these time intervals was tested and found to have no significant difference. This, validated the questionnaire and we found it to be reliable.

The questionnaire contained sixteen questions pertaining to the demography, practice of LFA, routine use of workstations, scavenging systems, gas analysers and choice of volatile agents as well as carrier gas preference. The participation was voluntary, and the identity of the participants was kept confidential.

The questionnaire contained two parts, the first part intended to collect general information such as years of experience in anaesthesia, region of practice, subspecialty of the participant if any and the practice setting of the participant. The second part dealt with questions specific to the practice of LFA, use of oxygen analysers and agent analysers, routine use of $ETCO_2$ monitors and bispectral index (BIS) monitors, type of anaesthesia machine being used routinely, preferred carrier gas and volatile agent as well as the volatile agent in routine use [Appendix 1 available online].

Survey responses were analysed using Statistical package for the social sciences version 11, by SPSS Inc. (Chicago). Categorical data were analysed using Pearson's Chi-square test and Fisher's exact test and was considered statistically significant if $P < 0.05$.

RESULTS

A total of 166 questionnaires were returned, making a response rate of 83%. Of these two were omitted due to the disparity in facts presented, thus obtaining a response rate of 82%. The demographic data are summarised in Table 1.

The maximum number of respondents to our survey were in the early years (0–5) of anaesthesiology practice (42%). Response analysis showed that 52.4% were from South India whereas 39% were from North India, with a skewing of response population to South India. Of the respondents, 82% were males and 17.6% were females. The question on practice setting of the

Table 1: Demographic variables

Variables	*n* (%)
Years of experience in anaesthesia (years)	
0–5	69 (42)
6-10	29 (17.6)
11-15	22 (13.4)
16-20	18 (10.9)
21-25	12 (7.3)
>25	14 (8.5)
Region of practice	
North India	64 (39)
South India	86 (52.4)
Region not specified	14 (8.5)
Gender	
Male	135 (82.3)
Female	29 (17.6)
Subspecialty*	
General	80 (48.7)
Cardiac and vascular	6 (3.6)
Critical care	10 (6)
Paediatric	62 (37.8)
Others	23 (14)
Practice setting	
Teaching	
Government	84 (51.2)
Private	22 (13.4)
Nonteaching	
Government	32 (19.5)
Private	26 (15.8)

*Subspecialty: Some were practicing general as well as paediatric or critical care

respondents yielded responses as 48.7% practicing in the general surgery setup, 37.8% respondents practicing paediatric anaesthesia and other subspecialties together accounted for 23.6%. Most (51%) practiced in government teaching hospitals.

Responding to the question on routine practice of LFA, 73.8% of the respondents practiced LFA routinely [Figure 1]. Regarding the use of low flow routinely in government hospitals, our survey revealed that 63% of those who practiced in teaching government hospitals practiced LFA. Respondents from nonteaching private hospitals had a 100% usage of low flow routinely. Ninety per cent of respondents from teaching private hospitals used low flows routinely. Of those respondents who used low flows routinely, 31.9% used a low flow rate of 0.5–1 L. Of the respondents who claimed to use low flows, 10.4% were using flows more than 2 L, which does not qualify as "low flow" [Figure 2]. The percentage of actual low flow users was thus 63.4%. Regarding reduction of flows, 48.5% reduced the flows after 10 min of induction while 32.1% reduced the flows after 15 min. Fifty-seven per cent respondents reduced the flows stepwise. Most of the respondents (44.5%) used oxygen concentration of 30–40% whereas 26.8% used 41–50% O_2 concentration.

Oxygen analysers were used by 50.6% respondents while using low flows whereas agent analysers were used by only 36%. Of the respondents, 54.8% preferred nitrous oxide as their carrier gas while performing general anaesthesia (GA). $ETCO_2$ was used routinely by 66% whereas BIS monitoring was used by 11.6%. Workstations were available for performing LFA for 64.6% anaesthesiologists and minimum alveolar concentration (MAC) values were displayed by 43.9% of the machines used. Analysis of our data showed that of the 32% respondents from government teaching hospitals who performed LFA only 27% had workstations to perform the same, revealing that 5% of those who used low flows were lacking adequate facilities to conduct the same. All those working in the nonteaching private hospitals had workstations to perform LFA. There seemed to be a paucity of workstations, especially in the nonteaching government hospitals. Only 33% of respondents worked in a setup with scavenging systems [Table 2]. Of those who practiced low flow in paediatric setting, 50% had agent analysers whereas 98% used $ETCO_2$ monitoring and 20.6% BIS monitoring. The maximum percentage of the respondents used FGF at the rate of 0.5–1 L and 56% used O_2 concentration of 30–40% [Table 3]. Recovery profile and other aspects were not part of the survey.

The use of $ETCO_2$, oxygen analysers, agent analysers and BIS monitoring were compared between the government and private setup using Chi-square test and no statistically significant difference was found. The concentration of O_2 used during LFA in both government as well as private setup was also analysed

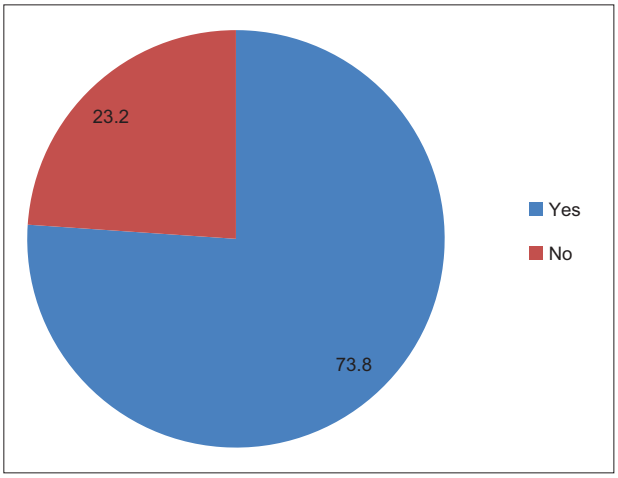

Figure 1: Routine practice of low flow anaesthesia

Table 2: Availability of workstations, scavenging systems and minimum monitoring equipment for anaesthesiologists practicing low flow anaesthesia in India

Anaesthetic Equipments	Percentage of respondents using
Oxygen analysers	51.2
Agent analysers	35.4
$ETCO_2$ monitors	65.9
BIS monitors	11.6
Work stations	64.6
Work stations with MAC display	43.9
Scavenging systems	33.5

BIS – Bispectral index; MAC – Minimum alveolar concentration

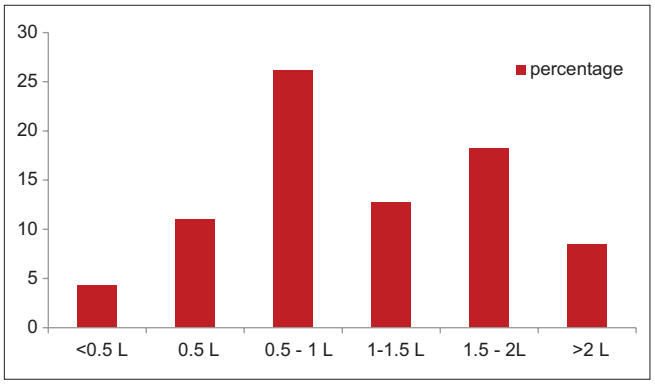

Figure 2: Fresh gas flow rates during routine use of low flow anaesthesia

Table 3: Practice of low flow anaesthesia in paediatric subspecialty by survey respondents and monitoring facilities utilised by them

Parameters Analysed	*n* (%)
Total number of survey respondents practicing low flow anaesthesia in paediatric subspecialty (%)	62 (37.8)
FGF rates used (L) (percentage in paediatric subspecialty)	
0.5	2 (3.2)
0.5-1	30 (48.3)
1-1.5	10 (16.12)
1.5-2	14 (22.58)
>2	6 (9.6)
O_2 concentration (percentage in paediatric subspecialty)	
30-40	35 (56.45)
41-50	22 (35.48)
51-60	4 (6.45)
>60	1 (1.6)
Usage of $ETCO_2$ (percentage in paediatric subspecialty)	61 (98.3)
Usage of BIS (percentage in paediatric subspecialty)	13 (20.96)
Agent analyser (percentage in paediatric subspecialty)	33 (53.2)
Scavenging system (percentage in paediatric subspecialty)	33 (53.2)

BIS – Bispectral index; FGF – Fresh gas flow

using Fisher's exact test and found to have no statistical difference ($P = 0.584$).

On routine overall use of volatile agents, 55.5% said they used sevoflurane, 54.7% used isoflurane,30.3% used halothane and 11% used desflurane [Figure 3]. When asked about the agent of their choice, 32.9% preferred sevoflurane, 15.2% preferred isoflurane and only 1.2% preferred halothane.

DISCUSSION

With the availability of sophisticated and modern anaesthesia workstations anaesthesiologists can practice safe LFA, cutting down the economic burden as well as contributing to a "greener earth." We conducted this survey to collect evidence on the practice of LFA in India as we found lack of surveys on this practice in Indian setup.

Our survey responses revealed that 73.2% of respondents practiced LFA routinely. The practice is prevalent among anaesthesiologists of India with no statistically significant difference between government and private sectors. Even now, there is a significant number who do not practice LFA in India (26.2% of respondents). High flows without scavenging system is a far from ideal situation posing significant health, financial and environmental risks.

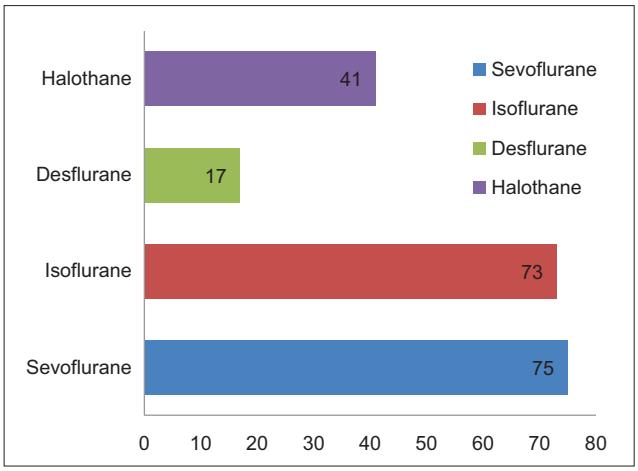

Figure 3: Volatile agents routinely used (Some respondents chose more than one volatile agent as 'routinely used')

Analysis of our survey results revealed that there are lacunae in concepts regarding true LFA as 10.4% respondents answered that they used >2 L flows and still were under the impression that they were performing LFA.

LFA starts with high flows of 4–6 L/min and then is reduced to 1 L/min after 10 min.[7] For minimal flow anaesthesia the time for reduction of flows is 15–20 min.[7] To our question on how long after induction are flows reduced, 48.5% responded that they reduced flows after 10 min, which is in accordance with the teaching of LFA. Of the respondents, 32.1% decreased the flows in 15 min whereas 15.7% in 20 min. Using the time duration is however one way of practicing LFA. The more reliable method has to be one based on MAC and the end tidal concentration of gases, including volatile anaesthetic agents. During anaesthesia, the oxygen uptake corresponds to the basal metabolic rate of the patient. Initially, the uptake of N_2O and volatile agents are high and decreases with duration of anaesthesia.[8]

Once the FGF is reduced, an inspiratory oxygen concentration level of 30% can be maintained with a fresh gas O_2 concentration of 50–60%.[8] On querying about O_2 concentrations used routinely with low flows, 45.1% responded that they still use 30–40% O2 concentration in fresh gas flow.

The safe conduct of LFA requires stringent monitoring throughout its conduct. The minimum monitoring required for LFA include the use of oxygen and agent analysers, inspired and expired CO_2 monitoring, monitoring minute ventilation and peak pressure.[8,9]

To know the monitoring standards while using low flows, we included questions on the use of agent and oxygen analysers and use of $ETCO_2$ and BIS. Evaluation of survey responses reveal that there is a paucity of monitoring equipment as well as provision of modern workstations and scavenging systems in our country which may be an obstacle in practicing LFA safely [Table 2].

Nitrous oxide is used in current anaesthesia practice primarily to facilitate a reduction in the use of opioids and other anaesthetic agents and to facilitate quicker induction when newer inhalational agents are unavailable.[10] When using air as a carrier gas during LFA, a mild increase in the concentration of the inhaled anaesthetic agent (0.2–0.25% of MAC value) is to be used.[8] BIS monitoring is desirable when air is used as a carrier gas for detection of intraoperative awareness. Nitrous oxide is still the preferred carrier gas for 54.2% respondents.

N_2O accounts for around 6% of the heating effect of greenhouse gases in the atmosphere. It also causes ozone depletion.[5,11] The National Institute for Occupational Safety and Health, USA recommend 25 ppm as recommended exposure limit for N_2O (for 8 h).[12] There is a lack of use of scavenging systems in most of the OTs in India as revealed by our survey. Only 33.5% respondents had scavenging system in their hospitals. Scavenging systems are highly recommended to reduce occupational exposure to WAG.[13]

All gases delivered from the anaesthesia machine are released to the atmosphere which adds to the greenhouse effect. The molecules of halothane, isoflurane and enflurane pass to the stratosphere where they are dissociated by the UV radiation to release free chlorine that acts as a catalyst in the breakdown of ozone.[14] Nitrous oxide also acts as a catalyst. Although the contribution to the global release is very small from anaesthesia practice, we have a clear duty to minimise the release of these chemicals into our atmosphere.[15] Desflurane and sevoflurane are safer in this aspect as they are free of chlorine. All these agents remain in the atmosphere adding to the greenhouse effect. The atmospheric lifetimes of desflurane are 21.4 years, sevoflurane 1.4 years and isoflurane 3.6 years.[16] As revealed by our survey results, although only 3% opted for halothane as their agent of choice, 30.3% were forced to use halothane routinely, most probably because there were no alternatives in their workplace.

Provision of modern anaesthesia workstations with MAC monitoring is essential to the safe and successful practice of LFA. Around 80% of the respondents had workstations although MAC value display was available only for 43.9% respondents. The initial investment cost of workstations with agent analysers and scavenging system may be an obstacle for the widespread practice of LFA in our country. Ryan and Nielsen[16] in their article on global warming potential of inhaled anaesthetics have suggested methods to reduce the environmental pollution by a certain change of practice by anaesthesiologists such as avoiding N_2O use and using low flows.

The limitations of the study were that, as the conference was conducted in South India, there is a skewing of population to the south, and second, the cross section who participated in the survey itself is very small.

In future, more information can be gathered by more institution based studies comparing the cost effectiveness of LFA in India. Studies should cover occupational hazards and scavenging systems need to be installed. Continuing education, feedback enquiries and hospital and government implemented guidelines can contribute to better and safe anaesthetic practices in our country.

CONCLUSION

Our survey revealed that low flow anaesthesia is being practiced in India by many anaesthesiologists. There is a lack of adequate monitoring facilities and scavenging systems. In a large country like ours, with lots of health care facilities performing surgeries under general anaesthesia, our role in adding to global warming and ozone depletion become important.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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APPENDIX

Appendix 1: Survey Questions

1. General information:
   a. Years of experience in anaesthesia: ----------
   b. State/Region where you practice: ----------
   c. Gender:
      Male ☐ Female ☐
   d. Please indicate your subspecialty
      General ☐ Cardiac and Vascular ☐
      Critical Care ☐ Paediatric Anaesthesia ☐
      Other ☐ (please specify) ----------
   e. Please indicate your practice setting
      Government Hospital
      Teaching ☐ Nonteaching ☐
      Private Institution
      Teaching ☐ Nonteaching ☐

2. Do you routinely practice low flow anaesthesia?
   Yes ☐ No ☐
   - If No, kindly return the questionnaire. Thank you for your participation.

3. What is the fresh gas flow rate you use?
   <0.5L ☐ 0.5 L ☐ 0.5-1L ☐
   1-1.5L ☐ 1.5-2L ☐ >2L ☐

4. How long after induction do you decrease the flow to low flow?
   10 m ☐ 15 m ☐ 20 m ☐ >20 m ☐

5. Do you reduce the flow stepwise?
   Yes ☐ No ☐

6. What concentration of oxygen do you use when practicing low flow anaesthesia?
   30–40% ☐ 41–50% ☐ 51–60% ☐ >60% ☐

7. Do you use oxygen analyser?
   Yes ☐ No ☐

8. Do you use agent analyser?
   Yes ☐ No ☐

9. Do you monitor ETCO2 routinely in all cases?
   Yes ☐ No ☐

10. Which is the carrier gas of preference?
    N2O ☐ Air ☐

11. Kindly specify the type of anaesthesia machine being used at your centre?
    Workstation ☐ Conventional Boyles Machine ☐

12. Is BIS monitoring routinely used?
    Yes ☐ No ☐

13. Does your workstation display MAC values?
    Yes ☐ No ☐

14. Do you have scavenging system at your centre?
    Yes ☐ No ☐

15. Which volatile agent do you routinely use at your centre?
    a. Halothane
    b. Isoflurane
    c. Desflurane
    d. Sevoflurane

16. Please specify the agent of your choice while practicing low flow anaesthesia.