PROJECT CHARTER

Low Flow Administration of Anesthetic Gases

Developed in collaboration with the Ontario's Anesthesiologists Environmental Sustainability Working Group, including: Dr. Amanda Jasudavisius, Dr. Anita Rao, Dr. Connor Brenna, Dr. David Ohrling, Dr. Elaine Ng, Dr. Martin Van Der Vyver, Dr. Melissa Ho, Mike Apostol, Dr. Syed Ali Akbar Abbass

Team members: Operating Room Nurses, Anesthesiologists, and Facilities staff

Executive Sponsor:

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Please contact CASCADES@utoronto.ca if you have any questions.

NAVIGATION

Goal & Scope

1 What do you want to achieve?

Anesthesiologists should utilize low or minimal fresh gas flow (FGF) for general anesthesia with an inhalational anesthetic agent. Minimal FGF reduces the amount of anesthetic agent used and released to the atmosphere, thereby limiting greenhouse gas emissions.

2 Define the limits of what you want to be included in the project and consider the environmental impacts you are targeting for change.

Project Scope: General anesthesia using inhalational anesthetic agents.

Emissions Scope: Scope 1; these emissions are direct GHG emissions originating from sources controlled and owned by an organization, such as on-site boilers and certain medical gases.

Problem/Opportunity Statement

3 Briefly state the problem you want to solve or the opportunity you want to realize.

Inhalational anesthetic agents are all potent GHGs with global warming potentials hundreds to thousands of times that of C02. In most health centres, waste anesthetic gases are released directly to the atmosphere where they exert their greenhouse gas effect for years. The volume of inhalational anesthetic agent used during surgery and released into the atmosphere decreases by lowering the fresh gas flow. (1,2) Sevoflurane is the least environmentally toxic inhalational anesthetic and is the preferred choice for sustainable anesthetic delivery. In the past, minimal flow anesthesia with sevoflurane was controversial because of concerns of production and accumulation of Compound A in the breathing circuit, and its potential association with renal damage. However, many studies have shown that sevoflurane is safe to use with minimal flows negating the need for higher (i.e., 2L/min) FGF. Minimal flow anesthesia is endorsed by the Canadian Anesthesia Society which recommends FGF ≤1 and ideally 0.5L/min in their **2023 Revised Guidelines to the Practice of Anesthesia** (see Section 10) (3).

Low flow anesthesia with sevoflurane is common in many jurisdictions (4). Consideration should be given to programming the minimum flow on automated end-tidal anesthetic agent concentration control (Et control) mode on anesthetic delivery units (ADU) to 0.5L/min.

In addition to the environmental savings associated with lowering FGF, additional benefits include enhanced temperature and humidity preservation, as well as cost savings through more efficient use of anesthetic gases (6).

Current State of the System/Process

4 What do things look like today?

- After induction of anesthesia, inhalational anesthetic agents are delivered at a targeted concentration to maintain anesthesia.
- Fresh gas flow rate is set manually by the anesthesiologist or is automatically set by the ADU when Et control is enabled.
- On Et control, the minimum FGF is pre-programmed and is typically set in the range of 0.5 – 2L/min.

Root Cause Analysis

5 What gets in your way?

Education & Awareness

- Anesthesiologists are unaware of the environmental impact of anesthetic gases
- Historical concerns regarding Compound A and plasma fluoride
- Product monographs have (erroneous) warnings about low fresh gas flow rates. For example, “Fresh gas flow rates of less than 2 L/min in a circle absorber system are not recommended, as safety at lower rates has not yet been established.” (7)

Clinical workflow

- ADU programmed at 2 L/min on Et control for unwarranted concerns over accumulation of Compound A and fluoride in breathing circuit.

Infrastructure

- Some anesthetic gas machines may not be able to deliver <0.5L/min on auto-control (though they can be set manually).
- Concern that warranty may be voided if machines are modified by the hospital’s medical engineering department.

Design the Improvement & Define Change Ideas

6 What are your ideas to achieve your goals, address your root causes and close the gap from your problem statement?

Education & Awareness

- Run educational sessions for anesthesiologists and trainees to socialize the importance of addressing environmental sustainability and emphasize the importance of minimizing FGF **(Resource: Video – coming soon!)**
- Review the **Guidelines for Environmental Sustainability (Section 10)** of the Canadian Anesthesia Society's 2023 Guidelines to the Practice of Anesthesia with your team. (3)
- Review the financial benefits of conserving anesthetic agent by running minimal FGF.
- Review the literature on FGF rates that clearly establishes the safety of low flow, and share with colleagues (Resource: Lit on Safety of Low FGF).

Clinical workflow

- Change hospital policy and anesthesiologist practice patterns to select low flow when administered anesthetic gases.

*Note: A quality improvement project at tertiary hospital in the UK incorporated the following elements in an effort to promote low FGF: email to staff explaining the project; initial questionnaire and spot audits of behaviours; 'low flow board' in the department to highlight project aims and monthly progress; **this paper** offers a helpful breakdown of the project (8).*

Design the Improvement & Define Change Ideas

6 What are your ideas to achieve your goals, address your root causes and close the gap from your problem statement?

Clinical workflow continued

- Strategies to safely reduce FGF include:
  - "During induction of anesthesia, the desired inspired anesthetic concentration can be achieved by increasing the vaporizer setting rather than by increasing the FGF rate." (1)
  - "During endotracheal intubation, FGF can be paused rather than turning off the vaporizer, thereby avoiding flushing additional anesthetic vapor out of the anesthesia circuit into the atmosphere of the OR. " (1)
  - "During maintenance of anesthesia, a low FGF rate can be maintained (similar to closed circuit conditions). This requires continuous monitoring of inspired oxygen concentration (FiO_2) to ensure adequate oxygen concentration, and monitoring of exhaled concentrations of anesthetic vapor to ensure adequate alveolar anesthetic concentrations." (1)
  - "During emergence from anesthesia, the volatile anesthetic vaporizer can be turned off while a low FGF is maintained to ensure that adequate time is allowed for a smooth and timely emergence. It is not necessary to add N_2O after turning off the volatile anesthetic vaporizer, and this practice is to be discouraged from an environmental perspective". (1)
  - American Society of Anesthesiologists' **Protocol for a Safe Minimum Fresh Gas Flow Practice)** (9).

Design the Improvement & Define Change Ideas

6 What are your ideas to achieve your goals, address your root causes and close the gap from your problem statement?

Infrastructure

- Consult biomedical engineering department to program ADU to minimal flows when Et control is enabled.

Note: At a Toronto area hospital, the engineering department requested guidance from GE to reprogram their GE Aisys machines to set the default minimum flow with sevoflurane from 2 L/min to 0.5 L/min on Et control. The process was easy and had no associated costs.

Note: Manufacturers like GE acknowledge the environmental benefits of reducing FGF (10).

Finances & Procurement

- Purchase anesthetic gas machines that can deliver low or metabolic rates.
- Create a business case with the buy back period and potential cost savings of the modified or new machines given the increased efficiency in anesthetic gas use they will facilitate.

Measure & Test Impact

7 How will you estimate the environmental impact of your changes?

Activity/Outcome Metric

- **MAC-hours of common anesthetic gases over a month**
- **Average FGF and vaporizer setting for each gas**

Source(s):
- Pharmacy procurement data
- EMR data
- Self-audit

Considerations:
- Monthly counts are recommended to observe progress, but data can be processed for any given time frame.

*Consult the **Eliminate Desflurane charter** for an alternate measurement strategy based on containers of gas (see also [8]).

Related Environmental Metric*

Kg CO2e per MAC-hour:

Gas	FGF 0.5	FGF 1	FGF 2
Sevo @ 2%	**0.64 kg CO2e**	**1.29 kg CO2e**	**2.58 kg CO2e**
Iso @ 1.2%	**1.39 kg CO2e**	**2.79 kg CO2e**	**5.57 kg CO2e**
Des @ 6%	**31.48 kg CO2e**	**62.97 kg CO2e**	**125.94 kg CO2e**
N2O @ 60%	**9.75 kg CO2e**	**19.5 kg CO2e**	**39 kg CO2e**

Source(s):
- Sevo, iso, and des calculated using Association of Anaesthetists' Anesthetic Gases Calculator.
- N2O calculated using data from Hanna and Bryson (10).
- Above metrics are based on the following assumed GWP100 for each gas:
  - Sevoflurane: 130 (5)
  - Isoflurane: 510 (5)
  - Desflurane: 2540 (5)
  - Nitrous Oxide: 320 (8)

Environmental Impact

Considerations:
- Tally the kg CO2e/MAC-hour for all gases.
- There should be a REDUCTION in this overall number over time as practitioners reduce their FGF.
- To translate your results to stakeholders:
  - Use the Natural Resources Canada Greenhouse Gas Equivalencies Calculator
  - Convert amount in kg CO2e to g CO2e then divide by 206 g CO2e (the average emissions per km in Canada [12]) to obtain km driven equivalent (11).
- **Calculations will yield ESTIMATES only**

Embed & Spread

8 What steps have been taken to ensure lasting change? How could it be spread to other contexts?

Micro (What can you do?)
- Embed education on the environmental, financial, and clinical value of reducing FGF.

Meso (What can you do within your organization?)
- Program all ADU to default to 0.5 L/min or lower as minimum FGF with Et control mode.

Macro (What can your organization do?)
- Incorporate environmental sustainability education into curriculum for anesthesiologists.

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