

# Simulator-based study of the Dräger Apollo Low Flow Wizard

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## Introduction

The Low Flow Wizard (LFW; Dräger, Lübeck, Germany) provides real time guidance for cost effective user optimization of fresh gas flow (FGF) range, and thus anesthetic agent, during general inhalational anesthesia. The LFW continuously informs users whether FGF is too high, appropriate or too low and its color-coded display (red: too low; green: appropriate; yellow: too high; Figure 5) responds in real-time to changes in FGF performed by users.

## Objectives

The objective is to determine if the Low Flow Wizard feature, as implemented in the Dräger Apollo workstation, alters volatile anesthetic consumption.

## Methods

Because a study during actual clinical use with patients involves many potentially confounding variables, we used a mannequin patient simulator (Human Patient Simulator, HPS, version B, CAE Healthcare/Medical Education Technologies, Inc., Sarasota, Florida, USA) that consumes and exhales volatile anesthetics. The “patient” was a 64-years old, 70 kg male with a pancreatic head mass scheduled for a laparoscopic procedure. A multi-parameter physiological monitor (Merlin 6M1046, Philips Healthcare, Andover, MA, USA) placed on top of the Apollo displayed the ECG, heart rate, SpO2 and at first noninvasive and then invasive blood pressure. In this within group study and with prior IRB approval (UFIRB #2011-U-0532), each of 15 participants acted as his or her own control. Each participant was asked to anesthetize the same “patient”, as simulated by the HPS as they normally would, twice: first with the LFW inactivated and subsequently with the LFW enabled. The volatile anesthetic was isoflurane. Both simulation runs were set up to have similar time durations for the different phases of anesthesia: induction and maintenance. We started a 10 minute timer whenever the clinicians said that they were ready for surgical prep and ended the scenario after 10 minutes had elapsed. We announced first incision 4 minutes after prep accompanied by elevation of BP and HR which declined over the next 5 minutes. Emergence was not simulated.

Isoflurane vapor consumption was calculated by integrating over time the product of FGF (from the Apollo MediBus data port) times isoflurane volumetric concentration at the Apollo’s equivalent of the FGF hose (from a Datex Capnomac Ultima multigas analyzer). We used an isoflurane liquid to vapor volume conversion factor of 1:180.1 and a density for liquid isoflurane of 1.496 g/ml. The isoflurane vaporizer was weighed before and after each simulation run on a digital scale (Model EK-12Ki, 12000gx1g, A&D Engineering, San Jose, CA, USA) to determine isoflurane consumption (in g) for the entire simulated anesthetic. Measurements via the digital scale were in agreement with, and thus validated, the isoflurane consumption derived from integration over time.

## Results

During the maintenance phase of the simulated anesthetic, the median fresh gas flow rate dropped from 2.5 l/min to 0.98 l/min ( $p=0.001969$ ) and the median liquid isoflurane consumption rate decreased from 16.05 ml/hr to 8.55 ml/hr ( $p=0.01286$ ) when the Low Flow Wizard recommendations were made available. There was no significant difference in alveolar isoflurane concentration, mean arterial blood pressure or heart rate between the two groups, confirming that the anesthetics were equivalent.

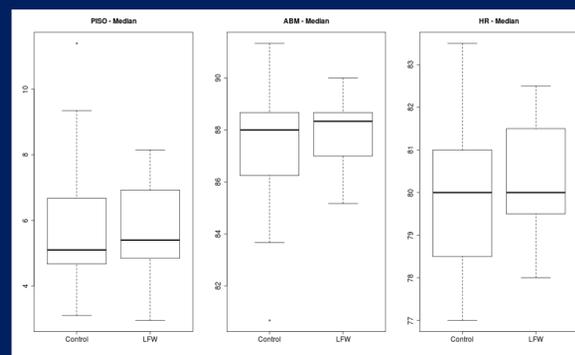


Figure 1. Comparison of alveolar concentration of isoflurane (Piso), mean arterial pressure (ABM) and heart rate (HR) with and without the LFW.



Figure 2. The simulated environment where the study was conducted using an HPS.

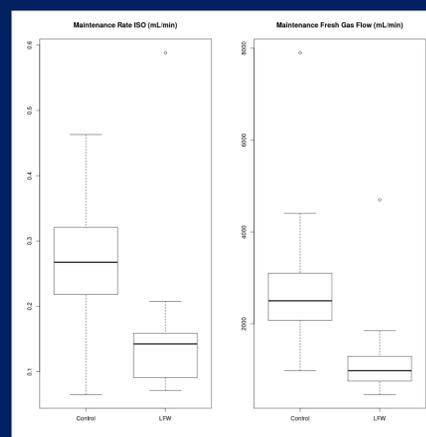


Figure 3. Comparison of liquid isoflurane consumption rate and FGF rates w/ and w/out the LFW.

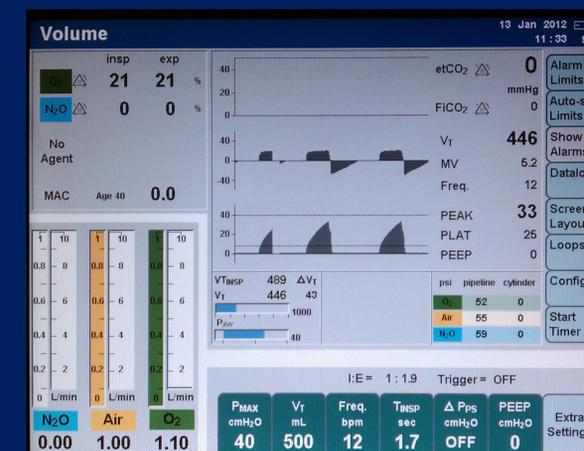


Figure 4. The Dräger Apollo user interface with the Low Flow Wizard feature inactivated (empty grey box near middle).

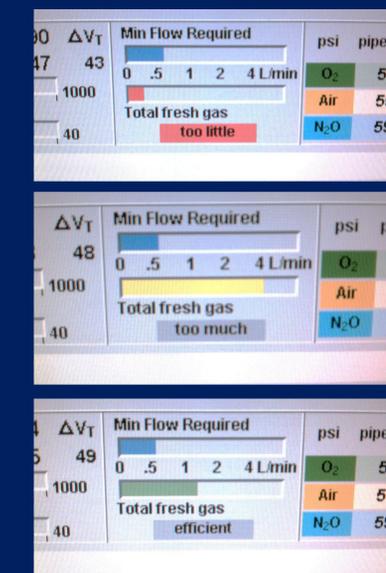


Figure 5. The Low Flow Wizard displaying messages for too low (top), too high (middle) and just right (bottom) FGF rate.

## Conclusions

Availability of the Low Flow Wizard results in large reductions (47% on average) in isoflurane consumption during the maintenance phase of simulated anesthetics. We anticipate a similar reduction in volatile anesthetic agent consumption when the LFW is used with actual patients, resulting in cost savings and reduced environmental pollution.

