We would like to address some of the issues raised by Dr. Finegan in his accompanying editorial.²

The intent of our report was not to discuss the range of our pre-admission anaesthetic activities but rather to describe how we deal with one specific groups of patients – those requiring anaesthetic consultation – in the pre-admission period. At the Toronto Hospital, we have taken an approach to pre-admission anaesthetic assessment very similar to that described by Dr. Finegan. We too have developed a centralized Pre-Admission Clinic (PAC) which operates in conjunction with a Same Day Admission Surgery Unit (SDASU). The Anaesthesia Consultation Clinic which we describe is, as in Dr. Finegan's programme, held daily in tandem with the PAC process. We agree that the Pre-Admission Program should be developed as part of an organized approach to the management of elective hospital admissions. We are fortunate to have the necessary administrative, clinical, technical and clerical support to develop and broaden our programme.

In the pre-admission period we provide both routine preoperative anaesthetic assessments as well as anaesthetic consultations. We chose to review our experience with the pre-admission consultation process because we believe that this may be most applicable to the majority of your readers. Although our experience matches that of the University of Alberta Hospitals with respect to cost savings achieved by the operation of a PAC/SDASU, we believe that not all anaesthetists currently have in place the institutional administrative structure to allow the functioning of such a comprehensive programme. A Pre-Admission Anaesthetic Consultation Clinic requires minimal resources and can be established and administered as an independent programme through the Anaesthetic Department. While we believe that all anaesthetists should work toward the development of a comprehensive multi-disciplinary Pre-Admission Programme, we also believe that the absence of such a programme should not preclude their establishing a Pre-Admission Anaesthetic Consultation Service while continuing to develop the remainder of a comprehensive pre-admission programme.

Our report was a description of our initial experience with the Anaesthesia Consultation Clinic. Dr. Finegan describes the figure of 19% "inappropriate" referrals as "clearly unacceptable." We indicated in our report that the large proportion of inappropriate referrals was due to one surgeon who consistently sent healthy patients for consultation. We indicated the need to educate surgeons to allow them to recognize which patients should be referred. Our impression from our subsequent experience is that our surgeons have, in fact, become "educated" through the consultative dialogue between anaesthetists and surgeons.

We agree with Dr. Finegan that a 5% "operative delay" subsequent to a preoperative consultation is "clearly unacceptable." As we indicated, 16 of the 20 delays in our report were the result of failure to carry out laboratory investigations recommended by the consultant anaesthetist. During the period of this review, we had asked the referring surgeon to arrange the investigations requested by the consultant anaesthetist. We found this to be inefficient and consequently we have changed the functioning of our service so that the consultant anaesthetist, rather than the referring surgeon, is responsible for ensuring that the recommended laboratory investigations are performed, reviewed, and acted upon.

We agree with Dr. Finegan that the creation of pre-admission anaesthetic assessment programmes offers anaesthetists leadership roles in an increasingly important activity. We encourage other anaesthetists to develop an interest and become active in these programmes.

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Cost of anaesthesia

To the Editor:

Rationalizing the costs of anaesthesia has been the subject of much discussion at our institution. We read with interest a recent letter in this Journal containing an equation for calculating the cost of inhalational agent anaesthesia.¹

That equation gives cost as price for set vapour concentration, fresh gas flow, and time at sea level. However, to allow comparisons between volatile agents of different potencies, cost is better expressed as price per MAC hour.²

An equation using fixed constants for known agents¹ cannot be used for new volatile agents. We use a formula derived from the ideal gas-like behaviour of unsaturated vapour,³ which also takes into account the temperature, atmospheric pressure, and units of measurement.

$$\begin{aligned} \$\dot{X}_{\text{liquid agent}} &= C_{\text{liquid agent}} \times \dot{V}_{\text{gas}} \times 60 \text{ min} \\ &\times \frac{\text{MAC}_{\text{agent}}}{100\%} \times \frac{W_{\text{mol agent}}}{\rho_{\text{liquid agent}}} \times \frac{P_{\text{Bar}} \times 10^{-3} \cdot \text{m}^3 \cdot \text{L}^{-1}}{R \times T} \end{aligned}$$

$\$X_{\text{liquid agent}}$ is the MAC-hour cost of agent (\$),

$C_{\text{liquid agent}}$ is unit cost (\$ · ml⁻¹) of liquid agent,

$\dot{V}_{\text{gas}}$ is the fresh gas flow (L · min⁻¹),

$\text{MAC}_{\text{agent}}$ is the agent's minimum alveolar concentration (%),

$W_{\text{mol agent}}$ is the agent's molecular weight (g · mol⁻¹),

$\rho_{\text{liquid agent}}$ is the agent's liquid density (g · ml⁻¹),

P_{Bar} is the atmospheric pressure (Pa),

R is the ideal gas constant (8.314 J · K⁻¹ · mol⁻¹) and

T is the temperature of the gas (K)

Substituting 101325 Pa for atmospheric pressure, 294.15K for room temperature, and the molecular weights, liquid densities, and minimum alveolar concentrations (MAC) of halothane, enflurane, and isoflurane^{4,5} concurs with previously published values. Figures for desflurane^{4,6} and sevoflurane^{4,7,8} which have been published recently can also be applied (Table I).

We submit that it is important to include the cost of carrier gas or gases. In Australia, the cost of one litre of bulk oxygen gas is 0.2 cents, while one litre of nitrous oxide from cylinders costs 1.25 cents. Halothane costs \$37.80 per 250 ml bottle, enflurane costs \$129.42 per 250 ml, and isoflurane costs \$95.03 per 100 ml. Desflurane and sevoflurane are not (yet) available in Australia.

Table II shows the calculated prices of the available inhalational anaesthetics in 100% oxygen and in 70% nitrous oxide, at commonly used fresh gas flow rates, expressed in Australian dollars per MAC hour. For each agent, cost is directly proportional to the vaporizer setting and the flow rate of fresh carrier gas. This is the rationale for the use of low-flow closed circuit anaesthesia.^{2,9,10,12}

While use of nitrous oxide decreases agent cost in direct proportion to the reduction in MAC, the increased cost of the carrier gas can contribute significantly to total cost. With halothane, the use of nitrous oxide *increases* the calculated costs by over 60%! Halothane, therefore, is cheaper to use with oxygen alone. Virtue¹⁰ reached the same conclusion using different assumptions.

Breakeven analysis reveals that, at current prices, the MAC-sparing effect of nitrous oxide remains economically important while enflurane costs more than \$32.62 per 250 ml bottle, and isoflurane more than \$22.19 per 100 ml bottle. The breakeven point for desflurane is \$4.80 per 100 ml; for sevoflurane it is \$9.63 per 100 ml.

TABLE I Physical properties and minimum alveolar concentrations (MAC) in 100% oxygen and in 70% nitrous oxide of selected common^{4,5} and new^{4,6-8} volatile anaesthetic agents

	<i>Halothane</i>	<i>Enflurane</i>	<i>Isoflurane</i>	<i>Desflurane</i>	<i>Sevoflurane</i>
Molecular weight	197.4	184.5	184.5	168.0	200.1
Liquid density	1.87	1.52	1.50	1.44	1.51
MAC in 100% O ₂	0.74	1.68	1.15	6.00	2.05
MAC in 70% N ₂ O	0.29	0.56	0.50	2.83	0.66

TABLE II Cost of volatile agent anaesthesia expressed as Australian dollars per MAC hour of agent in 100% oxygen and in 70% nitrous oxide. Prices are proportional to the carrier gas flow. Currently, the MAC-sparing effect of nitrous oxide is not economically significant with halothane (see text).

<i>Anaesthetic agent</i>	<i>MAC (%)</i>	<i>Agent + carrier price (\$Aus per MAC hour) at nominated total gas flows</i>				<i>Carrier gas</i>
		<i>1 L · min⁻¹</i>	<i>2 L · min⁻¹</i>	<i>3 L · min⁻¹</i>	<i>6 L · min⁻¹</i>	
Halothane	0.74	0.41	0.82	1.23	2.46	100% O ₂
	0.29	0.68	1.36	2.04	4.08	70% N ₂ O
Enflurane	1.68	2.75	5.50	8.25	16.50	100% O ₂
	0.56	1.44	2.88	4.32	8.64	70% N ₂ O
Isoflurane	1.15	3.43	6.86	10.29	20.58	100% O ₂
	0.50	2.00	4.00	6.00	12.00	70% N ₂ O

Some related expenses which do not feature in this Table include: intravenous drugs;¹² choice of breathing circuit;¹³ replenishing soda lime absorbers;¹¹ and operating room staff salaries.¹⁴ Analysis of total operating room costs in our hospital for conducting a common surgical procedure (laparoscopic cholecystectomy) shows that surgical consumables contribute 38%, while staff wages costs 53%. Anaesthetic costs (drugs and depreciation of monitoring equipment) constitute the remaining 9%. In particular, isoflurane delivery makes up less than 1% of the total cost!

Using our calculations, accurate estimates of inhalational agent and carrier gas costs have allowed us to keep the cost of delivering anaesthesia in better perspective in today's cost-conscious environment. Our formula can also be used when newer, and inevitably more expensive, agents become available, to allow rational discussion of their economic impact.

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Erratum

Eisen LB, Fisher JA. Cost of soda lime (Correspondence). *Can J Anaesth* 1993; 40: 81–3.

Please note that the following material was incorrectly displayed, the amendments are underlined:

The cost of soda lime as a function of flow is therefore;

$$\begin{aligned} \text{CS (cents)} &= 1.965 \dot{V}\text{CO}_2 T \left(1 - \frac{F}{\dot{V}} \right) \\ &= -1.965 \left(\frac{\dot{V}\text{CO}_2}{\dot{V}} \right) \text{TF} + 1.965 \dot{V}\text{CO}_2 T \end{aligned}$$

Note that for $F \geq \dot{V}$, no soda lime is needed, so CS = 0.

Converting Dr. Dion's equation for halothane cost from dollars to cents, we obtain the cost of halothane (CH) as a function of fresh gas flow, where P is the vaporizer concentration of halothane in percent:

Also, in the captions for Figures 1 and 2 the symbols for "minute ventilation" should appear as ($\dot{V}$).