Cost per anaesthetic

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Introduction

HOW MUCH DOES IT cost to give an anaesthetic?

It will be most interesting and instructive from the point of view of economics to know when one is engaged in the practice of anaesthesia, especially in hospital practice when cost is taken for granted. It is apparent that the components making up the cost per anaesthetic are multiple and variable. Patients in a private hospital have been known to be billed a few hundred dollars for a few days of oxygen therapy by the mask.

The tables on the cost of various anaesthetic drugs given below will be a guideline to encourage and exhort all practising anaesthetists to economise. The figures refer to drugs and gases (pipe-line supply) used in the University Hospital.

The cost of an anaesthetic per se includes cost of premedication; induction agents; maintenance of anaesthesia, best expressed by the hour, either under spontaneous respiration or intermittent positive pressure ventilation (manual or automatic). Special techniques may include regional blocks, ketamine anaesthesia, neuroleptic-analgesia.

The cost of use of disposable syringes, disposable transfusion sets and intravenous cannulae may be included in the total cost of an anaesthetic.

This article will describe mainly the costs of expendable anaesthetic materials which are under the control of the anaesthetist and are dependent on the technique of anaesthesia and the breathing system used.

Table I — Drugs used in Premedication

	Preparation and Dosage	$ cts
Syrup Vallergan	6 mg per ml; 1.5 — 2 mg/kg	2 per mg
Inj. Atropine	0.6 mg	5
Hyoscine	0.6 mg	16
Phenergan	50 mg	20
Pethidine	50 mg, 100 mg	4; 7 cts
Morphine	15 mg, 30 mg	6; 10
Pentazocine	30 mg	70 cts
Water for injection.		5

Comments

Trimeprazine tartrate (Vallergan), commonly used for paediatric premedication, is a strong central sedative, an anti-histamine, anti-emetic, and spasmolytic. The vallergan forte (6 mg/ml) is given 1.5 - 2 mg/kg 1½ to 2 hours before anaesthesia (Cope, 1959).

Atropine and Hyoscine

The belladonna derivatives are about the commonest used, and are relatively cheap. Hyoscine is used more often nowadays for its amnesic and sedative properties in suppressing recall after anaesthesia or reducing the chance of awareness during Caesarean section (Crawford 1971, Liew 1972).

Analgesics

Of the narcotic-analgesics, Pentazocine (Non D-D-A) is most expensive and the advantages over the others are minimal.

Table II — Intravenous Induction Drugs

		$ cts
Thiopentone sodium	0.5 G	43 cts
(2.5% solution)	1 Gm	63 cts
Methohexitone Sodium	500 mg into 50 ml	3.90
(1% solution)	Saline	
Propanidid (Epontol)	500 mg in oily base	70 cts to 1.40
Ketamine Hcl	1% solution (10 mg per ml)	
	20 ml per bottle (200 mg)	6.90
	5% solution (50 mg per ml)	14.90
	10 ml per bottle. (500 mg)	

Comments

Methohexitone (1-1.5 mg/kg) is 2½-3 times more potent than thiopentone. It costs 39 cts per 5 ml of an induction dose whereas thiopentone (3-4 mg/kg) cost 12 cts for an equipotent dose — that is, three times cheaper.

Also a solution of Methohexitone can be safely used up to a period of 10 days, especially kept in a refrigerator. It will be wasteful to open a gram of thiopentone to do a case, unless the balance is left for use by the emergency anaesthetist within 12 hours.

Cost of an Anaesthetic for ECT (University Hospital)

With the non-relaxant intravenous technique (Delilkan, 1969) and use of Ectonus stimulator, using a single intravenous dose of methohexitone (1 mg/kg) premixed with atropine 0.6 mg, the cost is some 45 cents for a 50 kg patient. Similar cost will be for a dental anaesthetic.

Intravenous ketamine Anaesthesia (1.5 — 2 mg/kg)

Intravenous ketamine anaesthesia is usually given when indicated such as for skeleto-muscular operations in the presence of a full stomach; certain abscesses in the head and neck (Delilkan, 1970) or where preservation of airway protective reflexes is desirable. An orthopaedic adult patient may require 500 mg (10 ml of a 5% solution, cost $15.00) for reduction of a fracture lasting 30 minutes. Ketamine is a reserve drug.
Intramuscular ketamine (4-10 mg/kg) anaesthesia is expensive.

Table III — Anaesthetic Gases and Maintenance Anaesthesia

(1 cubic foot = 6¼ imperial gallons;
1 imperial gallon = 4.5 litres)

1. Pipeline oxygen 240 cu. ft per cylinder at $6.50; 24 cylinders in series.
   Cylinders on anaesthetic machine e.g.
   48 cu. ft $2.25.
   24 cu.ft $1.90.
2. Nitrous Oxide
   Pipeline nitrous oxide: 3,600 gallons per cylinder;
   4 cylinders in series.
   Cylinders on anaesthetic machine: 100 gallons (450 L) capacity costs $4.50 - $5.00
   200 gallons (900 L) capacity costs $9.00-$10.00.

Comments

It costs 1 cent per litre or 5 cents per min at a flow of 5L/min or $3.00 for 300 L/hour as calculated below:

Nitrous Oxide: 100 gallons of nitrous oxide cost $4.50. Thus one imperial gallon = 4.5 litres cost 4.5 cents or 1 litre of nitrous oxide costs 1 cent.

Or a 200-gallon cylinder of nitrous oxide containing 900 L which at a flow rate of 5 litres per min lasts 180 mins (3 hours). The cost is thus $3.00 for 300 litres per hour (5 L/min). Nitrous oxide runs at 5 cents per minute at a flow of 5 L/min.

Oxygen

Pipeline oxygen (240 cu ft cylinders).
1 cu ft = 6¼ imperial gallons= 23.32 litres costing 2.5 cents.

Therefore 1 litre of oxygen costs 0.088 cent or 0.09 cent approximately.

The cost of nitrous oxide, litre for litre, is 12 times that for oxygen while it is also used at a flow 2½ times less than that of oxygen (e.g. 5 litres nitrous oxide, 2 litres oxygen). Pipeline oxygen is therefore quite cheap for anaesthetic use. The cost is astronomical only when used at high flows on a patient for days in a ward!

Controlled or automatic ventilation with the Manley Ventilator

This machine is gas driven (expensive), and has a non-rebreathing circuit (expensive). Being a minute volume divider, the patient's minute volume equals the volume of fresh gas from the rotameters.

Table IV — Manley Ventilator

High Flows	Cost per Hour	Total
Oxygen: 3 litres/min	18 (20) cents	$4.40
Nitrous Oxide: 7 litres/min.	$4.20	
Moderate flows:		
Oxygen: 2 litres/min	12 (15) cents	$3.15
Nitrous Oxide: 5 litres/min.	$3.00	

In general, gas-driven ventilators (Manley, Howells) with non-rebreathing circuits are expensive. It is usually extravagant and unnecessary to use more than 7 litres of gases for a 50 - 60 kg patient, whose minute volume is about 5 - 5.3 litres. The fear of insufficient hyperventilation and awareness during light relaxant-nitrous oxide-oxygen anaesthesia is the reason for using high flows of more than 7 litres.

The present trend is moderate hyperventilation (pCO_2 around 30 - 32 mmHg) with a concentration of nitrous oxide between 72 - 74% in oxygen to provide sufficient narcosis (and analgesia) (triad of anaesthesia; Gray, 1960).

The following table showed moderate hyperventilation at moderate flows with a Manley ventilator on two patients undergoing cardio-pulmonary bypass after induction of anaesthesia.

Table V — Manley Ventilator with moderate flow rate of fresh Gases:

		Arterial Blood Gas.
Patient I .50 kg	oxygen 2 (28.5% oxygen)	pCO_2 = 30 mmHg
	nitrous oxide 5	pO_2 = 130 mmHg
Patient II 40 kg	Oxygen 1.8	pCO_2 = 28 mmHg
	Nitrous oxide 4.7	pO_2 = 136 mmHg

The East Radcliffe (basically non-rebreathing) anaesthetic ventilator with incorporation of a soda-lime cannister and reservoir bag (rebreathing) is economical for use during anaesthesia at such flows of oxygen 1.5, and nitrous oxide 3 - 4 litres per minute.

T-piece: For the T-piece for IPPV in paediatric anaesthesia (Rees, 1950), the flow of fresh gas to prevent significant rebreathing is 100 ml/lb (220 ml/kg) body weight with a minimal of 3 - 4 litres in the newborn and young children.

Table VI — Inhalation Anaesthetics and Others

Diethyl ether	500 ml	$ 3.25
Ethyl chloride spray	100 g	$ 1.80
Halothane/Fluothane	250 ml	$69.40
Penthrane	125 ml	$65.00
Soda lime	18 kg	$35.00
Cyclopropane (not used)		$ 1.62

Halothane (1 ml liquid halothane = 211 ml vapour at N.T.P.)

Spontaneous Respiration with Halothane in a Magill circuit

The Magill circuit is now shown to be an efficient system down to fresh gas flow rates probably equivalent to the alveolar ventilation of the patient

(Kain & Nunn, 1967; Norman & Sykes, 1968), e.g. 4 - 4.5 litres alveolar ventilation in a 50 - 60 kg patient.

Vaporisation: 250 ml of Halothane is vapourised to a 1% mixture at
9 litres/minute in about 15 hours (Murray 1966);
at 6 litres/minute in about 22 - 23 hours;
at 4.5 litres/minute in about 30 hours.

Thus at a flow of 4.5 litres per minute of 1% halothane, the cost is some $2.50 per hour.

A Method of Estimation of Cost of Halothane in Various Breathing Circuits

On the Magill circuit, a known volume of halothane is placed in the Fluotec or Goldman vapourizer. Fresh gas, e.g. at a flow of 4.5 litres/minute, is used. The volume left at the end of 1 hour is measured. The difference gives the volume of halothane used in 1 hour.

Use of Halothane in Low Flow Breathing Circuit

Use of halothane in low flow breathing circuit, e.g. VIC (Vapouriser in circuit), (Gurubatham 1971): Halothane from a Goldman Vapourizer in a VIC system with oxygen at 200 - 250 ml per min costs on the average $1 an hour.

Other reports (Synopsis of Anaesthesia 6th ed. p. 203) showed the following costs:

1. 1% halothane in a 6 litres/minute flow will cost 50p ($4) per hour for halothane alone.
2. 3% halothane in a 1 litre flow to a rebreathing system will cost 25p ($2/-) per hour.
3. The cheapest method of administration is the V.I.C.

An azeotropic mixture (Law Gim Teik) consists of halothane 68 (two-thirds) and ether 32 (one-third)) parts by volume usually used in the Goldman vapouriser. It is relatively cheaper.

Comments

The freeze-dried preparation for suxamethonium in solution remains fairly potent up to one week in the air-conditioned theatre. We have not used ampoule preparation of 5% solution (100 mg in 2 ml).

The non-depolaring muscle relaxants cost about the same for equipotent or curarizing doses. Thus 3 ampoules ($1.90) of alloferine containing 30 mg may be used for 2 patients for short operations.

3 ampoules of curare ($1.80) containing 45 mg may be used for one patient for a fairly long surgery.

3 ampoules of pancuronium ($3.15) containing 12 mg may be used for 2 patients.

Alloferine (0.25 - 0.3 mg/kg) is 2½ times more potent, and pancuronium (0.08 to 0.1 mg/kg) is 6 - 7 times more potent than curare (0.6 mg/kg).

Reversal: It will be wasteful to draw up excess neostigmine in a syringe only to squirt the excess on the theatre floor.

Muscle Relaxants and Reversal Agents

1. Suxamethonium (freeze dry)	500 mg; $1.50 per bottle	15 cts per ml of 50 mg
2. d-tubocurare	15 mg in 1.5 ml at 60 cts (45 mg in 3 amp = $1.80) Multiple dose 3 mg/ml x 10 ml = $1.90	12 cents per 3 mg 19 cents for 3 mg in 1 ml.
3. Di-ally-nor-toxiferine	10 mg in 2 ml at 63 cents — $1.05	
4. Gallamine	120 mg in 3 ml at 67 cts	
5. Pancuronium	4 mg in 2 ml at $1.05	
6. Atropine	0.6 mg x 2 = 10 cents	
7. Neostigmine	Paediatric ampoule 0.5 mg/ml	15 cets per amp.
Bulk purchase: Multiple dose 5 ml (2.5 mg/ml) at $1.26		25 cts per ml
Small quantity purchase: $1.80 for 5 ml		35 cts per ml.

Local Anaesthetics and Neuroleptic-analgesics

Lignocaine	0.5% x 50 ml	$6.50 or 13 cts/ml
	1% x 50 ml	$7 or 14 cts/ml
	2% x 50 ml	$7.50 or 15 cts/ml
	5% heavy (spinal)	55 cents
	Xylocard 100 20 mg/5 ml	40 cts.
Bupivicaine	0.5% with 1/200,000 adrenaline x 20 ml	$3.75 or 19 cts per ml
	0.25% with adrenaline x 20 ml	
Haloperidol	5 mg/ampoule	21 cents.
Droperidol	2.5 mg per ml x 10 ml	18 cents per ml.
Fentanyl:	0.05 mg/ml; dosage: 0.1 — 0.2 mg	$1.50 per ampoule.
Phenoperidine	1 mg per ml	35 cents per ml.

Intravenous fluids 500 ml per bottle

Dextrose 5%	$ 1.60
Dextrose/saline	$ 1.60
Haemacel	$ 9.00
Rheomacrodex 10% in N/S or 5% dextrose	$17.50
Normal saline	$ 1.76
Ringer's lactate	$ 2.08
Ringer's lactate with 5% dextrose	$ 2.24

Disposable syringes with needles: 10 cents for 2.5 ml to 10 ml syringes; 15 cents for 20 ml syringes. The convenience and sterility are important in anaesthetic practice. One sees 20 ml syringes open indiscriminately for gastric aspiration, measurement of excreta.

Each endotracheal tube lasts on the average of six autoclavings (Stark and Pask, 1962). Taking the average of 10 autoclavings for each tube in the University Hospital, the cost is 50 cents per intubation.

Discussion

The cost per anaesthetic is described as small and modest — compared with surgical materials and not rising significantly over the years. For example, a disposable drainage tube cost $15 each; and blood for transfusion costs $100 a bottle by the time it is used for the patient. The cost of direct surgical materials and heparinised or ACD blood for a case of open heart surgery may be $1500 — $2000.

There is also a growing concern on the long-term harmful effects on the theatre and anaesthetic staff of breathing small quantities of nitrious oxide, halothane (both expensive agents) and other gases within the environment of the theatre (BJA 1971).

The average cost of anaesthetic may be worked on the following term:

$$\frac{\text{Total Expenditure per year on Expendable Anaesthetic Materials}}{\text{Number of anaethetic per year.}}$$

Resuscitation Drugs and Others

Sodium bicarbonate	50 ml of 7.5%	$ 3.35
THAM - E	36 gm in 150 ml	$22.00
Heparin	5,000 u per ml x 5 ml	$21.00 ($4.20 per ml)
Hydrocortisone succinate	100 mg	75 cts — $3.80
Isoprenaline	0.2 mg per ampoule	$ 1.50
Nalorphine	1 mg per ml amp	53 cents
	10 mg per ml	40 cents
Adrenaline (1/1000)	1 mg/ml	18 cents
Arfonad	250 mg per bottle	$5.30
Endotracheal tube		average $5.00

This is a nonsatisfactory figure, since some drugs and gases (entonox, oxygen, compressed air) are used in other places in the hospital and some anaesthetics are short (e.g. ECT sessions). Ether is often used for cleaning plaster marks; oxygen, compressed air are used in the wards and ICU, carbon dioxide for periotoneoscopy and insufflation. These should therefore not be chargeable entirely to anaesthesia.

The average cost of an anaesthetic for a 550-bed provincial teaching hospital in England may be £1 ($8) (Wilson 1966) based on total anaesthetic drugs and gases bill per year; and £3·55p. ($26/-) for anaesthetists and drugs (Wilson 1961). They commented on the economic modesty of the speciality (Shackleton 1960).

Jones (1957, 1961) showed an overall increase of 30% on the cost of each anaesthetic in 5 years at the Groote Schuur Hospital, between 1955-1960.

The prices quoted in this article refer to bulk purchase and by contract and are less than those when purchased in small quantities.

The ways to economise will be to encourage careful use of anaethetic drugs; use of optimal flow of anaesthetic gases for different anaesthetic circuits; discriminate use of certain expensive drugs and when indicated; more conservative use of disposable syringes, needles, cannulae; and better employment of personnel and better supervision.

Should it include the cost of anaesthetists, a much sought-after world commodity?

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References:

British Journal of Anaesthesia (May 1971): Editorial; A personal risk. Cope, R.W., and Glower, W.J. (1959), *Lancet* 1, 858.

Crawford, J.S. (1971) Awareness During Operative Obstetrics During Anaesthesia. *Brit. J. Anaesth.*, 43, 179.

Delilkan, A.E. (1969). Electronconvulsive Therapy Non-Relaxant Anaesthesia. *Brit. J. Anaesthesia.* 41: 884.

Delilkan, A.E. (1970). Ketamine. The Answer for One Anaesthetic Problem? *Malayan Medical Journal*, 24, 273.

Gray, T.C. (1962). *Irish J. Med. Science*, 419, 499.

Gurubatham, A.I. (1971). Closed Circuit Halothane Non-Relaxant Anaesthesia. *Anaesthesia*, 1, 49.

Jones, C.S. (1957). *S. Africa Med. J.*, 31, 906. (1961).

Law, G.T. Personal Communication.

Liew, P.C. (1972). An Improved Technique of Anaesthesia for Caesarean Section (to be published).

Norman, J., Adams; Sykes, M.K.; (1968). Rebreathing with Magill Attachment, *Anaesthesia*, 23, 75.

Rain, M.L., and Nunn, J.F. (1967). Fresh Gas Flow and Rebreathing in the Magill Circuit with Spontaneous Respiration. Proc. R. Society Med. 60, 749.

Rees, G.J. (1950). Anaesthesia in the Newborn. *Brit. Med. J.*, 2, 1419.

Shackleton, P. (1960). The Economics of Anaesthesia, 15, 229.

Stark, D.C.C. and Pask, E.A. (1962) *Anaesthesia* 17, 195.

Wilson, A.M. (1966). What price Anaesthesia? An investigation into costs. *Brit. Med. J.* 2, 1190-1192.