Review Article

Vapourisers: Physical Principles and Classification

Address for correspondence:
Dr. Vithal Dhulkhed, Department of Anaesthesiology, Krishna Institute of Medical Sciences Deemed University, Karad - 415 110, Maharashtra, India.
E-mail: drvithalk@hotmail.com

Vithal Dhulkhed, Akshaya Shetti, Shraddha Naik, Pavan Dhulkhed
Department of Anaesthesiology, Krishna Institute of Medical Sciences Deemed University, Karad, Maharashtra, India

Access this article online
Website: www.ijaweb.org
DOI: 10.4103/0019-5049.120141
Quick response code

ABSTRACT

Vapourisers have evolved from rudimentary inhalers to the microprocessor controlled, temperature compensated and flow sensing devices, which are universal today. The improvements in the design was influenced by the development of potent inhalational anaesthetics, unique properties of some agents, a deeper understanding of their mechanism of action, inherent flaws in the older vapourisers, mechanical problems due to thymol deposition, factors influencing their output such as temperature and pressure variations. It is important to review the principles governing the design of the vapouriser to gain insight into their working. It is fascinating to know how some of the older vapourisers, popularly used in the past, functioned. The descendant of Oxford Miniature Vapourizer, the Triservice vapouriser is still a part of the military anaesthesia draw over equipment meant for field use whereas the Copper Kettle the first precision device is the fore-runner of the Tec 6 and Aladdin cassette vapouriser. Anaesthesia trainees if exposed to draw over techniques get a deeper understanding of equipment and improved skills for disaster situations. In the recent advanced versions of the vapouriser a central processing unit in the anaesthetic machine controls the operation by continuously monitoring and adjusting fresh gas flow through the vapouriser to maintain desired concentration of the vapour.

Key words: Anaesthesia equipment, history of vapouriser, principles of vapourisers, the development of vapourisers, understanding vapourisers, vapouriser

INTRODUCTION

Anaesthesiologist should understand the basic physical principles and how they will influence the design of the vapouriser.[1] This will help the anaesthesiologist to select the vapouriser well-suited in his practice and to use them safely, economically and to maintain them in optimum working condition. This review cannot be expected to cover every detail of this vast topic. The objective is to give an insight into the operating principles in simple and lucid manner for the student of anaesthesiology.

PHYSICAL PRINCIPLES

What is a vapour? The gas below the critical temperature is popularly called vapour. Above its 'critical temperature', any amount of pressure will not compress a gas into liquid form; but it remains a gas.

It is also useful to know how much of liquid anaesthetic is consumed during anaesthesia. As an approximate working figure (for halothane, enflurane, isoflurane and sevoflurane) 1 ml of liquid anaesthetic on vapourisation produces 200 ml of its vapour.[2] To be more precise use the formula (1):

$$\text{Vapour output of 1 ml of liquid agent [Table 1]} = \frac{22,400 \times \text{Density}}{\text{Molecular weight (MW)}} \quad (1)$$

Millilitres of liquid used/hour ≈ set percentage × fresh gas flow (FGF) in L/min × 3 (for sevoflurane use 3.3), i.e., if we set isoflurane 2% on the dial and a FGF rate of 1 L/min; 6 ml of liquid per hour is utilized.[2]

These figures are approximate meant for general guidance for calculation.

How to cite this article: Dhulkhed V, Shetti A, Naik S, Dhulkhed P. Vapourisers: Physical principles and classification. Indian J Anaesth 2013;57:455-63.

Saturated vapour pressure (Psv)

In a closed container vapour starts forming over its surface and its pressure increases. At equilibrium it reaches a maximum at a particular temperature and is called saturated vapour pressure (Psv). The Psv increases as the temperature increases and vice versa. It is constant for a particular agent at a specific temperature and is independent of ambient pressures at different altitudes and depths. The Psv of all the volatile anaesthetics mentioned are measured at 20°C. The Psv of volatile anaesthetic agent is the most important property and it should be well-understood to gain insight into the working of a vapouriser.[3,4] For example, Psv of isoflurane is 239 mm Hg.

Boiling point (BP)

It is the temperature of a liquid at which its vapour pressure is equal to the atmospheric pressure. The BP will be lower with lower atmospheric pressure. Anaesthetic agents with lower BPs are more affected by variations in barometric pressure (Pb) than agents with higher BPs.

Dalton's law

The total pressure is equal to the sum of individual partial pressures of the gases present in the mixture. This principle will also allow us to estimate the vapouriser output variation in hypobaric and hyperbaric environment.

Latent heat of vapourisation

The amount of heat energy utilised in the formation of vapour from a liquid without a change in temperature is defined as latent heat of vapourisation. More volatile liquid vapourises faster and cools faster.

Minimum alveolar concentration (MAC) (MAC in volume %; vol. %).

The MAC value for an inhalational agent is the MAC in vol.% of end-tidal alveolar gas at 760 mm Hg (1 atm) that causes a lack of response to painful stimulation in 50% of patients.

MAC values can also be expressed in terms of units of pressure, i.e. mm Hg by multiplying the MAC vol.% value with 760 mm Hg. Considering MAC in terms of a minimum alveolar partial pressure of the specific agent rather than volume % is more appropriate because the partial pressure or anaesthetic tension (which will indicate the density of gas molecules) in the brain determines the anaesthetic potency. Psv as explained above does not vary with Pb. A given partial pressure represents the same anaesthetic potency under various Pbs; this is not the case with volumes per cent[5] (also see below, effect of Pb on vapouriser output) [Table 1].

Specific heat or heat content

It is the number of calories required to raise the temperature of one gram of a substance by 1°C. If a substance or a material has Specific heat or heat storage capacity it can supply heat for a longer time to the anaesthetic agent to vapourise.[6] Copper and water are used as reservoirs of heat, e.g. copper: 0.092 cal/g°C (at 20°C), water 1 cal/g°C (at 18°C).

Thermal conductivity

The body of a vapouriser should be made of good conducting material to conduct heat energy from the environment to the agent and also material of good specific heat. It should be bulky enough to store a good amount of heat. For example, the thermal conductivities of some of the commonly used metals are in watts per meter per Kelvin (W/m/K); copper 385.0, brass 109.0, aluminium 205.0, steel 50.2.

Vapourisers

The function of a vapouriser is to deliver safe concentrations of volatile anaesthetic vapour to the breathing circuit.[7]

Understanding how a vapouriser works

When William Thomas Green Morton used his inhaler it was a simple device. It consisted of a container and two ports. Inhalation through one port drew air through

Table 1: Physical properties of inhalational anaesthetic agents

Agent	BP (°C) (at 760 mm Hg)	MAC (vol %)	MACP (mm Hg)	Psv (mm Hg)	Molecular weight (g)	Density (g/ml)	Vapour output/ 1 ml liquid
Halothane	50.2	0.75	5.7	243	197	1.86	211.5
Enflurane	56.5	1.68	12.8	175	184.5	1.52	184.5
Isoflurane	48.5	1.15	8.7	239	184.5	1.5	182.0
Methoxyflurane	104.7	0.16	1.2	22.5	165	1.42	193.0
Sevoflurane	58.6	2.1	16	160	200	1.52	170.0
Desflurane	23.5	6-7.25	46-55	678	168	1.45	193.0
Ether	34.6	1.92	14.6	442	74	0.72	218.0
Trichloroethylene	86	0.17	1.3	58	131	1.5	256.5

BP – Boiling point; MAC – Minimum alveolar concentration; MACP – Minimum alveolar partial pressure; Psv – Saturated vapour pressure

the other port and air passed over a sponge soaked in ether, carrying ether vapours to be inhaled by patient. However, this was a rudimentary device since the vapour output was highly variable. Flagg's can and its modified version the King Edward Memorial Hospital, Mumbai (KEM) bottle work on a similar line.[8,9] It was dangerous to use this kind of device with potent anaesthetics. The vapouriser since has been through numerous modifications.

The diagram shows a simple basic vapouriser. Its important part is the vapourising chamber (VC) or the sump [Figure 1a-c].

Here inside VC the objective is to create Psv in the space over the liquid anaesthetic agent to deliver known amount of vapour. For example, the Psv of isoflurane is 239 mm Hg. Hence, the concentration of isoflurane created is 239/760 (Pb - ambient pressure), i.e., approximately 31% V/v in the VC. This percentage if inhaled is too high and dangerous to patient and has to be lowered to the safe levels. Hence two channels are created making the FGF entering the vapouriser divide into two streams. One stream flows into the VC and gets fully saturated with anaesthetic vapour. The other portion passes through the bypass pathway. The FGF stream carrying the saturated vapour joins the bypass flow. The diluted vapour concentration in the combined gas flow is the output concentration. The ratio of the two streams is the splitting/split ratio.[10,11]

The control dial varies the split ratio according to set concentration. The output concentration depends upon how much gas passes through each pathway. If the dial is set for higher concentration more fresh gas is diverted into the VC. For example when we set the dial concentration to 1% for isoflurane the split ratio is 44.5:1, i.e. if FGF into the vapouriser is 5000 ml; 110 ml will flow into the vapourising chamber, which will pick up 50.5 ml of isoflurane vapour (31% of 110 ml+50.5ml=160.5ml) and 4890 ml bypasses and the resulting output concentration is 1% (50.5 ml vapour in total outflow of 5050.5). The split ratio is varied by a control regulator. This controller in older vapouriser was at the inlet of the VC and in newer it is at the outlet.

Split ratio for vapourisers with split ratio control knob at the VC inlet

$$= \frac{100-\pi}{\pi} \times \frac{Psv}{Pb-Psv} - 1 \quad (2)$$

π - Set vol.% on the dial; if it is 1% then $\pi = 1$, Pb-ambient pressure, Psv-saturated vapour pressure of the concerned agent.

Split ratio for vapourisers with split control knob at the VC outlet

$$= \frac{100-\pi}{\pi} \times \frac{Psv}{Pb} - 1 \quad (3)$$

However, at the higher rate of flow the time for the fresh gas to saturate with vapour is inadequate. This causes the output concentration to fall. The solution is to increase the surface area of vapourisation to increase the efficiency of vapourisation. This is achieved by providing wicks in contact with the agent. Simple plates or channels (baffles) are also incorporated in VC that encourage mixing of carrier gas with vapour, ensuring saturation before the carrier gas returns to the anaesthetic circuit [Figure 2a and b].

Another method is to bubble the FGF through the agent. As the agent vapourises it cools. The Psv falls. This decreases the output concentration. One solution

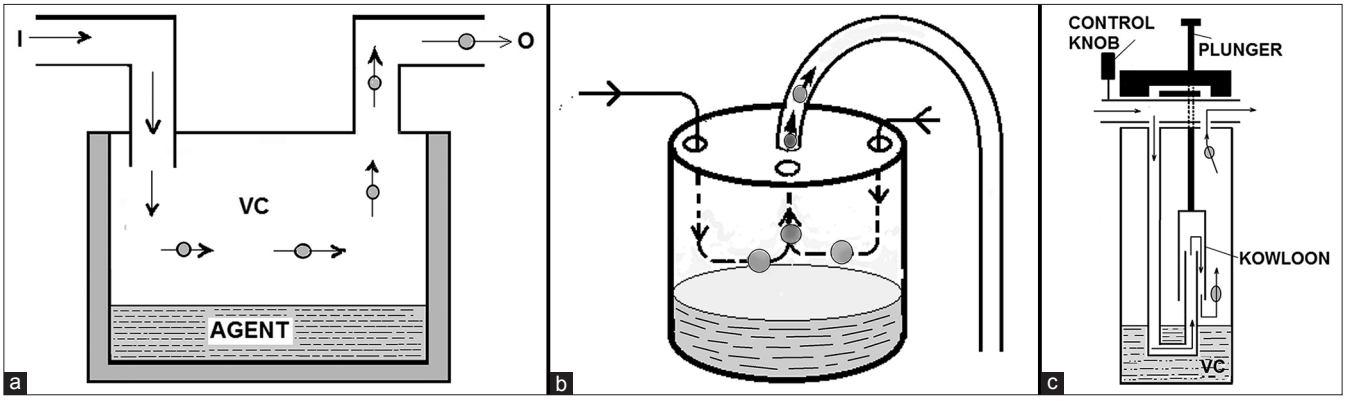

Figure 1: (a) Generic simple flow over vapouriser: I – Inlet port; O – Outlet port; vapourising chamber; Plain arrow shows fresh gas flow (FGF); Arrow with circle shows FGF carrying vapour; (b) Flagg can; (c) Boyle's bottle

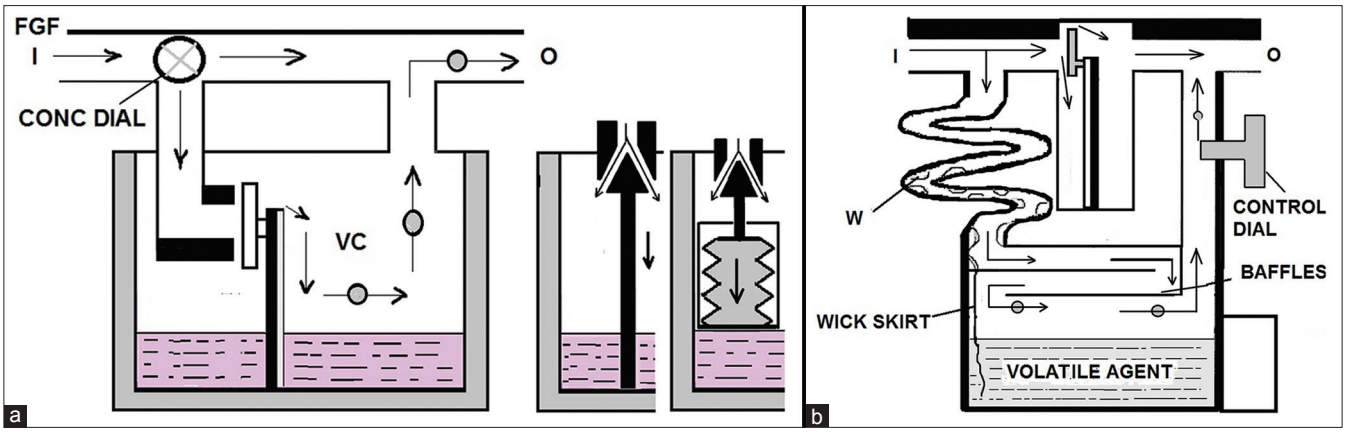

Figure 2: (a) Splitting of fresh gas flow by the control valve at the inlet, bimetallic strip, bellows assembly (b) advanced vapouriser incorporating W-wicks, baffles, etc.

is to supply heat to the liquid anaesthetic. The material of the vapouriser is made of good conducting material, which conducts heat from the surrounding air. The chamber can be encased in a water jacket so that water with high specific heat can supply heat for a longer time. It is also made-up of thick metal casing, which absorbs heat from the surrounding air, stores it and supplies it to the anaesthetic.

As the liquid cools and vapour output falls there should be an additional method of compensation to increase the flow of FGF into the VC so that it carries higher amount of vapour. One simple way is to measure the temperature and alter the flow setting with the help of a reference chart. This is a tedious process, since it requires frequent corrections. Hence automatic temperature compensating unit (TCU) or valve has been devised. It can be a metallic bellows assembly with volatile liquid inside such as ether or Freon. As the liquid anaesthetic cools the bellows starts collapsing since the content inside gets smaller in volume. This opens the inlet port wider allowing more flow into the chamber. A metal rod also can be used since the metal contracts with the drop in temperature. Another method uses another physical property of a metal. Dissimilar metals have different coefficients of expansion when they are heated. Two different kinds of metal strips are fused together to form a bimetallic strip. When cooled one metal shrinks more than the other making the bimetallic strip to bend in one direction and in opposite direction as it warms. It is fixed in such a way that as the temperature falls it alters the splitting ratio by its deflection away from the port in the VC inlet (allowing more flow into VC) or deflects towards the port in the bypass channel (decreasing bypass flow portion) ultimately increasing FGF into the VC.

Depending on how it is made to function a vapouriser can be delegated to one class or another.

CLASSIFICATION

Draw over versus plenum

When a patient inspires negative pressure is created in the breathing circuit connected to a simple vapouriser, this is called draw over type. Carrier gas is drawn into the vapouriser and passes over the anaesthetic liquid and the mixture is inhaled by the patient. In another type (presently commonly used in anaesthesia delivery system) carrier gas from higher pressure source than the ambient pressure is pushed through the vapouriser to take up the anaesthetic vapours. The mixture then flows into the breathing circuit having lower pressure. This is the plenum type[1] with or without variable bypass as discussed above.

Measured flow vapouriser

Independent stream of measured FGF is led into VC with the help of a separate flow meter. It carries vapour and this is mixed with a separate measured fresh flow with the aid of another flow meter to give required concentration, e.g. Copper Kettle.[12]

Injection type, e.g. Siemens vapouriser for halothane, enflurane, isoflurane. A calibrated throttle valve is opened or closed by the anaesthetist. The more it is closed (more resistance to the FGF), the higher the pressure transmitted by the FGF into the VC. This pressure tends to force liquid to atomize at the injector nozzle. The number of molecules of liquid injected is proportional to the resistance to gas flow at the throttle valve (controlled by the concentration control dial). The liquid droplets vapourise in the flowing fresh gas stream. Thus, since the liquid is not

vapourising within the VC, thermal compensation is not necessary [Figure 3].

Temperature compensated

As explained above.

Flow over or bubble through

As detailed earlier.

Agent-specific or nonspecific

Agent specific vapourisers are calibrated for a specific agent. They have keyed fillers meant for filling the right agent and the chances of filling with the wrong agent is less likely. If multiple agents can be used as in an older vapouriser it is nonspecific.

Vapouriser inside or out of circuit

It means vapouriser is placed in FGF line and not in the circle system. In contrast, very old models such as the Boyle's bottle or Goldman bottle with low resistance characteristics; could be inserted within the inspiratory limb of the circle system. This is vapouriser inside circuit (VIC). The newer generation plenum vapourisers with inherent high resistance characteristics cannot be used either in the draw over circuit or in the closed circuit as VIC.

The plenum vapourisers

Boyle's bottle

This vapouriser is variable bypass, can operate as bubble through or flow-over without wicks, non-agent-specific. It has low resistance in-circuit. It has no interlock system which is used to allow only one vapouriser at a time in the modern anaesthesia machine. It is not temperature compensated. When the control knob, which is just a crude split ratio controller, is in the down position, the cowling over the U-tube descends and brings the FGF closer to the surface of the agent or forces it to bubble through ether, increasing output by increasing the gas/liquid interface. There is the potential for a surge of high concentration of ether when first turned on. Two versions for ether and halothane (smaller capacity without bubble through) were made.

Tec 2 (Ohmeda) halothane vapouriser

Launched in 1959 it can be called the first modern precision agent specific vapouriser. It was widely accepted. The earlier type, Mark 1 (Mk 1) was short-lived. By fixing a vapour control dial to the rotational 'Barrel' of Mk 1 (which caused practical problem) Mk 1 was upgraded to Tec 2.

It is classified as agent-specific for halothane, variable bypass, flow over with wicks, low resistance, temperature compensated with bimetallic strip in vapour path. Its other features were; metal heat sink or reservoir, non-keyed filler, no interlock system. However, it was prone to pumping and pressurizing effects (discussed later). The bimetallic strip decreases the flow through the VC when temperature increases [Figure 4a]. The control knob is calibrated to 0-4%.

At low flows, at high concentration settings, it was made to deliver purposefully higher output than indicated to accelerate induction; however, at low concentration settings its output was much less. One problem that was very bothersome was the bimetallic strip getting stuck due to thymol deposition; a stabilising agent in 0.01% concentration added to halothane.[13] Even the control spindle dial got stuck frequently.

Tec 3 vapouriser

It was introduced in the late 1960s due to drawbacks

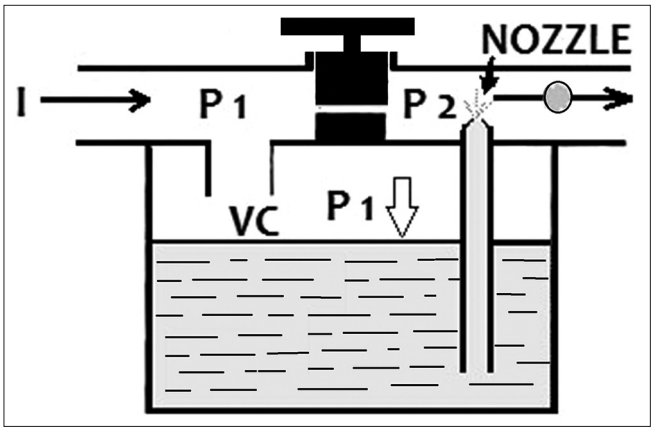

Figure 3: Siemens vapouriser

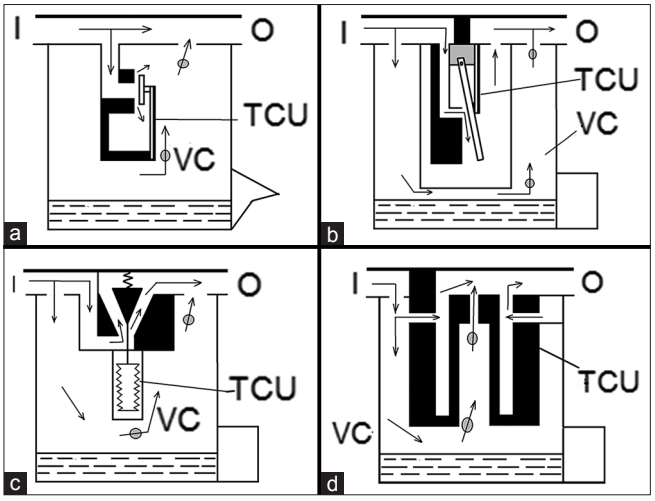

Figure 4: Temperature compensating assembly in older vapourisers: (a) Tec 2, (b) Tec 3, (c) Ohio 100, (d) Drager 19

of the Tec 2 particularly the problems of the thymol causing operating spindle to stick, the pumping effect and the high concentration at low flows. Its precision milled rotary valve eliminated thymol deposit problems.[14]

The VC has two concentric wick skirts, which enclose nickel plated copper helix in between. This assembly forms a long spiral channel through which carrier gas flows before entering the VC preventing back pressure problems. The bimetallic strip within the bypass chamber increases flow through the bypass chamber when temperature increases [Figure 4b] This vapouriser has an experimental pre 'Selectatec' mounting.

Ohio 100

The temperature compensating device in this is bellows and thimble valve, which increases the flow through the bypass when temperature increases [Figure 4c].

Drager 19

It features an annular valve constructed of dissimilar metals as a TCU that increases the flow through the bypass when temperature increases [Figure 4d].

Tec 4 vapouriser

A vapouriser designed for 'out-of-circuit' use in continuous flow techniques of inhalation anaesthesia with built in temperature-compensated and pressure-compensated capabilities. The Tec 4 was introduced for BOC Model 2000 anaesthetic machine in 1983. It was a remodelled Tec 3. To overcome the problems of Tec 3 it incorporated internal baffle system to reduce the danger of liquid agent entering the bypass chamber on tilting. Another interesting modification, to ensure only a single vapouriser operation at any time, was the safety interlock system. This vapouriser is available for different specific agents, i.e. enflurane (dial setting range 0-7%), halothane (0-5%), isoflurane (0-5%) [Figure 5].

Draw over

The most widely available draw over vapouriser is the Epstein, Macintosh and Oxford (EMO) and the Oxford Miniature Vapouriser (OMV).[15]

The EMO

It is a temperature compensated vapouriser, which produces an accurate output of 0-20% ether. It is usually used in-series with the Oxford Inflating Bellows (OIB) which is incorporated as a part of the EMO system. It can be classified as variable bypass, flow-over without wicks, low resistance, agent-specific for Ether, temperature compensated by Ether or Freon filled metal bellows and capsule, temperature stabilised by the water jacket surrounding the VC, transportable, but heavy (10 kg).

In its temperature compensating unit (TCU), the position of the compensating indicator will show if the unit is in good working order. It consists of a rod with a black and red band and a metal top. At 20°C - 25°C the metal top and the black band should show, at temperatures above 32°C the red band will begin to show. If only the metal band can be seen at 20-25°C the compensating unit is faulty [Figure 6].

The OMV

It is a small thermally buffered light weight vapouriser, which was originally produced to be used together with the EMO in order to speed the induction of

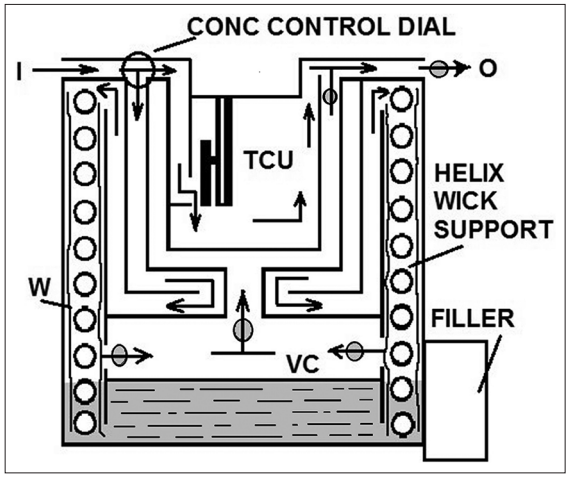

Figure 5: Tec 4

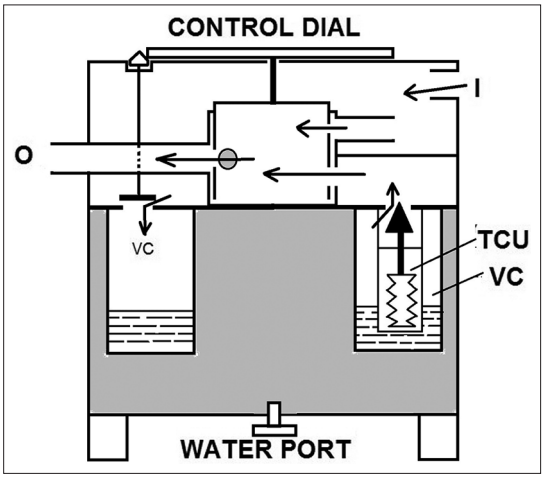

Figure 6: Epstein, Macintosh and Oxford

anaesthesia. Its capacity is 50 ml for volatile agent. It is portable, easily cleaned and serviced. It has the facility of a small heat sink or reservoir containing 30% glycol in water to provide a large thermal mass. It can be described as variable bypass, flow-over with metal mesh wicks, low resistance, multiple agents (halothane, trichloroethylene, enflurane, methoxyflurane and isoflurane) not temperature compensated. Different scales for percentage delivery are available for each agent. Output is affected by ambient temperature changes.[16] Its maximum output is 2-4% with halothane. Vapour output can be increased by arranging two units in the series and is required for induction with Sevoflurane.[17,18] It is very convenient for field use and can be used in series with a self-inflating bag or for halothane induction in series with an EMO[19] [Figure 7].

Goldman halothane vapouriser

Adapted from Leyland fuel pump it is variable bypass with very simple splitting device. It has no wicks and is not temperature compensated. It has low resistance in-circuit, can be used in-circuit and non-agent-specific (but intended for halothane). With halothane the maximum output is 3%. If used in a circle system continuous vigilance over anaesthetic depth and hemodynamic parameters is essential since the output varies dramatically depending on whether patient is spontaneously breathing (lower) or ventilated by positive pressure (higher).

Measured flow device

Copper Kettle: The copper kettle is classified as measured-flow, non-temperature compensated, bubble-through, out of the circuit and agent non-specific. This marvellous piece of invention way back in 1952 using sound physical principles was the forerunner of the present day advanced vapourisers like Tec 6 Desflurane vapouriser and cassette vapouriser[20] [Figure 8].

The FGF enters the device and bubbles through a sintered disc or porex unit and is mixed with the vapour free FGF. Obviously, it has no dial on the vapouriser. Rather the flow through the VC and the flow bypassing the chamber are controlled by separate flow meters. To get the required anaesthetic concentration the SVP of the anaesthetic vapour at the indicated temperature is used as input into the calculation and the rates of the two flows, bypass flow and VC flow are suitably altered. This calculation is aided by a circular slide rule provided with the vapouriser.

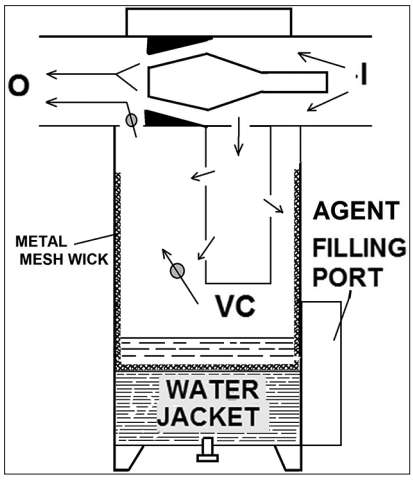

Figure 7: Oxford miniature vapouriser

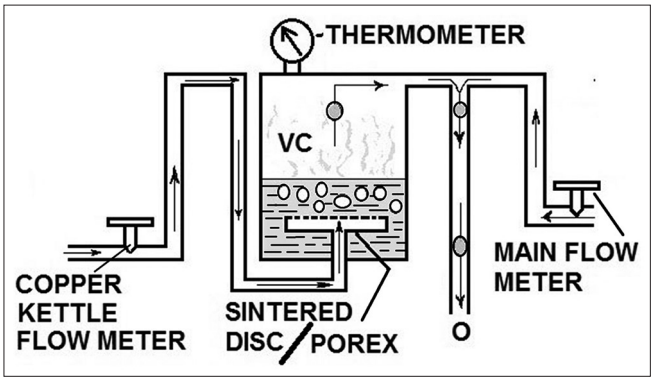

Figure 8: Copper Kettle

For example, suppose it is intended to get 1% isoflurane output from this vapouriser. First the inflow rate of oxygen into the VC can be set at 100 ml/min (isoflurane Psv at 20°C = 239 mm Hg, Pb = 760 mm Hg). The VC will form 239/760 = 31.4% vapour. The vapour picked up by 100 ml is

$$V = VC\,\text{inflow} \times \frac{Psv}{Pb - Psv} = \text{approximately } 46\,\text{ml}.$$

The total out flow from VC is 146 ml. This must be diluted with extra FGF delivered by adjusting the other main flow meter, which will decrease the concentration to very nearly 1% vol./vol. (FGF of 4500 ml/min is delivered by the main flow meter to give a total flow of 4646 ml. 46 ml of the vapour diluted in total 4646 ml gives very nearly 1% concentration of isoflurane. Directly this can be calculated by multiplying splitting ratio given by Eq. 1 with vapouriser inflow for any required percentage of an agent.

Variables affecting the performance

The back pressure

Transmission of pressure backwards from the reservoir bag into the vapouriser during intermittent positive

pressure ventilation caused variation in output concentration.[13,21]

The pumping effect or the Hill and Lowe effect

The back pressure is transmitted to both chamber and bypass. The fresh gas, which enters these channels obviously gets compressed. The bypass has smaller volume than the chamber. More fresh gas than intended flows into the chamber. The split ratio is altered. The higher volume of FGF in the chamber picks up more vapours. When pressure is released for expiration the compressed gas expands. The expanding chamber gas containing anaesthetic vapour enters not only outlet, but also back into bypass channel where pressure is lower, through the inlet tube. The bypass channel, which is normally free of vapour, now carries this additional vapour increasing the outlet concentration. This is pumping effect. If the length of inlet tube is increased the expanding chamber gas remains in the inlet tube only and will not enter the bypass channel. If outlet resistance is increased the back pressure effect is minimized. If one way valve is incorporated in the outlet channel, pressure transmission is prevented.[22] This effect is more pronounced with low flows. This arrangement is seen in Tec 5.[23]

The pressurizing effect

The pressurizing effect on the contrary is seen with higher flows.[24] This effect is due to compression of fresh gas in the chamber. However, the amount of vapour added to it remains same since the Psv is not affected by ambient pressure. During expiration when the pressure is released, the gas expands and its total volume is increased; however the amount of vapour remains same and hence dilution in output concentration.

Temperature

In the temperature range specified and at commonly used dial setting the variation in output concentration is not significant. Below the range the TCU may be less responsive and the output can be less than expected. Output may be unpredictable at higher temperatures. Under no circumstances must the temperature of the anaesthetic agent reach Boiling Point (BP), as the concentration delivered will then become impossible to control. As altitude increases, BP falls. In situations of extreme temperatures, vapourisers should be allowed sufficient time, i.e., 10 min/°C to reach the indicated temperature range.

Barometric pressure

Vapourisers are calibrated at sea level.[5,25] Changes in ambient pressure may significantly affect the output of older Tec-type vapourisers (i.e., those in which gas flow splitting occurs at the entrance to the VC) in terms of volumes per cent (significant increase with lower ambient pressure) but the effect on anaesthetic potency (i.e., in terms of partial pressure of the agent) is minimal, approximately 30%. However, James and White tested Fluotec Mark II and Drager halothane vapourisers at sea level and at 5000 ft (1524 m) and 10,000 ft (3048 m) of altitude.[26] At any given setting, the delivered percentage of halothane increased with altitude; however, its partial pressure remained constant. Therefore, when these devices are used at a given vapouriser setting, anaesthetic is delivered at a constant potency regardless of altitude.

In contemporary vapourisers the flow split occurs as gas leaves the VC, so that for any given dial setting and FGF, the volume of gas saturated with vapour that leaves the VC remains constant, to be diluted by the bypass flow. By splitting flow at the exit of the VC, these vapourisers become pressure compensated.

The American Society of Testing and Materials (ASTM) anaesthesia workstation standard requires that the effects of changes in ambient pressure on vapouriser performance be stated in the accompanying documents.[27]

Carrier gas composition

The viscosities of air and to a greater extent nitrous oxide are lower than those of oxygen. In the variable bypass vapourisers, the characteristic of the flow splitting valve results in decreased gas flow through the VC and hence reduced output, when using air and especially nitrous oxide compared with 100% oxygen. The effect is not clinically significant.[12,28]

SUMMARY

Anaesthesiologist before operating any vapouriser has to be fully familiar with its operating principles and the accompanying instructions provided by the manufacturer. The present generation of vapourisers, which are agent specific and widely in use now, operate by partially diverting the FGF into the VC, which is automatically varied by the TCU. Draw over vapourisers are of low resistance and less efficient compared with the plenum types designed to be used outside the breathing system. They are, however, robust, portable and better suited for 'field anaesthesia'.

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Source of Support: Nil, **Conflict of Interest:** None declared

Announcement

Dr. TN Jha and Dr. KP Chansoriya travel grant

From the year 2013, the Dr. TN Jha and Dr. KP Chansoriya travel grant will be awarded to the participants from 15 states. All the states can select their candidate during their annual conference and send them with the recommendation of the Secretary. Only one candidate is allowed from each state. In case if two states have a combined annual meet but separate as per the records, have to select one candidate from each state. If more than 15 states recommend the candidates for the award, selection will be made on first come first served basis.

Dr. M V Bhimeshwar
Secretary - ISA
Email: isanhq@isaweb.in Phone: 040 2717 8858 Mobile: +91 98480 40868