Use of Halothane vaporizer for the administration of Sevoflurane during general anesthesia

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Abstract

The vaporizer based on specific saturated vapor pressure for each inhalation anesthetic agent. The purpose this study is to determine the precise corresponding sevoflurane concentrations when halothane vaporizer is used for supplying it. This study is carried out by using a mathematical equation based on the difference in saturated vapor pressure, splitting ratio of halothane and sevoflurane at different delivered concentration dial of halothane vaporizer. The data of this study provides a comparative table that help to use halothane vaporizer to provide a precise known delivered sevoflurane concentration. The results concluded that halothane vaporizer is suitable to deliver sevoflurane concentrations (up to 3%) that can be used for maintaining general anesthesia.

Keywords: Vaporizer; Halothane; Sevoflurane

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Introduction

An ideal inhalational anesthetic agent should have rapid smooth induction, provide optimal surgical conditions with rapid recovery and minimal side effects [1]. Sevoflurane is less soluble than isoflurane, which means that inductions and recoveries are even faster. Mask inductions with sevoflurane were faster and of better quality than with isoflurane [2]. Sevoflurane has little advantages of less airway hyper reactivity and quicker emergence and discharge from post anesthetic care unit [3]. Different anesthetic agents have different volatilities which mean that they have different saturated vapor pressures (SVP) [4]. The process of evaporation in a closed container will proceed until there are as many molecules returning to the liquid as there are escaping. At this point the vapor is said to be saturated, and the pressure of that vapor (usually expressed in mmHg) is called the saturated vapor pressure [5].

Depending on the saturated vapor pressure, each inhalational anesthetic agent has a special vaporizer that delivers the required inhalational concentration to the patient 6. The splitting ratio for a certain inhalational anesthetic agent is differs from the splitting ratio of other anesthetics although they have the same delivered inhalational concentration to the patient [7]. As a result of the financial crisis and the shortage in the supplying the required equipment and medications that used in anesthesia inside the operative theatres in Iraq, an attempt had been done to use halothane vaporizers for the administration of sevoflurane. Despite the availability of sevoflurane there was no sufficient number of their vaporizers, therefore we had to look for a way to get benefit from this anesthetic agent for maintaining general anesthesia. This subject may not be of importance in other places of the world but represent a suitable solution for a medical problem in our operating theater.

Method

Based on mathematical issues that depend on values of atmospheric pressure, saturated vapor pressure, splitting ratio and their corresponding inhalational concentration, a comparative table was found that enabled the use of Halothane vaporizers for Sevoflurane administration. Saturated Vapor Pressure is the partial pressure of the vapor phase of a substance when at equilibrium with its liquid phase (e.g. in a closed container) [8]. Each inhalational anesthetic agent has a special SVP (table 1) [9].

Table 1.

Saturated vapor pressure of common anesthetic agents

Gas	Vapour press. TORR (20 °C)
Halothane	243
Enflurane	175
Isoflurane	238
Desflurane	669
Sevoflurane	157

In all cases the SVP of volatile anesthetics is much higher than that required for anesthesia and therefore, if they are to be given in a controlled manner, dilution must occur. Variable bypass vaporizer is one in which the total gas flow is divided in two streams by a variable resistance proportioning valve. Usually a small percentage enters a vaporizing chamber, picking up molecules of volatile agent, while the majority travels through a bypass line. The major part of the gas stream from the Rotameter thus bypasses the vaporizer and is mixed with saturated vapor downstream from the vaporizer compartment.

The ratio of vaporizing chamber flow rate/ bypass path way flow rate is referred to as the Splitting ratio (R) (Figure1) [10].

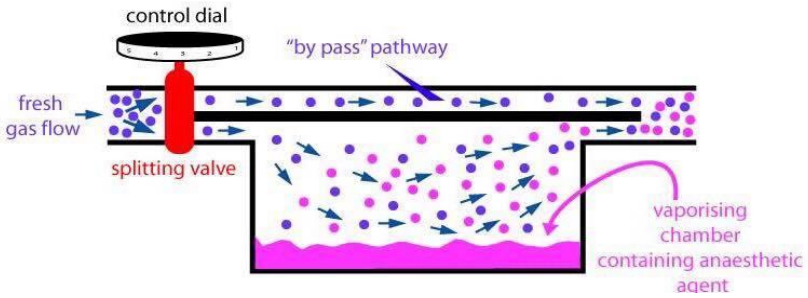

Figure 1.
Principle physics of vaporizer

SVP of Sevoflurane is about 157 mmHg (20.65% of atmospheric pressure) that's mean 206 ml of Sevoflurane vapor is carried by 794 ml of fresh gas flow in the vaporizing chamber. Therefore, 1 ml of Sevoflurane is carried by 3.85 ml of fresh gas flow in the vaporizing chamber. From this fact, splitting ratio can be determined for each delivered Sevoflurane concentration (table2). SVP of Halothane is about 243 mmHg (31.97% of atmospheric pressure) that's mean 319 ml of Halothane vapor is carried by 681 ml of fresh gas flow in the vaporizing chamber. Therefore, 1 ml of Halothane is carried by 2.13 ml of fresh gas flow in the vaporizing chamber. From this fact, splitting ratio can be determined or each delivered Halothane concentration (table 2).

Table 2.
Splitting ratio of Sevoflurane and Halothane in different delivered concentration

Concentration %	Splitting ratio	
	Sevoflurane	Halothane
0.5	1 : 51.94	1 : 92
1	1 : 25.97	1 : 46.92
1.5	1: 17.31	1: 31.29
2	1 : 12.98	1 : 23.4
2.5	1: 10.38	1: 18.77
3	1 : 8.64	1 : 15.64
3.5	1: 7.42	1:13.46
4	1 : 6.49	1 : 11.73
4.5	1: 5.77	1: 10.43
5	1 : 5.18	1 : 9.38

According to the results obtained from table 2, sevoflurane has a higher splitting ratio than halothane, therefore, for a constant concentration dial of halothane vaporizer, the delivered sevoflurane concentration is lower the preset dial concentration of halothane vaporizer. A precise delivered sevoflurane concentration can be estimated mathematically. (table 3&Figure 2).

Table 3.
Halothane concentration and corresponding Sevoflurane concentration

Halothane concentration %	Sevoflurane concentration %
0.5	0.3
1	0.6
1.5	0.8
2	1.1
2.5	1.4
3	1.7
3.5	2
4	2.2
4.5	2.5
5	2.8

Figure 2.
Halothane concentration and corresponding Sevoflurane concentration

Discussion

As the surgical levels of anesthesia can usually be achieved with concentrations of 0.5 - 3% sevoflurane with or without the concomitant use of nitrous oxide [11]. Therefore, Sevoflurane in a vaporizer of Halothane can achieve the recommended doses of maintenance of anesthesia specially in an adult patient (table 4) [12, 13].

Table 4.
Minimal alveolar concentration (MAC) value of Sevoflurane according to age

Age of patient (years)	Sevoflurane in Oxygen (%)	Sevoflurane in 65%N_{2O} /35% O_2 (%)
0 – 1 months	3.3	3.3
1 - < 6 months	3	3
6 months - < 3 years	2.8	2
3 - 12	2.5	2.5
25	2.6	1.4
40	2.1	1.1
60	1.7	0.9
80	1.4	0.7

The maximal Sevoflurane concentration by dialing halothane vaporizer to 5% in this study was 2.8%. However, Tobias JD. Am J Ther found that Sevolurane concentration reach 3% when halothane vaporizer dial at 5% [14] which is clinically insignificant from our study. Total gas flow rate affects the final achieved Sevoflurane concentration, the higher flow rate the lower Sevoflurane concentration at a certain dial concentration of Halothane vaporizer [15, 16, 17].

Conclusion and Recommendation

Although it is not routinely recommended, in certain circumstances where sevoflurane vaporizers are not adequate or available, this study help to solve this problem by allowing use of halothane vaporizer for sevoflurane administration to provide an inhalational concentration that is sufficient for maintaining general anesthesia.

Conflict of interest

None.

Funds

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