CASE REPORT

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Low flow anesthesia will gain eras (enhanced recovery after surgery)

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ABSTRACT

As we know, the volatile agent needs fresh gas flow to be carried out to the patient. It is very common in anesthesia practice, we use the fresh gas flow more than 2 liters per minute. In recent practice, the more flow we gave, the more volatile agent blew out to the patient. The present of APL (adjustable pressure limit) also leaks out of the circuit, we spend more gases, volatile agent, hence gave more pollutant to the operating theater. The consequences of those are an increase of anesthesia expenses and change the way of health care being delivered.

ERAS (Enhanced Recovery After Surgery) is popular with its quick recovery after surgery, include quick emergence post anesthesia, that will reduce the time in the operating theater, recovery room, and as results, reduce the cost of anesthesia and surgery.

Keyword: *Low flow anesthesia, quick emergence, reduce cost*

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INTRODUCTION

Re-breathing technique of expiration gas after absorption of carbon dioxide was done by Dr. John Snow, using caustic potash to absorb CO_2 from expired gas. The simple concept “To and Fro” system by Waters and circle system by Brian Sword, which used soda lime for CO_2 absorption. Those were superior in the early half of the century when such expensive agent such as cyclopropane, halothane, etc. On the other hand, to use these agents need optimal high flows, so then low flow anesthesia becomes less popular. Other involved factors were information of disadvantage in using high percentage O_2 for long period, necessity of other gas to decrease O_2 concentration, second gas effect in closed circuit, awareness of pollution, and high cost of volatile agent have promoted the use of low flow anesthesia.[1]

Some advantages using low fresh gas flow (0.35-1 L/min) are: improves dynamics of inhaled anesthesia gas with low flow fresh gas, enhances mucociliary clearance, prevents the losing of body temperature and reduces water. With economic reduction approximately by more than 75% in anesthesia gas consumption.[2]

In this case, we will report a female 16-years-old, underwent muscular transfer with general low flow anesthesia.

CASE REPORT

A 16-years old woman, ASA I, was admitted to hospital and planned for muscular transfer procedure, because an accident that happened before, she could not move her right arm. The first surgery was an open reduction internal fixation with plate and screw (ORIF-PS) on her right humerus, right distal radius, bone graft, and nerve transfer, used general anesthesia without any complication. After the surgery, she still could not move her right arm, so the team prepared for muscular transfer.

Previously patient was prepared in preparation room and then moved to operating theater without any premedication. Patient was calm, BP 112/67 mmHg, HR 90 x/min. RR 14x/min, O_2 saturation was 98% room air. We gave Fentanyl 100mcg while giving pre-oxygenation with O_2, later we add more 50mcg before incision.

We continued with propofol titration until she hypnotized (50mg), then we gave O_2 via face mask while kept her airway clear. Atracurium 30mg was given to facilitate the intubation procedure, followed by 10 mg/hour continuously. It was stopped later on because of muscle’s contraction evoked evaluation (total consumption 60mg).

After intubation, make sure the position of the tube was right, the tube fixated with tape and connected to a ventilator (with new CO_2 absorber and no leak ventilator) for ventilation support. Ventilator was set to target TV 7-8 ml/kgBW, RR 12x/min, $etCO_2$ 35-40 mmHg, fiO_2 inspiration around 40% and MAC 0.8-1. For analgesia, we gave morphine 2mg bolus followed by 1mg/hour continuously, which stops 1 hour prior to the end of the operation.

Hemodynamic recorded during the operation: BP 85-105/46-68 mmHg, HR 65-105x/min. We used flow 0,5 L/min, with O_2 50% (O_2 inspiration 38-42%) Sevoflurane 3 vol% (inspiration 2.4-2.5%), MAC 0,8-1. $EtCO_2$ 36 – 40. Duration of operation is 8 hours 30 minutes.

An hour prior to the end of the operation, we stopped morphine drip (total consumption 15mg). Thirty minutes before the end of the operation, sevoflurane was turned down to 1.5 vol% (inspiration 1.2%, flow 0.5L/min with MAC 0.5). As soon as the operation ended, we stopped the sevoflurane (MAC 0,5, sevoflurane inspiration 1.1%), increased the fresh gas flow to 10 lpm, followed by reversal agent, then within 1 minute, observed MAC decreased to 0.4 (sevoflurane inspiration 0.6%, $etCO_2$ 42) and spontaneous breathing started.

After 3 minutes, the MAC observed at 0.2 (inspiration sevoflurane 0%, $etCO_2$ 43) and tidal volume sufficient enough. Then 1 minute later, we sucked the oral secret out of the mouth, to clear the airway. After the airway cleared, sevoflurane by the amount of MAC 0.2, we asked the patient to open her eye and tried to communicate with her, she was following the command really well, which conclude that anesthesia effect had worn off. By the end, we observed that the MAC reached 0.1, then we extubated the patient smoothly.

DISCUSSION

Low flow anesthesia defines by delivering fresh gas flow less than 1 L/min. These gas uses to carry anesthetics agent to patients.

Category of gas flow:

Metabolic flow	250 mL·min-1
Minimal flow	500 mL·min-1
Low flow	1000 mL·min-1
Medium flow	1-2 L·min-1
High flow	2-6 L/min

Minimal oxygen requirement for the metabolic process at rest and normothermic is 250ml/min and should be administered as 100 % O_2.[2,3]

With low flow anesthesia, the leakage free system will reduce the fresh gas flow to the volume which is absorbed and metabolized by the patient while under anesthesia. There is a distinction between non-quantitative and quantitative anesthesia in a closed system; non-quantitative anesthesia, the constant volume maintained by adjusting the fresh gas flow so it fills the breathing system. Breathing pattern does not change while in quantitative anesthesia. Not only gas filling but also breathing pattern, constant internal pressures, composition of carrier gas and volatile agent, affected by that breathing pattern.[4]

The basic need for low-flow anesthesia are:[3]

1. Monitors

Usual routine monitors. (ECG, pulse oximeter, blood pressure and other monitoring determined by the severity of the case). Others are capnograph and oxygen monitor that essential to observe the change when flows decreased. The analyzer of the agent not really essential, but will give confirmation amount of volatile agent that given.

2. CO_2-absorption

The CO_2 absorber is the most important part of the entire system, that allowing re-circulated gas being inhaled after absorbing CO_2 from expired gas. Two types of the CO_2 absorber (soda lime and baralyme) will remove CO_2 from expiration gas uses chemical reaction which produces water in the end and heat. These end product advantage for warming and humidifying gas delivered to the patient.

The basic chemical reaction:

$$H_2O + CO_2 \leftrightarrow \text{à } H_2CO_3$$
$$H_2CO_3 + 2NaOH \leftrightarrow Na_2CO_3 + 2H_2O + Heat$$
$$Na_2CO_3 + CaOH \leftrightarrow 2NaOH + CaCO_3$$

Soda lime and Baralyme will be discolored when exhausted. The change of the color because the decrease of the pH in the canister and increased by CO_2. Capnograph can be used to indicate absorber exhaustion. 450 g of soda lime will last for about 2 hours.[3,5]

3. Volatile delivery

Volatile delivery can be delivered by:

Vaporizer out of the circuit. Used most in the anesthetic system today. The vaporizer passed by fresh gas flow to the patient circuit.

A vaporizer in the circuit. The low resistance of vaporizer places in actual breathing circuit and will be picked up as gas travel around the circuit. Rarely used nowadays because of the possibility of overdose.

The injectable method of volatile delivery, which need calculation, are infusion pump and syringe.

4. Gas delivery

Delivery of the gas is performed with a standard anesthetic machine, which its flow meter must be able to set less than 1 L/min. Dual flow meters for each gas is implanted at some machine, first one graded from 200 ml to 1 liter and from 1 to 10 liters. All electronic machine can deliver flows below 1 liter.[2,3]

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5. Closed circuit

Gas is flow to the patient and returns to the patient via CO_2 absorber in a circular pattern using a closed system. Same gas will be recycled with small amounts being released from ventilator or breathing valve to allow some fresh gas to be introduced.[3]

Induction of low flow anesthesia is identical to conventional mode; pre-oxygenation, analgesia and hypnotic agent, also muscle relaxant if needed, Endotracheal tube or laryngeal mask, then connected to the rebreathing system. The initial phase with the high fresh gas flow (4-6 L/min), will have adequate pre-oxygenation and distribution of anesthetic gases to achieve the desired level of anesthesia. Initial phase's duration depends on the amount of flow reduction and individual uptake (4-5 L/min, 6-8 min), after this time, oxygen and nitrous oxide levels will reach 30% O_2 and 65% N_2O. For isoflurane, the vaporizer is set to 1.5 %.[4]

Sevoflurane will need 2.5% setting and desflurane 4-6% setting. After 6-8 min, an expiratory concentration corresponding to 0.8 MAC/ minimum alveolar concentration. Total gas uptake after 10 minutes of the adult patient is about 600 ml, so at this time, the flow can be reduced to 1 L/min and low flow anesthesia can be initiated. Oxygen concentration 30 % in inspiration can be maintained if the fresh gas oxygen concentration increased to 50% after the flow has been reduced. The amount of anesthetic agent also been reduced, which is introduced by the fresh gas flow. If the concentration of the agent should be maintained at 0.8 MAC, the vaporizer must be adjusted for 3.0%. Before reducing fresh gas flow to 0.5 L/ min, the initial phase should be extended to 15 min and 20 min for the obese patient. Because rebreathing fraction is increased compared with low flow anesthesia, oxygen concentration should be increased to 60%, which is 50% represent an absolute minimum value. Concentration anesthetic agent in expiratory at 0.8 MAC can only be maintained if the concentration of enflurane is increased to 2.5%, enflurane and sevoflurane to 3.5% and desflurane increased 1 % above initial setting. Wash-in and wash-out's speed can be described as the time constant of the system. According to the Conway equation: $T = VS/(VF\text{-}VU)$ the time constant T is proportional to the system volume VS (machine and lung volume) and at a constant rate of uptake VU, inversely proportional to the amount of anesthetic agent fed into the system at the time.[4,6]

Outgassing of alcohol during anesthesia in an intoxicated patient is not to be inhibited, fresh gas flow at least 1 L/min should be used in order to provide a continuous wash out effect. Patient with ketoacidosis, during anesthesia, which there is an increase in acetone concentration in the blood, fresh gas flow should be maintained at least 1 L/ min to prevent acetone concentration buildup in the breathing system.[7]

The carbon monoxide accumulation in breathing system is clinically insignificant, even with long duration minimal flow anesthesia, also carboxyhemoglobin concentration slightly increases in the blood. Compound A has nephrotoxic effect at 800 ppmh, whilst in minimal flow anesthesia with sevoflurane, the peak was found at 50-60 ppm.[4]

The need for absorber breathing system and dependence on gas monitoring may limit the use of low flow in poorer countries. Also the limitation of the available vaporizer and accumulation of unwanted gases in the breathing system.[8]

In practice, low flow anesthesia technique is beneficial for the patient by improving pulmonary dynamics of the anesthetic gases, increasing mucociliary clearance, maintaining body temperature and reducing fluid loss. Reduction consumption of anesthesia gas results in significant decrease down to 75%, decrease greenhouse gas emissions and lower impact to the ozone layer.[4]

From the literature, we can adjust the volatile agent, in this case, we use sevoflurane to 3 Vol% to achieve MAC around 0.8. So, the MAC 0.8, achieved by a volatile set at 3 vol% after induction and the monitoring for CO_2 absorber was done by using $EtCO_2$.

Hemodynamic was stable and without any support. So we can maintain anesthesia by using the low flow of gas flow and predicted MAC with only small amount of volatile agent used and low fresh gas flow wasted, which means low cost for anesthesia.

On the other hand, the time for the emergence was short so the time in the operating room or in the recovery room was decreased significantly.[9]

CONCLUSION

Low flow anesthesia is a good choice to achieve ERAS (Enhanced Recovery After Surgery). As we used low-flow anesthesia, the time that we need for the patient to wake up shorten significantly and the total volatile agent used can be suppressed. In another hand, cost will remarkably cheaper (time for recovery was shortened, decreasing of volatile agent being used, minimal environment pollution, gas consumption was low)

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