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RE-ENGINEERING MAPLESON B CIRCUIT

Anaesthesiology

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ABSTRACT

A proper breathing system is the corner stone for the oxygenation and for the delivery of anaesthetics to the patients during surgery. Various types of circuits are used for this purpose. Mapleson B circuit is one among it. Its use is discontinued for its inefficiency in the past. Hunt for a new breathing system will never end till the invention of a universal breathing circuit which can be used in all age groups and in both the types of ventilations. We have modified the Mapleson B circuit by introducing a unidirectional valve. This modified Mapleson B system is functionally comparable with Bain's circuit and closed circuit.

KEYWORDS:

Mapleson B system, unidirectional valve,n modified Mapleson B circuit

INTRODUCTION

Breathing systems are used for the delivery of anaesthetic gases, oxygenation of the patient and elimination of CO2 from the patient. The basic components of the breathing systems are reservoir bag, APL valve, FGF, corrugated tube with its connectors. The breathing systems are classified by the presence or absence of re-breathing and the location of the various components 1-3. An ideal breathing system should be simple, safe, permit both types of ventilations, effective in elimination of co2 and economic. A number of modifications in the breathing systems are introduced time to time to upgrade the efficiency of the circuit. Bain's circuit is modified from Mapleson D circuit, Jackson-Rees circuit is a modification of Ayer's T-piece, and Lack's system is a modification of Mapleson A circuit and Hampherydevi circuit derived by combination of ADE 4-11. We introduce a novel modification in an obsolete Mapleson B circuit to reduce its disadvantages.

CURRENT SCENARIO

Most of the available circuits require high fresh gas flow rate except the circle system 3,14. This higher flow leads to loss of heat and humidity rapidly. Economy is directly related to the fresh gas flow rate 12. Very few breathing system has provision for attaching the scavenging system. The absence of scavenging system leads to theatre pollution 13. As the expired gas stays near the operation field it may also lead to accidental explosions.

Despite the very high flow rate, re-breathing is not eliminated completely. Re-breathing depends on the flow rate, type of respiration, type of the circuit and etc .The circuits with soda lime for CO2 elimination are not considered for comparison now. Re-breathing also depends on the duration of expiratory pause. If the expiratory pause is too short, only very small amount of CO2 is washed away 13. Any reduction in the flow rate will lead to re-breathing and dangerous accumulation of co2 in the patients.

The functional ability of the breathing system is dependent on whether the patient is breathing spontaneously or on controlled ventilation and age of the patients. In controlled ventilation Bain's circuit is the most efficient breathing circuit. In spontaneously breathing patients Mapleson A circuit is the most efficient breathing circuit. JR circuit perform well in paediatric age group [14].

Checking the integrity of the inner tube is very difficult in Bain's circuit15.Accidental disconnection of the inner tube will convert the whole Bain's circuit into a dead space [16].

UPGRADING MAPLESON B CIRCUIT

The following modifications are incorporated in the obsolete Mapleson B system (Fig. 1)

1) Unidirectional valve (UDV): We introduce an UDV between FGF and the APL valve .The UDV is placed just proximal to the APL valve. This allows isolated accumulation of adequate volume of FGF in the corrugated tube and reservoir bag .This UDV will prevent entry of expired air into the corrugated tube and completely eliminates the mixing of the expired gas with fresh gas. This UDV facilitates compartmental storage of FGF in the circuit.

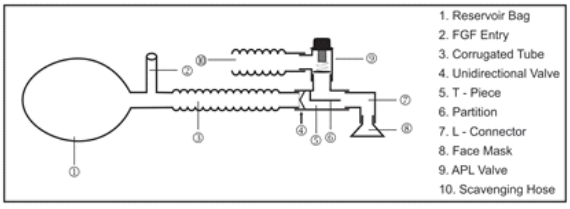

Fig .1:- Illustration of the Modified Mapleson B system

2) Relocation of Fresh Gas Flow: The FGF is connected between the reservoir bag and UDV, very close to the reservoir bag. It will facilitate adequate and rapid filling of the reservoir bag and corrugated tube

3) T-piece: A T-piece is introduced for the connection of various components. The corrugated tube with UDV in one end, the face mask with its connector on the other end and the APL valve on the side is connected. The T-piece is partitioned into two half horizontally .The FGF will flow in the lower half while the exhaled air will pass in the upper half of the T-piece. This partition will provide BY-PASS path for both the FGF and expired air.

4) Scavenging system: A scavenging system is connected to the APL

vale for safe disposal of the vented gas.

FUNCTIONAL ANALYSIS

DURING SPONTANEOUS RESPIRATION

The APL valve is in fully opened position. The fresh gas fills the reservoir bag and the corrugated tube up to the UDV. After reaching the adequate pressure the UDV allows the

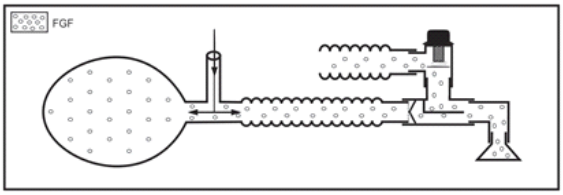

Fig .2. First inspiratory phase

unrestricted movement of FGF through it. During the first inspiration, whatever fresh gas present in the corrugated tube and reservoir bag reaches the patient without any resistance in the lower partition of the T-piece (Fig.2.).

During expiration, the UDV prevents the expired air entering into the corrugated tube. The corrugated tube and the reservoir bag are isolated now. The expired air passes in the upper partition of the T-piece.

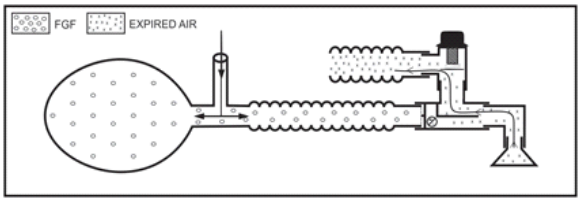

Fig.3. Expiratory phase

So, during expiration, the expired air is selectively vented into the scavenging system through the APL valve without mixing with the FGF (Fig.3).

The elimination of CO2 from the system is independent of the pattern of respiration and FGF rate. During expiratory pause, the FGF washes out the alveolar gas in the T-piece, near the patient. During the expiratory phase and expiratory pause

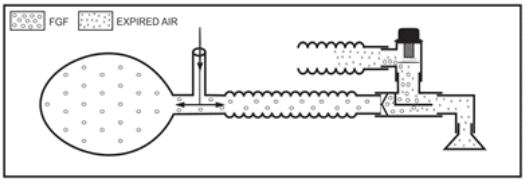

Fig.4. Expiratory pause phase

phase the corrugated tube, reservoir bag and T-piece to some extent are replenished with fresh gas (Fig 4).

During the subsequent inspirations this FGF along with a very small quantity of alveolar gas occupied the T-piece enter into the patient. The flow rate required is equivalent to the minute volume.

CONTROLLED VENTILATION

The APL valve is in the partially closed position, according to the need. During expiration the UDV prevents the flow of expired gas into the corrugated tube. The expired air passes through low resistance upper partition of the T-piece. So, the alveolar gas fills only the small area distal to the UDV (Fig.3).During expiratory pause, the excess FGF wash out the alveolar gas in the T-piece partially. The corrugated tube is filled with FGF alone, simultaneously (Fig.4). During inspiration, the patient is ventilated with FGF and very minimal alveolar gas.

Some amount of the FGF escapes through APL valve during controlled ventilation. This wasted ventilation is minimized by the partition in the T-piece. The flow rate is calculated by adding the minute volume with the quantity of air wasted through the APL valve.

DISCUSSION

The Mapleson B circuit has become obsolete because of high re-breathing in both types of respirations17.The introduction of UDV will completely block the re-breathing of the circuit. UDV is not new to the breathing system. The closed system is equipped with two UDVs. Ambu's bag is armed with two UDVs. A non-rebreathing valve was incorporated in Ayres's T-piece to reduce its disadvantages4 .Incidentally, this modified circuit has some similarity to non-rebreathing system 1.This UDV will ensure the compartmental storage of FGF in the circuit.

The FGF can be attached anywhere between the reservoir bag and the UDV. When it is attached very near the reservoir bag, it allows rapid filling of the circuit and reduce the wastages. At the same time it will facilitate easy and quick detection of its disconnection.

T-piece acts as a pivot for the attachment of various components. The horizontal partition provides a by-pass route for both FGF and expired air. The circuit dead space is equivalent to the volume of this T-piece. This dead space is further reduced by placing the UDV at inner end of the T-piece. The APL valve is located very close to the patient. So the overall dead space is very low. This APL arrangement makes this system most economical 12,18. The T-piece is designed with variable diameter to avoid faulty connection of the modified Mapleson B circuit 19.The scavenging system is attached for safe and distal disposal of the expired gases. This modified circuit exerts very minimal drag. In paediatric patients the small reservoir bag is used to avoid volutrauma.

A lung model was proposed for the evaluation of any breathing circuit. It was also suggested that a non-rebreathing system doesn't require testing for the obvious reasons 3.So, the lung model is not used for the functional analysis of this modified Mapleson B circuit.
The capnography is an ideal method for detecting the onset of re-breathing20.The capnography recorded with this circuit showed re-breathing is very minimal. The absence of CO2 in the corrugated tube and reservoir bag proves the compartmental isolation and storage of FGF in the circuit without mixing with the expired alveolar gas. Further the functional analysis of this circuit is extrapolated from the various previous studies 3. It is confirmed by our experiments with the volunteers using the modified Mapleson B circuit. Contamination of the circuit is very minimal. A conventional heat and moisture exchange filter can be attached in the circuit for the compensation of heat and moisture loss. . The simple design will help assembling and disassembling of the circuit easy.

This modified Mapleson B circuit can be used efficiently and effectively in all extremes of age and in both types of ventilations.

CONCLUSION

Mapleson B circuit has become obsolete because of its own drawbacks. By introducing the suggested modifications, namely the introduction of Unidirectional valve ,T-piece with partition , relocation of FGF and attaching scavenging system , the modified Mapleson B circuit can be used efficiently and effectively in all age group of patients and both types of ventilation. This Bi-pass Mapleson B system (BiMBS) performs potentially equivalent to the Bain's circuit and the circle system. As there are no hidden parts, the pre-use checking is also easy and quick. Moreover, the availability of two or more different breathing system will ensure the SAFE ANAESTHESIA PRACTICE in various clinical situations.

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