10 x MAX

A PROPOSED SIMPLE METHOD FOR RAPID AND SAFE ACHIEVING OF THE DESIRED ET VALUE OF THE VOLATILE AGENT

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The beginning of the GA with volatile agents follows the usual steps:

1. Preoxygenation
2. i.v. induction
3. Insertion of an airway device (ETT/LMA) and connection to the CKT
4. Start the mechanical ventilation and let the bellows reach the top by the PROGRESSIVE filling of the CKT.

1. The following parameters are selected for the mechanical ventilation:
   - Vt = 8 ml/kg
   - RR = 10 BPM
   - PEEP = 5cm H_2O (up to you)
   - FiO_2 = 1 (only in the beginning)
   - Total flow: 3ml/kg/min x 10

   Now….

OPEN THE VAPORIZER TO THE MAXIMUM (OVERPRESSURE)

Some interesting things start happening:

1. The CKT starts filling up with AA and equilibrates with the machine, then
2. AA starts filling the lungs (FRC)

In the end both the CKT and the FRC are equilibrated. Now the uptake can start!

Let's use some mathematics:

$$\tau \text{ (tau)} = \frac{\text{VOLUME}}{\text{FLOW}}$$

The CKT has an internal volume of 0.5 L (pediatric CKT). The total flow, for a 70 kg patient with the above parameters is:

3 ml/kg x 70 kg x 10 = 2100 ml/min

So, the τ CKT = $\frac{500}{2100} = 0.23 \text{ of minute}$

That is 0.23 x 60 = 13.8 seconds.

4 τ = 13.8 x 4 = 55.2 seconds

Let's see what happens in the lungs.

The same τ (That is τALV) becomes:

$$\frac{\text{FRC}}{\text{ALVEOLAR VENTILATION}}$$

The FRC = RV + IRV = (approx.) 30ml/kg x 70 kg = 2100 ml

The τ = 0.375 min = 22.5 seconds

If we combine the two time constants, τCKT + τALV we get a MTT (Mean Transit Time) of

36.3 seconds

In reality it may take a little bit longer as the tow time constants are not simultaneous. The ALV one has a certain delay.

The idea is that by the end of the first minute that is almost two time constants, the two compartments system (CKT + ALV) are approximatively 86% equilibrated. The whole system reaches total equilibration in roughly 3 minutes, including the time delay.

1τ = 36.3 " → 4τ = 145.2"= 2' 25"

However, if we use the OVERPRESSURE method (increasing delivered and inspired tension above that desired in the alveoli) we will notice that by the end of the first minute the ET value of the AA has reached 1.1-1.2 MAC.

The "10 x MAX" method is thus the result of basic theory combined with many trial and error experiements.

Some particular aspects must be considered:

1. The time constant method uses fixed volumes, whilst the presented method lets the bellows progressively rise. Could we call this notion **"dynamic τ"**?
2. There are different volumes of CKTs (different CO2 absorber housings, circuit tubing diameters for instance).

Some particular aspects must be considered (cont.):

1. FRC varies physiologically.
2. Reaching the desired ET value doesn't reflect what happens on the other side of the alveolar membrane, t.i. absorption. So, we must bear in mind that:

"A prediction of anesthetic uptake base upon patient size allows the amount and timing of anesthetic uptake to be decided before the patient's actual response is observed. If the prediction is wrong, the desired anesthetic level will not be attained and the rate of administration will require modification. The use of a monitor for end expired (or approximately alveolar) anesthetic tension allows this modification to be made easily. Using those monitors, anesthetic drug administration can be tailored to achieve the inspired and alveolar tension desired"

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The "10 X MAX" method has several advantages:

1. Follows a logical path.
2. Is physiologically related to the patient's weight and by consequence, oxygen consumption.
3. Offers a smooth delivery and uptake of the AA in a timely fashion.
4. Since we are used to think decimally the method is very easy to understand, recall and apply.

However, we must not forget that the living world is not always a mathematic book. Accepting individual variations offers us the flexibility of delivering a safe and rewarding anesthetic.