Ventilo

Impact of Predicted Body Weight, actual weight, temperature, and patient category for initial ventilator settings

To calculate the tidal volume, it is necessary to first calculate the predicted body weight since lung size does not depend on the actual weight, but on height and gender [1]. It is recommended to use physiological tidal volumes from 6–10 mL/kg $_{PBW}$ during surgery [2,3] and in intensive care patients without acute respiratory distress syndrome (ARDS) [4,5], and from 4–8 mL/kg $_{PBW}$ in the case of patients with ARDS [6,7].
To determine the minute ventilation, and therefore the respiratory rate (RR) for a given tidal volume (V_T), we use the Predicted Body Weight (PBW). The initial minute ventilation is first determined by the **patient category** (100 mL/kg $_{PBW}$ for patients undergoing scheduled surgery and at least 150 mL/kg $_{PBW}$ for intensive care patients), and thereafter adjusted according to their body mass index (**BMI**) and **body temperature** as described below.

Actual weight

The actual weight is used to calculate the body mass index (BMI) in kg/m^2. BMI can help to gently adjust the initial ventilation settings and the positive end expiratory pressure (PEEP) level.

Initial ventilation

When Radford's nomogram was published in the 1950s [8], obesity prevalence was close to 10%[9], it is now around 30 –40% depending on the country (https://www.cdc.gov/obesity/data/adult.html). Baseline metabolism can be slightly increased in the case of obesity and calculation of the required minute ventilation should be slightly adjusted according to the actual weight [10]. Actual weight does not appear to be better than the predicted body weight to predict baseline metabolism in obese patients [11].
In obese patients, the most recent studies show that ventilator requirements are slightly increased compared to non-obese patients during surgery [10,12].
In the PROBESE study [12], which evaluated two levels of PEEP during surgery in patients with BMI >35 kg/m^2, the mean initial minute ventilation (101 mL/kg $_{PBW}$) was comparable to that in non-obese patients under mechanical ventilation in the operating room (see figure below). At the end of surgery, the mean minute ventilation in obese patients was 124 mL/kg $_{PBW}$.
In an observational study that evaluated ventilatory settings in more than 2000 obese patients, the mean minute ventilation was also in the same range (106 mL/kg $_{PBW}$)[10]. However, the mean minute ventilation increased with BMI. In patients with a BMI of 30–35, 35–40 and >40, the mean minute ventilation was 103, 107, and 118 mL/kg $_{PBW}$ respectively.
We therefore use the Predicted Body Weight to estimate the initial minute ventilation with a slight adjustment according to the BMI, and considering that arterial blood gas evaluation is required 15 to 30 minutes after initiation of mechanical ventilation and after each change of the ventilatory settings.

PEEP setting

Morbid obesity (BMI >40 kg/m^2) is associated with increased risk of atelectasis [13] and respiratory complications [10]. PEEP can improve respiratory mechanics in obese patients [14]. The use of higher perioperative PEEP levels may reduce hypoxemia during the post-extubation period in patients with morbid obesity[12].

Body temperature

Body temperature can be used to adjust the initial minute ventilation. It is recommended to target a minute ventilation of 100 mL/kg $_{PBW}$ [8,15,16] and increase by 10% for each degree Celsius above 37 °C and decrease by 10% for each degree Celsius below 37 °C. This is an historical estimation [8,16]. In the case of hypothermia, the baseline metabolism is reduced and CO_2 production is lowered, in case of hyperthermia, the opposite applies[17]. It is also recommended to increase minute ventilation by 20% in the presence or suspicion of acidosis. This is taken into account in our equations with the assumption that the majority of intensive care patients have acidosis, systemic inflammation, and increased metabolism.

Patient category

The ventilator settings in surgical and intensive care units target different patient categories with different CO_2production (due to metabolism, temperature, presence of sepsis, amines, etc.). Our recommendations are based on recent literature that clearly differentiates between surgical patients (scheduled surgeries) and intensive care patients in whom protective ventilation is increasingly used with tidal volumes often close to 6 mL/kg $_{PBW}$ and with RR often greater than 25/min, sometimes exceeding 30/min. In patients undergoing mechanical ventilation for scheduled surgery, the V_T is often between 8 and 10 mL/kg $_{PBW}$ and the RR often below 15/minute.
The **100 mL/kg $_{PBW}$** minute ventilation recommended more than 60 years ago by Radford still seems to be used in "elective surgical" patients[10,12,18-25]. For "emergency surgery" patients, the minute ventilation will be **125 mL/kg $_{PIT}$**. In contrast, for intensive care patients, a ventilation of at least **150 mL/kg $_{PBW}$** is more often used, whether or not there is an ARDS. [4,26-44].

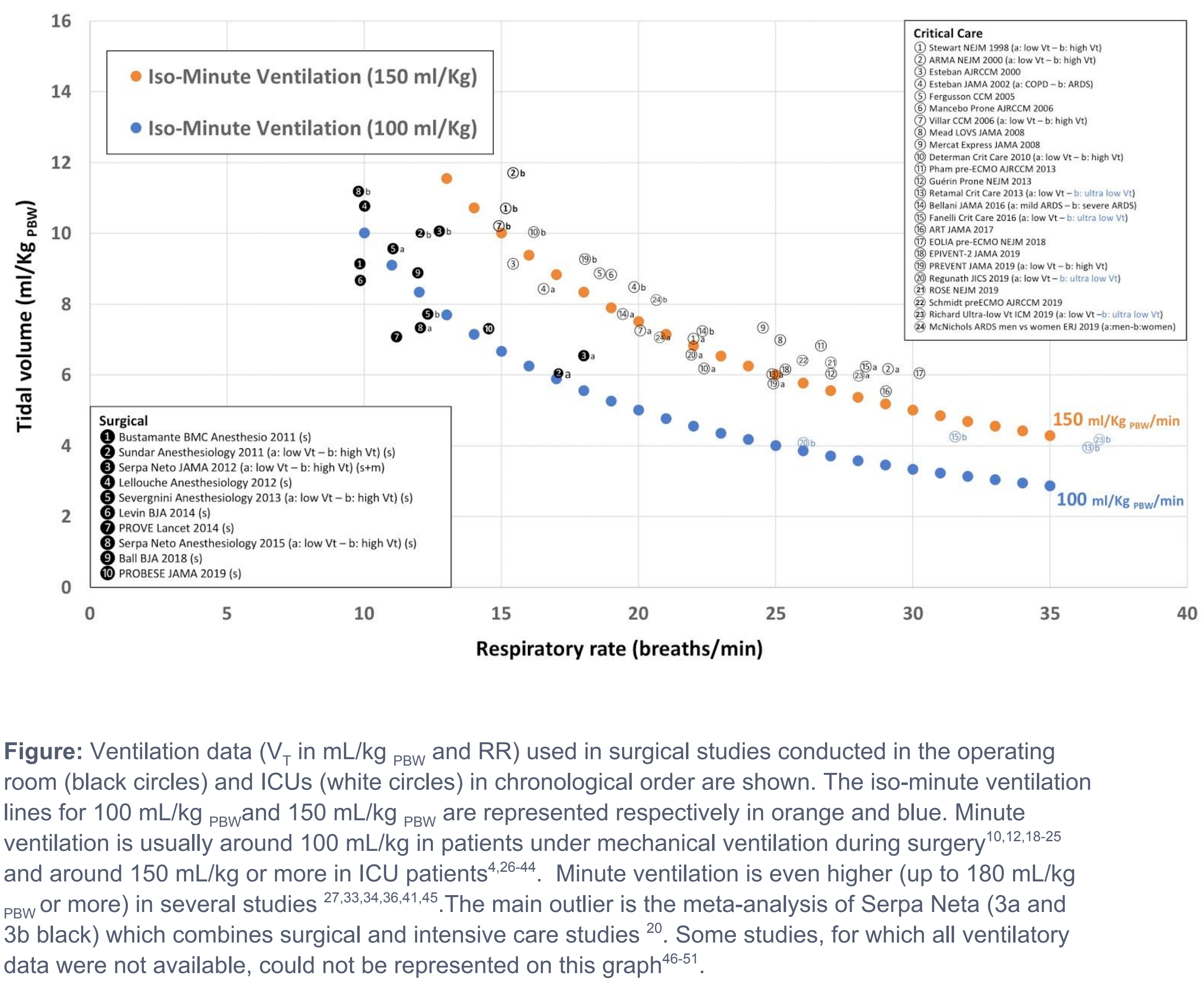

Figure: Ventilation data (V_T in mL/kg $_{PBW}$ and RR) used in surgical studies conducted in the operating room (black circles) and ICUs (white circles) in chronological order are shown. The iso-minute ventilation lines for 100 mL/kg $_{PBW}$and 150 mL/kg $_{PBW}$ are represented respectively in orange and blue. Minute ventilation is usually around 100 mL/kg in patients under mechanical ventilation during surgery[10,12,18-25] and around 150 mL/kg or more in ICU patients[4,26-44]. Minute ventilation is even higher (up to 180 mL/kg $_{PBW}$ or more) in several studies [27,33,34,36,41,45].The main outlier is the meta-analysis of Serpa Neta (3a and 3b black) which combines surgical and intensive care studies [20]. Some studies, for which all ventilatory data were not available, could not be represented on this graph[46-51].

With the widespread use of protective ventilation today, with lower V_T and RRs often above 25/minute in recent years[52], the question of dead space (V_D) is all the more relevant. Indeed, with a constant V_D, if the V_T decreases, the V_D/V_T increases. In addition, instead of being present 10 or 15 times per minute (at low RRs), the dead space gas is re- "inhaled" 25 to 30 times per minute!

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