



Positive End-Expiratory Pressure Improves Respiratory Function

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Abstract

The Pressure-Volume Curve has been studied and most extensively applied with patients with acute respiratory distress syndrome. From the first description of ARDS in 1967, investigators noticed that the static compliance was reduced.

Keywords: Ventilator surface; Lung parenchyma; Bronchiolar narrowing; Respiratory failure; Inflammatory stenosis; Emphysema

Introduction

Measuring chord compliance was suggested as a way of diagnosing different forms of respiratory distress. A few years later the super syringe technique was introduced and striking differences from normal were seen in ARDS. Matamis found a nearly reproducible pattern of changes in Pressure-Volume Curve according to the ARDS stage and chest radiograph findings. These early findings led to much research on the P-V curve in ARDS, and attempts to define certain features of the curve and correlate them with other physiologic measurements, such as dead space, shunt, and oxygen delivery. In ARDS the P-V curve appears sigmoidal in the volume range in which it is acquired. This is the same shape as a P-V curve from a healthy subject, except that in healthy lungs in the volume range between FRC and TLC the curve is concave down and relatively linear until high pressure is reached. In addition, the P-V curve in ARDS has a lower volume excursion to TLC and the entire curve is shifted down on the volume axis [1]. That shift, however, is not apparent when performing a Pressure-Volume Curve, since the volume scale is usually referenced to the end-expiratory lung volume, not to absolute lung volume. Suter in 1975 showed that the end-expiratory pressure that resulted in the maximum oxygen transport and the lowest dead-space fraction resulted in the greatest total static compliance in 15 normovolemic patients in acute respiratory failure.

Methodology

Suter written the present data suggest that an optimal situation is achieved in acute pulmonary failure when tidal ventilation takes place on the steepest part of the patient's pressure-volume curve that is, when the highest compliance is achieved [3]. This is where investigators and clinicians first started to get the idea that the majority of alveoli are closed below the knee of the Pressure-Volume Curve. Gattinoni coined the term Pflex, which they defined as the pressure at the intersection of 2 lines, a low-compliance region at low lung volume and a higher-compliance region at higher lung volume. Using computed tomography, they found that compliance correlated only with normally aerated tissue and specific compliance was in the normal range, which led to the baby lung concept in ARDS [4]. Roupie using the multiple-occlusion method found that if the upper inflection point is a point that represents increased strain on alveoli, then many patients with ARDS were being subjected to increased parenchymal strain [5]. That study highlighted the possibility that V T and pressure levels once thought to be safe might not be. The ARDS Network trial 47 of high-V T versus low-V T ventilation strategies, though it did not use Pressure-Volume Curve to set ventilator parameters, nevertheless supported this idea, because it found significantly lower mortality with a V T of 6 mL/kg of ideal body weight than with 12 mg/kg. Interestingly, assuming

the ARDS Network trial had patients similar to those in the Roupie study, almost all patients would have had plateau pressure below their upper inflection point. So if the upper inflection point is representative of the average strain on alveoli, this measurement might be useful for minimizing lung parenchymal strain [6]. In addition, nitrogen washout studies with anesthetized patients showed that the deflation limb of the Pressure-Volume Curve can be used to estimate the pressure required to raise FRC above its closing volume. From those data it appears that, at least in animal lung-lavage-injury models, it is better to ventilate the lungs on the deflation limb of the Pressure-Volume Curve to protect against lung injury. This seems to be especially true the smaller the VT becomes, such as with high-frequency oscillation [7]. Those data also illustrated the important concept of volume history in relation to the Pressure-Volume Curve. Where one is ventilating within the quasi-static Pressure-Volume envelope depends on where one starts. Although the end expiratory pressure may be the same in both cases, the lung volume can be quite different [8].

Discussion

Although it seems reasonable to conclude from these data that the P-V curve largely represents opening and closing of airways or alveoli, some caution must be advised. There are still conflicting data on how alveoli deform during a Pressure-Volume maneuver. Schiller using in vivo microscopy in lung-injury models demonstrated 3 behaviours of alveoli during mechanical ventilation, those that do not change size, those that change size throughout the inflation, and those that pop open at a certain pressure and rapidly change size. These data would seem to support the concept of recruitment [9]. However, Hubmayr showed that the features of an ARDS P-V curve can be obtained without having the alveoli open and close, but rather by forcing air into open, but liquid-filled, alveoli. That discrepancy may be due to the different models. Carney used a surfactant-deficiency model, whereas Hubmayr used an alveolar flooding model. To what extent those models represent what truly happens in human ARDS is unknown. Two published studies have addressed the effect of chest wall compliance in ARDS. Mergoni, with a group of medical and

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surgical patients, found that the chest wall contributed to the lower inflection point and that the response to PEEP depended on whether the patient had a lower inflection point [10]. If a lower inflection point was present, the patient tended to respond to an increase in PEEP as shown in (Figure 1). They also found that the total-respiratory-system Pressure-Volume Curve seemed accurate for estimating the lung upper inflection point. Ranieri found that in normal lungs there was no lower or upper inflection point [11]. In medical ARDS there was a lower inflection point from the lungs, which was on average 28% less than the lower inflection point of the total respiratory system. None of the patients had an upper inflection point. In surgical ARDS they found an upper inflection point from the chest wall, which was higher than the total-respiratory-system upper inflection point by a mean of 28%, and no lower inflection point as shown in(Figure 2). A more recent study, which used the sigmoid equation to fit total-respiratory-system, lung, and chest wall P-V curves from patients with ARDS, or pneumonia, or cardiogenic pulmonary oedema, found that the point of maximum compliance-increase ranged from zero to 8.3 cm H₂O and significantly influenced the total-respiratory-system inflection point in only 8 of 32 patients [12]. That may be because there were only 5 extra pulmonary-ARDS patients among 26 total ARDS patients, and those would be patients comparable to the surgical patients [13]. Despite the apparent safety and reproducibility of P-V curves when performed using the same technique on the same day, there are many problems with the routine use of Pressure-Volume Curves in ARDS. Pressure-Volume Curves are very dependent on the volume history of

the lungs, so the clinician must be careful when comparing curves from different days, different patients, or different studies [14]. There is no standard method for acquiring P-V curves, and different methods can yield very different Pressure-Volume Curve. The super syringe method generates artifacts because of on-going oxygen consumption during the maneuver, which causes a loss of thoracic gas volume, which is not usually measured, as well as gas-volume changes due to changes in humidity and temperature. Fortunately, during the inflation maneuver the loss in thoracic gas volume is generally equally counterbalanced by an increase in thoracic gas volume from the added humidity and expansion caused by body temperature. These effects, however, are in the same direction during deflation, and they increase hysteresis. The multiple-occlusion method may circumvent that problem. There is no standard method for acquiring Pressure-Volume Curve, and the peak pressure before and during the Pressure-Volume maneuver affect the shape of the P-V curve. Another problem with Pressure-Volume Curves is that they represent the aggregate behaviour of millions of alveoli. Most of the early studies describing the Pressure-Volume relationship in COPD were done with the hope of using the Pressure-Volume Curve to diagnose and establish the severity of emphysema. Since then, CT has supplanted the P-V curve as a means of diagnosing emphysema. Most of the early studies were done on spontaneously breathing COPD subjects rather than on mechanically ventilated subjects. This is probably because in mechanically ventilated subjects with COPD the major concern is for intrinsic PEEP and airway resistance, rather than lung elastic recoil or recruitment. Understanding public health problems such as obesity and, smoking, in terms of affecting women’s lung function is of paramount importance to society. There are many risk factors that can cause reduction of respiratory function in women. Most of these factors are preventable.

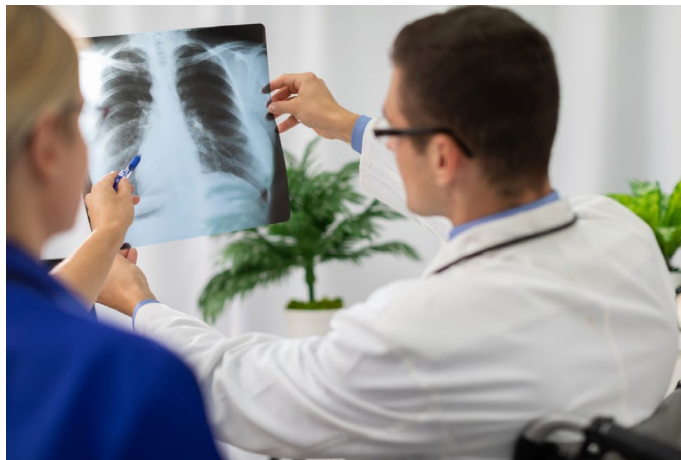


Figure 1: Chest wall compliance in ARDS.



Figure 2: Total-respiratory-system upper inflection point.

Conclusion

In attempting to reduce the risk factors to respiratory health, the first steps are to quantify the health risks and to assess their distribution. Some of the most important risk factors in this data set are: age, body mass index, smoking, asthma, educational status and ethnicity. Regarding age for example, it is clear that populations are aging in most low and middle income countries, against a background of many unsolved infrastructural problems. Aging is a process associated with chronic and disabling diseases. Chronic respiratory diseases are among the most frequent and severe of all, also in the elderly.

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Conflict of Interest

None

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