in patients with ALI. At this time, however, the use of the thermal-dye method remains useful for selected clinical research studies but is not necessary for standard clinical management. While awaiting the results of the NIH clinical trial of ARDS, investigators who are interested in using the thermal method for measuring extravascular lung water should consider carrying out these studies prospectively and should focus on groups of patients in whom an increase in extravascular lung water is likely to be a major determinant of outcome. Thus, patients with ARDS and sepsis would seem to be the most valuable groups to evaluate. Sequential measurements over the first 3 days could provide particularly valuable information. For example, a comparison of extravascular lung water levels in patients with ARDS could be carried out in a group of ARDS patients who had received ventilation with two different types of lung-protective ventilatory strategies or in patients who had received treatment with two different types of vasodilator strategies. In this way, investigators could generate potentially useful information regarding the effects of these therapies on extravascular lung water accumulation and the resolution of ARDS.

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Radiographic Assessment of Intravascular Volume

The 20th century Spanish poet and philosopher Miguel de Unamuno contemplates his health in the following passage:

I think of heart failure,
I try to discern among the shadows
its thin shadow,
I search the dark,
I think about my strong age

Although he refers to his struggle with death and immortality, this passage reflects the process whereby physicians attempt to discern the significance of three-dimensional thoracic structures displayed as radiographic shadows on a flat viewing screen. The practice of intensive care medicine requires precise interpretation of portable chest radiographic images, and this activity has been referred to as an extension of the bedside physical examination. From a radiographic image, the appearance and function of various thoracic structures may be inferred through serial examinations. For example, in a patient receiving mechanical ventilation, radiographic findings of a pneumothorax such as an inverted diaphragm are indicative of increased intrathoracic pressure with potentially dire consequences. In ventilator-supported patients, daily chest radiographs are obtained to confirm proper placement of tracheal tubes, intravascular catheters, and thoracostomy tubes, as well as for early detection of barotrauma, pneumonia, or atelectasis. In fact, portable chest radiography accounts for a large proportion of radiographic examinations within many US hospitals, and the majority of these are performed in ICUs. Furthermore, various investigators have reported a benefit from performing daily chest radiograph examinations in patients in unstable condition receiving mechanical ventilation. Accordingly, there is much useful information to be obtained from close examination of serial chest radiographs, and daily viewing has become an essential component of intensive care medicine.

A challenging issue in intensive care medicine involves the accurate assessment of intravascular volume status in critically ill patients. Unfortunately,
sole reliance on physical examination findings or clinical judgment has been noted to be misleading.4 5 Furthermore, use of the pulmonary artery catheter to assess intravascular volume has been associated with an elevated mortality.6 Thus, our ability to precisely determine the intravascular status of critically ill patients is limited, and a safe, noninvasive, robust method is needed.

In this edition of CHEST (see page 2087), Martin and colleagues examine the concept of using the chest radiograph as a means of assessing changes in intravascular volume in a group of ventilator-dependent patients with acute lung injury. These patients were part of a study examining the effect of albumin and furosemide or dual placebo on gas exchange, lung function, and clinical outcome. The authors systematically reviewed daily chest radiographs and quantified the vascular pedicle width, cardiothoracic ratio, and extent of pulmonary edema, as well as recorded the presence of interstitial lung markings, pleural effusions, and air bronchograms. Subsequently, information gathered from daily chest radiographs was compared with daily changes in fluid balance and weight. The authors reported that compared to the placebo-treated group, patients treated with colloid and diuretics demonstrated significant net fluid and weight loss over the 5-day treatment period. Moreover, daily net fluid loss and weight decrements were significantly associated with a decrease in the vascular pedicle width. Furthermore, other radiographic criteria, in particular the cardiothoracic ratio, did not correlate with changes in patient volume status. Analysis of a subset of 10 patients with pulmonary artery catheter measurements revealed a significant relationship between changes in the central venous pressure and vascular pedicle width. An important finding of this study was the decline in the vascular pedicle width associated with bedside measurements of net fluid and weight loss.

While estimation of the vascular pedicle and cardiothoracic ratio has been previously reported, the application of these measurements to assess the volume status of critically ill patients is a relatively novel concept. Milne and colleagues7 initially described the borders and significance of the mediastinal vascular structures to distinguish the various causes of pulmonary edema and coined the term vascular pedicle. However, use of these chest radiographic criteria as a means of differentiating the various causes of pulmonary edema were of limited clinical utility and not widely accepted.8 In contrast, another group of investigators found that in patients with burn-related injuries, an increase in the vascular pedicle width was observed following intensive intravascular volume resuscitation.9 Thus, a renewed interest in these radiographic criteria to estimate intravascular volume has developed.

How does measurement of the vascular pedicle width reflect intravascular volume? The radiographic anatomy of the vascular pedicle is comprised of the azygous vein, superior vena cava, subclavian artery, and aorta. Milne et al7 and Pistolesi et al10 described various factors associated with widening of the vascular pedicle and demonstrated a correlation between changes in vascular pedicle width and blood volume. These investigators surmised that the observed widening of the vascular pedicle results from enlargement of the distensible right-sided venous structures of the mediastinal silhouette, namely the azygous vein and superior vena cava. Consequently, the width of the vascular pedicle may increase with intravascular volume administration and resultant venous distention, or decrease with application of intrathoracic pressure leading to vascular compression. Although, a range of values for the vascular pedicle width have been reported, it should be stressed that use of absolute values may be misleading. In a recent report, utilization of a vascular pedicle width value of > 72 mm to estimate intravascular volume resulted in misclassification of the volume status of 30% of patients.11 Thus, changes or a lack thereof in the vascular pedicle width may be more useful in the daily care of critically ill patients.

While measurement of the vascular pedicle has certain attractive elements, there are limitations to its use. Vascular pedicle width measurements have been noted to vary with the type of radiologic study, becoming wider with an anteroposterior view. Body position may also alter this measurement, such that an increase in the vascular pedicle width occurs when moving from upright to supine positions as well as torso rotation to the right. Other clinical situations giving rise to a widened vascular pedicle include recent cardiac surgery, prior mediastinal irradiation, obesity, and application of positive end-expiratory pressure. In addition, measurement of the vascular pedicle may not be feasible in 25% of patients due to reasons listed above. From a practical standpoint, measuring the changes in vascular pedicle width in ICU patients requires standardization of the radiographic technique, maintenance of a similar body position (supine or semisupine), and notation of mechanical ventilator parameters. As for observer variation of the vascular pedicle width, there is a high degree of reproducibility, with several reports indicating high intrareader and interreader correlation coefficients.11

Despite the limitations of using the chest radiograph to assess changes in volume status, the findings of the report by Martin and colleagues are encouraging. In the final analysis, observed changes in the
vascular pedicle width as a means of estimating intravascular volume appear to be promising. Transferring the results of this study to daily practice will require further evaluation. A recent review of this topic proposes an algorithm using the vascular pedicle width to guide intravascular volume assessment. However, awareness of the limitations is important and this technique may diminish the need to use an invasive study under certain circumstances, but it is not intended to replace use of the pulmonary artery catheter.

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Would Euclid Approve of How We Select Mechanical Ventilators?

C hronic ventilatory failure (CVF) is a devastating condition that recognizes multiple etiologies and is associated with many different pathophysiologic findings. From the point of view of the patient, it is a frightening, relentlessly progressive disease that affects one of the most fundamental needs, the ability to breathe without discomfort.

The list of individual illnesses that may precipitate CVF is considerably long, and it is always worthwhile remembering that the primary organ or system affected by the disease is not necessarily the lung. Degenerative neurologic processes, such as multiple sclerosis or amyotrophic lateral sclerosis, or musculoskeletal defects, such as severe kyphoscoliosis, may be as likely causes of CVF as COPD, cystic fibrosis, or usual interstitial pneumonitis. Accordingly, though some of the most important clinical endpoints, such as hypercapnia and hypoxemia, are usually shared by all manifestations of the disease, the road leading to them may be quite different. Thoracopulmonary compliance, airway resistance, bronchialinspiratory rate time constant, and static and dynamic pressure-volume curves may exhibit very different, even opposite, characteristics, depending on the conditions of the lungs and chest cavity.

These considerations help explain why CVF shares a major management limitation with acute lung failure. In both cases, the need may arise to empirically apply a mechanical device to maintain life-supporting gas exchange, but the clinician usually lacks objective data to match the characteristics of the instrumentation used with specific, measurable aspects of the disease treated. As a consequence, even though ventilators have become very sophisticated, processor-driven mechanisms, much of the decision-making process is based on trial and error, or on the clinical intuition and predictions of the providers.

During the last 35 years, a few fundamental improvements have been added to mechanical ventilators, including the ability to deliver positive end-expiratory pressure, intermittent mechanical ventilation, and pressure support. These advances were directly aimed at improving two aspects of respiratory function—augmenting lung volume and supporting spontaneous ventilation. In both cases, readily measurable variables—PaO₂, PaCO₂, and respiratory rate—can be used to estimate the physiologic response to changes in ventilator settings. Newer ventilators, however, also incorporate technology to provide a far wider range of options,