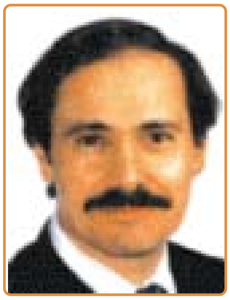
DIGITAL IMAGING IN RESPIRATORY CARE

by John Marini MD



Dramatic advances in imaging technology have already influenced important aspects of intensive care practice, and the respiratory care practitioner is no exception. For those of us old enough to remember "analog" equipment and their limited displays of primary data, a casual look at the ventilator of today is sufficient evidence of how far digital manipulation and processing of that same primary information has taken us. (Remember the needle gauge and bellows spirometer?) Other aspects of the cardiorespiratory environment have undergone even a more dramatic metamorphosis, and the trend shows little sign of slowing.

Digital acquisition and storage of imaging information, coupled to high speed computer processing and communication technologies that manipulate such data, have transformed the field of traditional "ionizing" radiology so completely as to allow bedside and even long distance transfer and interpretation of data as well as to allow development of therapeutic applications that eliminate the need for more invasive procedures. Computed tomographic (CT) data is not only acquired more rapidly and with greater precision than only a few years ago, but in such comprehensive and voluminous quantity that detailed reconstructions of virtually any anatomic aspect of interest can be accomplished from any desired viewing plane - after the data acquisition event and without requiring exposure to additional radiation or the inconvenience of transport from the ICU to the radiology suite. The digital database allows fundamentally different questions to be asked in retrospect than those that might have originally prompted the study. Research into the fundamental questions surrounding ARDS and its ventilatory management has been greatly aided by the use of CT densitometry. Insights from such work allow prediction of such fundamental questions as: 'Who will respond to PEEP?'; 'At what pressures does the injured lung open and close?'; 'How do the contours of the pressure volume curve relate to recruitment and over distention?'; 'What is the impact of prone positioning on lung expansion?' Methods such as positron emission tomography (PET) permit questions regarding the metabolic activity of tissues to be queried. As an independent methodology, PET helps to determine the benign vs. malignant potential of a solitary pulmonary nodule, and when combined with CT scanning has important applications in determining the quiescent or inflammatory nature of masses or fluid collections, in determining the extent of cancerous disease, and in staging lymphomas. Future prospects for metabolic imaging include important research as well as management applications.

With vastly improved imaging technology, the field of interventional radiology has burgeoned impressively in recent years. Nowadays it is often the "interventionalist" who is called first to help control bleeding from the lung or gastrointestinal tract, and many surgical interventions of earlier years have been obviated by this approach. The interventional radiologist can often accomplish difficult vascular access, lumbar puncture, tube placement, or abscess drainage when the unaided practitioner fails to do so (or should not try). Advanced imaging technology has encouraged the growth of an industry devoted to minimally invasive surgical interventions, whether performed by the interventional radiologist, by a specialist who takes particular interest in such procedures, or by the two working side by side. In ICU applications common examples include vascular stenting of coronary and cerebral vessels, catheter ablation of central pulmonary clot, and placement - and removal - of inferior vena caval filters. The trend toward less invasive intervention has only begun.

As dazzling as they have become, diagnostic techniques that employ ionizing radiation still entail transport of the patient, expense, and often exposure to worrisome cumulative doses of x-rays. They must not be undertaken if there is no indication to do so. Generally speaking, their primary purpose is to characterize the anatomic structures of interest, and the decision to undertake the imaging procedure is made by a practitioner who is motivated by some clinical consideration or event. Recent years have also seen dramatic progress in the non-invasive monitoring of the critically ill patient with techniques that pose negligible inconvenience or risk. Progress has been especially rapid in the bedside assessment of the lung. These methods are attractive for several reasons: 1) They do not involve transport; 2) They have the potential for continuous assessment; 3) No ionizing radiation is involved. These imaging methods make use of different physical media: sound, ultrasound, electrical conductivity, and simple observation. Acoustic evaluation is as old as the air conducting stethoscope. Yet acoustic monitoring and lung imaging is now possible using an array of microphones positioned so as to survey virtually all regions of the lung simultaneously. Using computer-

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ized algorithms that characterize the frequency spectrum of the detected sound, wheezes and rales can be classified and counted from each sampling zone. A crude three dimensional map that localizes the origin of the sound can be drawn using information relating to the intensity of the sound signal at each pick-up and its arrival time. Sound transmission can also be probed by "injected" standardized signals. Events such as mucus plugging, the development of a pneumothorax, and the onset of pulmonary edema are within the scope of this emerging tool, theoretically allowing for more timely intervention.

Ultrasonic imaging ("Echo") is a technique highly developed for applications in cardiology. For many years, it was left unexplored for most pulmonary purposes other than pleural liquid detection, as air filled lung is not amenable to this imaging medium. Abandonment of ultrasound for lung imaging acute respiratory failure, however, may have been premature. Edematous and consolidated tissues often present sound-reflecting interfaces that yield characteristic patterns of the underlying process. Although experience with pulmonary ultrasound is quite preliminary, this technique may offer an entirely different type of imaging information - the nature of abnormality, rather than the anatomic configuration of the density.

The electrical conductivity of lung tissue declines as it fills with air. When many electrodes are placed along a transverse plane, the pattern of regional impedance to an injected electrical current can image the lung according to those properties, producing a cross sectional "tomographic" image that complements the more detailed anatomic image obtained from CT slices of the region. This electrical impedance tomography (EIT) provides continuous dynamic information that may be of use in assessing such questions as tidal recruitment. This methodology, although still in the developmental research stage, is among the most exciting of these newer imaging modalities with implications for critical care.

Many incursions of digital technology into the daily life of the hospital are justifiably looked at with concern as well as amazement. The field of ICU imaging, however, may well be the exception. To this point we have received little but benefit, with lavish promises of more to come.

Hyperbaric Files... *Continued from page 58*

Monitoring equipment utilized with the monoplace chamber include ECG and noninvasive blood pressure devices, which is modified for use in the hyperbaric environment. These along with a transcutaneous tissue oxygen measurement can be utilized by connection through the side of the chamber door. Medication delivery to hyperbaric patients must be given intravenously using specially calibrated pumps. The use the Abbott/Shaw Lifecare model 3HB pump is frequently used and calibrated for medication delivery at 2 ATA. It can be used up to 3 ATA using a conversion chart in order to calculate the appropriate fluid delivery rate. In most cases try to avoid the use of lines and cap them whenever possible. The Sechrist chamber can be fitted to receive a total of four IV ports. A specially sized IV line is used that can pass through the door of the chamber and maintain an airtight seal. A back check valve is located within this tubing in case of accidental disconnection of tubing outside the chamber. Since Intravenous pressures can reach those expected from arterial catheters, a disconnect must be corrected immediately. Intramuscular or subcutaneous medications should not be given prior to therapy because they will have a delayed absorption when the patient is pressurized during therapy. This is due to the vasoconstriction effect of hyperbaric therapy. This effect is important when administering such medications as insulin, narcotics, or barbiturates and can result in inadvertent over-medicating.

Other considerations when managing the critical patient are the various catheters and drainage devices connected to the patient. Chest tubes are managed by connecting the drainage tube to a one-way valve called a Heimlich valve. The Heimlich valve is connected to a vented drainage bag for fluid collection. Nasogastric tubes are left open to drain usually in a vented collection bag or plastic glove. A vented collection bag, emptied prior to treatment, is used for Foley catheters. The Foley retention balloon may need to be filled with water in order to maintain placement. Surgical drains can be maintained with vented collection bags and vacuum type drains will continue to operate in the chamber.

Temporary pacemakers are safe to use in the chamber but an external pulse generator should not be placed within the chamber. The use of automated implanted cardiac defibrillators is acceptable up to 6 ATA. Nebulizer therapy of bronchodilators for COPD patients is possible in the monoplace chamber by use of an attached gas source through the door connected to a prefilled small volume nebulizer placed in the chamber with the patient. The flow is turned on from outside the chamber when administration is desired. The use of this therapy is desired at times due to the concern of air trapping associated with COPD patients and pressure changes effecting weakened blebs within their lungs. A patient who experiences a 10% pneumothorax in the chamber at 3 ATA will have an increase to 40% upon ascent (pressure reduction).

This was not meant to be a comprehensive examination at all equipment and procedures for treating critically ill patients but an attempt to shed light on the intricacies of practicing in a limited access, high pressure hyperbaric environment. It is important to continually practice with the equipment and procedures on a regularly scheduled basis in order to maintain proficiency. It is amazing how fast one can forget steps in a procedure or in the operation of a piece of equipment. So schedule a practice session soon.