Chapter 8.12
Imaging Advances of the Cardiopulmonary System

Holly Llobet
Cabrini Medical Center, USA

Paul Llobet
Cabrini Medical Center, USA

Michelle LaBrunda
Cabrini Medical Center, USA

INTRODUCTION

A technological explosion has been revolutionizing imaging technology of the heart and lungs over the last decade. These advances have been transforming the health care industry, both preventative and acute care medicine. Ultrasound, nuclear medicine, computed tomography (CT), and magnetic resonance imaging (MRI) are examples of radiological techniques which have allowed for more accurate diagnosis and staging (determination of severity of disease). The most notable advances have occurred in CT and MRI. Most medical subspecialties rely on CT and MRI as the dominant diagnostic tools an exception being cardiology. CT and MRI are able to provide a detailed image of any organ or tissue in the body without the necessity of invasive or painful procedures. Virtually any individual could be tested as long as they are able to remain immobile for the duration of the study.

DOI: 10.4018/978-1-60960-561-2.ch812

Image generation traditionally has been limited by the perpetual motion of the human body. For example, the human heart is continually contracting and relaxing without a stationary moment during which an image could be obtained. Lung imaging has been more successful than cardiac imaging, but studies were limited to the length of time an ill person is able to hold his or her breath.

Historically, imaging technology was limited by inability to take a picture fast enough of a moving object while maintaining a clinically useful level of resolution. Recent technologic innovation, resulting in high speed electrocardiogram-gated CT and MRI imaging, now allows the use of these imaging modalities for evaluation of the heart and lungs. These novel innovations provide clinicians with new tools for diagnosis and treatment of disease, but there are still unresolved issues, most notably radiation exposure. Ultrasound and MRI studies are the safest of the imaging modalities and subjects receive no radiation exposure. Nuclear studies give an approximate radiation dose of 10mSv and as high as 27mSv (Conti, 2005). In CT imaging, radiation dose can vary depending on the organ system being imaged and the type of scanner being used. The average radiation dose for pulmonary studies is 4.2mSv (Conti, 2005). The use of multi-detector CT (MDCT) to evaluate the heart can range from 6.7—13mSv. To put it into perspective, according to the National Institute of Health, an average individual will receive a radiation dose of 360mSv per year from the ambient environment. It is unlikely that the radiation doses received in routine imaging techniques will lead to adverse reactions such as cancer, but patients should be informed of the risks and benefits of each procedure so that they can make informed decisions. It is especially important that patients be informed when radioactive material is to be injected into their bodies. The reasons for this will be discussed later on in the chapter.

BACKGROUND

Coronary artery disease (CAD) is the leading cause of death in the U.S.. It is also the most common cause of the most costly heart disease in the U.S.—heart failure (Thomas & Rich, 2007). With a prevalence of almost 13,000,000, it carries an estimated cost of US$130 billion per year (Sanz & Poon, 2004). The American Heart Association calculates the cost of caring for those with cardiovascular disease at $300 billion per year (Raggi, 2006). According to the American Lung Association, lung disease is the third most common cause of death in America, responsible for one in seven deaths every year. Infections, particularly those of the lungs, are the number one killer of infants. An estimated 35 million Americans are currently living with lung disease such as emphysema, asthma, or chronic bronchitis. Even small technological advancement can lead to dramatic improvements in health care. Raggi (2006), the American Heart Association/American College of Cardiology and the National Cholesterol Education program III have describe simple screening tools to risk stratify patients (group patients into prognostic categories). These stratification tools involve assessment of lifestyle factors, genetic factors, and simple blood tests. For example, patients who smoke, are obese, inactive, have high cholesterol, and a family history of heart disease are more likely to have heart disease than people who lack these risk factors. Based on the results of the screening, recommendations can be made for further diagnostical procedures, treatments, and lifestyle interventions. Some of the more advanced diagnostic procedures include echocardiography, nuclear medicine (NM) scans, CT, and MRI.

ECHOCARDIOGRAPHY

Echocardiography uses the principle of ultrasound (sound wave) reflection off cardiac structures to generate images of the heart just as it does in producing images of an unborn baby in a pregnant woman. In the past three decades, echocardiography has rapidly become a fundamental component of the cardiac evaluation. Measuring the same feature from different angles (windows) with different types of sound wave detectors (transducer) is done to produce an image. The entire heart and its major blood vessels can be displayed in real time and in various 2-D planes. Transthoracic echocardiogram (TTE) imaging is performed with a hand-held transducer placed directly on the chest wall. In select situations in which a more direct image needs to be taken without the interference of the chest wall, chest muscles, and chest fat, a transesophageal echocardiogram (TEE) may be performed. In TEE, an ultrasound transducer is

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