25-on-25: Twenty-five Perspectives on Twenty-five Years of Cardiopulmonary Imaging

The 25th anniversary year of the Journal is an opportune time for both reflecting on the past and envisioning the future of cardiopulmonary imaging. The purpose of this special year-long feature is to provide our readers with the collective perspectives of 25 international leaders in the field regarding the following questions:

1. “What is the most influential article or advance in our specialty in the past 25 years?”
2. “Which potential advance or line of research of the last 25 years failed to live up to your expectations?”
3. “What are the greatest opportunities and challenges for our specialty in the coming 25 years?”
4. “What will our specialty look like 25 years from now?”

Each issue of JTI in 2010 will include the collective 25 responses to one of the four questions. We begin with the following question:

“‘What is the Most Influential Article or Advance in Our Specialty in the Past 25 Years?’”

Technological advances in computed tomography (CT), specifically volumetric CT with multi-detector (MD) row scanners, have revolutionized cardiopulmonary imaging in the past 25 years. MDCT exploits cone beam geometry to acquire multiple axial images per rotation at sub-second rotation speeds. Isotropic volumetric high-resolution data sets span the entire volume of the chest and can be reformatted to create high-quality two-dimensional (2D) and 3D images; these data sets are also amenable to image analysis. MDCT has advanced the characterization of diffuse lung diseases, emphysema, large and small airways diseases, the pulmonary circulation, and the heart. Routine clinical practice has embraced the incremental improvements in qualitative analysis; however, quantitative analysis of this data has been largely restricted to the academic research setting.

Denise R. Aberle, MD
Los Angeles, CA, USA

The conceptual understanding of chest disease and its radiographic manifestation as a multifactorial process determined by the interaction of anatomy, physiology, and biochemistry, has been the most important advance in our specialty. This conceptual understanding and the resulting integrative approach to thoracic imaging is probably best illustrated in Jud W. Gurney’s seminal article “Cross-sectional physiology of the lung,” published in 1991 in Radiology. This article has provoked a wide interest in pulmonary physiology and might ultimately have heralded the way for a functional approach to respiratory imaging.

Alexander A. Bankier, MD
Boston, MA, USA

The maturation of cardiac magnetic resonance imaging (MRI) over the past 25 years and more recently cardiac computed tomography (CT) coronary angiography has been the major advance in the field of cardiovascular radiology. It is indeed remarkable that the first reports on, for example, delayed enhancement of myocardial infarction by CT and MRI have been
published 25 years or more ago. Initially, myocardial infarct imaging using delayed enhancement of iodinated contrast agents was shown ex-vivo. Now, more than 30 years later, this application is emerging as a potential tool for myocardial viability imaging by using the latest CT technology. Analogous to CT, MRI has taken a long road to reach its current state of maturity. Initial patient studies using delayed enhancement of myocardial infarction using gadolinium-based contrast agents have been published 25 years ago. Now myocardial viability imaging by MRI is the prime indication for using cardiac MRI worldwide. Interestingly, this particular technique has expanded its potential beyond infarct imaging and is applied to many other diseases affecting the myocardium (eg, myocarditis). CT angiography has undergone rapid improvements over the last decade, resulting in high quality coronary angiograms nowadays. CT imaging principles were already defined and patented around 1980, but matured in the last 10 years to its current high quality level.

Albert de Roos, MD
Leiden, The Netherlands

The introduction of helical CT scanning in the early 1990s transformed the practice of thoracic imaging and its impact upon pulmonary medicine and thoracic surgery. This followed in the wake of high resolution CT, and was further improved with the advent of multidetector CT. The ability to image the entire chest with high spatial resolution within a single breath hold using multidetector helical CT represents the most significant advance in thoracic imaging over the past 25 years. The isotropic volumetric data sets, which allow for multiplanar and volumetric displays, provide an unprecedented means for visualizing and quantifying disorders of the airways, pulmonary vasculature, and lung parenchyma.

Warren B. Gefter, MD
Philadelphia, PA, USA

A truly disruptive technique in radiology completely changes the way a disease is diagnosed. Dr Martine Rémy-Jardin et al’s article on the CT diagnosis of pulmonary embolism published in *Radiology* in 1992 triggered extensive research in the field of PE diagnosis. With improving equipment, the role of CT increased until it is now both the most frequently utilized imaging exam for PE and the gold standard for diagnosis. This paper totally changed the diagnostic approach to PE and in addition has provided new clinical insights into a perplexing disease.

Lawrence Goodman, MD
Milwaukee, WI, USA

The most influential advance in chest imaging in the past 25 years has been the introduction of high-resolution CT (HRCT). Since the late 1980’s, this technique has become established as an indispensable tool in the evaluation of patients with suspected diffuse pulmonary disease. In the same time, it has replaced bronchography for the diagnosis and assessment of extent and severity of bronchiectasis. HRCT has been commonly used in clinical practice to detect and accurately characterize a variety of lung abnormalities. It has tremendously contributed to the understanding of diffuse lung diseases and small airway diseases, as well as their nature, causes and characteristics.

Philippe Grenier, MD
Paris, France

Willi Kalender takes much credit for the brilliant idea of making the table of a CT scanner move while scanning. Peter Vock reported the first clinical use of this major technological advance in 1990. In 1992, Martine Rémy-Jardin harnessed the technique and revolutionized the investigation of pulmonary embolism.

David M. Hansell, MD, FRCP, FRCR
London, UK
In my view, one of the most important landmark articles in clinical chest radiology within the past 25 years was the paper by Martine Rémy-Jardin et al describing for the first time spiral CT angiography (SCTA) of the pulmonary arteries as a method to diagnose acute pulmonary embolism (PE) that was published in *Radiology* in 1992. The methodology introduced in this article and the resulting further development of SCTA of the pulmonary arteries has helped to reduce the number of undiagnosed PE, to save thousands of lives, and to create a noninvasive tool for the further study of acute and chronic cardiopulmonary disorders.

**Christian J. Herold, MD**  
*Vienna, Austria*

Advances in CT technology revolutionized the evaluation of pulmonary and cardiac diseases. The entire thorax can be scanned in one breath hold or even without breath hold with faster scanners. High-resolution CT changed the concept of diagnosis in diffuse interstitial lung disease. CT enables not only structural but also functional evaluation of the heart.

**Jung-Gi Im, MD**  
*Seoul, Korea*

The advance of high-resolution CT (HRCT) and related articles by Murata et al published in *Radiology* in 1986 and Munk et al published in *Radiology* in 1988 are the most influential in my opinion. HRCT is undoubtedly the most important and useful diagnostic tool for pulmonary diseases. The first article by Murata et al led to a systematic process to interpret HRCT from the relationship between abnormalities and lobular structures. The second article by Munk et al was the first work of precise HRCT pathologic correlation and stimulated many investigators.

**Takeshi Johkoh, MD, PhD**  
*Hyogo, Japan*

The diagnosis of pulmonary embolism by CT. With the advent of fast CT scanning, bolus-enhanced breath-hold imaging of the pulmonary arteries became possible. Starting from the diagnosis of emboli in the central pulmonary arteries, CT worked its way down to the subsegmental branches. Performance, speed, availability and differential diagnoses made CT the imaging modality of choice. Multiple studies generated the evidence to assign CT a central role in the work-up of patients suspected of having pulmonary embolism in all current guidelines.

**Hans-Ulrich Kauczor, MD, PhD**  
*Heidelberg, Germany*

For me, it’s a tie between helical CT technology which has evolved to allow applications for thoracic CT not possible or even dreamed of when I was a medical student or house officer, such as CT pulmonary angiography, cardiac/coronary CT, volumetric HRCT and consistent low dose single breath hold CT for lung nodule detection and follow up, and the publication “Radiologic-pathologic correlations of small lung nodules with special reference to peribronchiolar nodules” by Harumi Itoh and colleagues in the *American Journal of Roentgenology* in 1978, which laid the foundation for many decades of subsequent and ongoing work using the principle of careful radiologic-pathologic correlation in diffuse lung disease.

**Ella Kazerooni, MD**  
*Ann Arbor, MI, USA*

MDCT is the most influential advance for diagnosis in the specialty in the past 25 years.

**Michio Kono, MD**  
*Ashiya, Japan*
The development of coronary CT angiography.

David C. Levin, MD  
Philadelphia, PA, USA

The most important advance in our specialty and in all of radiology in the past 25 years has undoubtedly been the transformation of image acquisition, storage and display from analogue to digital media. This, in turn, has enabled numerous technological developments, including digital radiography and multidetector CT, which have vastly expanded our diagnostic capabilities.

Heber MacMahon, MB, BCh  
Chicago, IL, USA

In my opinion, the most important advance in our specialty has been the development of high resolution CT. This has permitted a much greater understanding of interstitial lung disease. It has increased the accuracy of diagnosis, and the ability of the radiologist to understand the anatomic distribution of disease at the lobular level, to provide a quantitative analysis of the severity of disease and to assess response to treatment.

Theresa C. McLoud, MD  
Boston, MA, USA

Imagine what our specialty looked like 25 years ago—single slice CT, ultrasound with snowy images, MRI that few hospitals had. Now, current ultrasound equipment allows us to diagnose heart and lung disease in the fetus. CT and MR scans are replacing cardiac catheterization in many patients. CT has replaced angiography for the diagnosis of pulmonary embolism. Better care for our patients has progressed not only with improved scanners but also with advances in information technology, such as teleradiology and the electronic medical record. These major advances not only in scanner technology but also in information transfer (image anywhere, interpret anywhere) have led to much better patient care today.

Stephen W. Miller, MD  
Boston, MA, USA

The most influential advance in cardiopulmonary imaging in the last 25 years is multidetector CT. The most influential advance in imaging of interstitial and small airway diseases was high-resolution CT but alas it is now more than 25 years old.

Nestor L. Müller, MD, PhD, FRCPC, FFRRCSI (Hon)  
Vancouver, BC, Canada

The most influential advance in the diagnosis and management of patients with chest disease—using the broadest possible definition—would have to be the impact of high resolution CT on imaging the lungs. However, a close second is the emergence of PET as a potent clinical tool for assessing thoracic neoplasia.

David P. Naidich, MD  
New York, NY, USA

Gadolinium was introduced as a contrast agent in MRI in 1988 and propelled MRI into the limelight as a superior method for soft tissue and tumor imaging throughout the body without risks of iodinated contrast or ionizing radiation. Although the reputation of gadolinium has been tarnished by a few hundred cases of nephrogenic systemic fibrosis, in 300 million administrations, it remains one of the most effective and safest contrast agents available today.

Martin R. Prince, MD, PhD  
New York, NY, USA
Over the past 25 years, we have seen our specialty developing at a high pace imposed on us by the tremendous advances in CT technology. I would like to quote the introduction of high-resolution CT, which made the secondary pulmonary lobule an anatomical reality in daily practice, the arrival of fast-scanning multidetector-row CT (MDCT) technology, which opened unprecedented options for the evaluation of the thoracic vessels and cardiac cavities, and more recently, dual-energy CT. The ultimate consequence of this continuous trend has been the redefinition of the borders of thoracic imaging.

Martine R. Rémy-Jardin, MD
Lille, France

As a cardio-thoracic imager, I still cannot stop marveling every day over our ever expanding capabilities of non-invasively imaging the heart. I feel that we have been emerging from the dark ages where diagnosing heart disease was marred by the uncertainty of unclear, indirect, or invasive tests. The ability to see clearly into our patients hearts from outside is the holy grail of imaging. If we can image the heart, we can image anything.

U. Joseph Schoepf, MD
Charleston, SC, USA

Certainly one of the most important advances in cardiothoracic imaging in the last 25 years is the use of delayed enhancement to assess myocardial infarction by MRI. In an article by Kim et al published in the New England Journal of Medicine in 2000, these authors demonstrated that delayed myocardial enhancement with gadolinium may be reliably used to assess for myocardial viability. While the idea that myocardial infarctions enhance was not new, Kim et al made use of improved pulse sequences, validated the concept with animal models and demonstrated its clinical usefulness.

Arthur E. Stillman, MD, PhD
Atlanta, GA, USA

The development and validation of high-resolution CT has been the most important advance in pulmonary imaging during this period. A paper in the first issue of the JTI in 1985 by Zerhouni, Naidich, et al was the first to describe the HRCT findings of infiltrative lung disease in the way we think of them today. Although the description of HRCT findings has been refined and expanded, our current classification of HRCT abnormalities remains largely unchanged.

W. Richard Webb, MD
San Francisco, CA, USA

There have been many important advances in our subspecialty in the past quarter century, making this a very difficult question. If forced to choose the single most influential development, I would select CT pulmonary angiography (CTPA). The development of CTPA beginning in the mid-1990’s led to a wholesale change in the evaluation and treatment of pulmonary embolism. The topic remains a fertile area for research and, at times, controversy. Two groups deserve credit for bringing this important topic to the forefront, one headed by Martine Rémy-Jardin, MD, at Hospital Calmette in Lille France and the second by Larry Goodman, MD, at the Medical College of Wisconsin.

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