EDUCATION MODELS FOR THE EXPANDING ROLE OF CLINICAL MEDICAL PHYSICS

Perry Sprawls
Emory University, Atlanta and Sprawls Educational Foundation, www.sprawls.org

Abstract— **All modern medical imaging methods are significantly complex with many adjustable factors, especially relating to the digital imaging format, that determine image quality. Medical physics activities to achieve appropriate image quality must involve the actual clinical imaging procedures in addition to traditional quality control functions relating to equipment. This expanding role requires knowledge of the anatomical, physiological, and pathological characteristics of the human body and how they are visualized through imaging methods. Several methods, or models, for providing this education are compared with respect to their effectiveness and efficiencies.**

Keywords— **Image Quality, Procedure Optimization, Medical Sciences, and Expanding roles.**

I. INTRODUCTION

Effective medical physics educational activities are those that provide knowledge that the learner can use to perform specific professional functions. As the practice of clinical medical physics evolves and expands in scope so do the educational requirements. The purpose here is to compare some traditional and expanding medical physics activities in clinical medical imaging (diagnostic radiology) and describe several methods, or models, for providing the required education. There is no one educational approach or method that is appropriate for all medical physics educational programs. Each specific educational activity (classroom discussion, self-study, hands-on, etc.) is characterized by two conflicting factors, *effectiveness* and *efficiency*. Each program can select and develop methods or models that fulfill their needs and capabilities.

In the field of medical imaging the development of many new modalities and methods has greatly increased diagnostic capability by providing visibility of a more extensive range of clinical conditions within the human body. A significant factor is the potential for detection and diagnosis of pathologic conditions, including cancer, when they can be more effectively treated. The modern imaging methods with their increased diagnostic capability also are much more complex from a physics perspective.

Regardless of the imaging method, medical physicists are the professionals with the knowledge and experience for ensuring image quality and managing related risks. Factors that affect image quality are in two major categories: those relating to the equipment and associated technology, and those related to the actual imaging procedure for patients. For the purpose of educational needs the medical physics activities relating to the evaluation of equipment in the context of quality control and assurance programs is designated as *traditional*. These are the functions that we medical physicists have been performing for many years. The medical physics activities to ensure appropriate image quality relating to the actual imaging procedures are designated as *expanding* roles. These include a variety of professional functions and interactions that continue to increase in scope and "expanding" educational needs and learning activities.

II. TRADITIONAL MEDICAL PHYSICS ACTIVITIES

As a point of reference consider typical traditional medical physics activities illustrated in Figure 1.

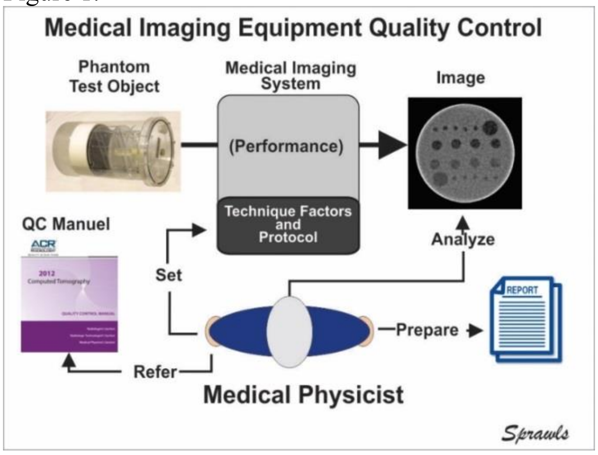

Figure 1. A traditional medical physics activity of performing quality control evaluation of imaging equipment.

These medical physics functions are not only valuable contributions to patient care; they are required by accrediting organizations, including the American College of Radiology (ACR) and government agencies, including the Federal Drug Administration(FDA).

A common function in most medical physics QA or QC procedures is to produce and evaluate images of specific test objects or phantoms. The imaging protocols or technique factors used are often prescribed in recommended testing procedures established by the agencies requiring the procedures.

This removes variations in the operating factors so that the testing provides an evaluation of equipment performance, not the imaging procedure itself. This is a major factor distinguishing between the more traditional role and the expanding role of medical physicists in clinical medical imaging.

III. MODERN MEDICAL IMAGING METHODS AND IMAGE QUALITY

The availability of a variety of imaging modalities and methods--CT, MRI, PET, ultrasound, in addition to radiography and nuclear medicine applications--provides the opportunity for visualizing a large range of body functions and pathologic conditions. With this increasing clinical capability comes an increased complexity of the imaging process and factors that can have an effect on image quality. A common characteristic of modern imaging methods is the production or formation of images in a digital format. While this provides many advantages it adds some complexity to the process. Digitizing is a sampling process in which the patient's body is divided into many small samples—voxels--and certain tissue characteristics within each voxel are displayed in corresponding pixels within an image. With virtually all imaging methods the size of voxels and pixels is an adjustable factor that has major impact on image quality. The significance is that voxel/pixel size affects two different image quality characteristics, blur (detail and resolution) and noise, and has an indirect effect on radiation dose to patients in many procedures. This is illustrated in Figure 2.

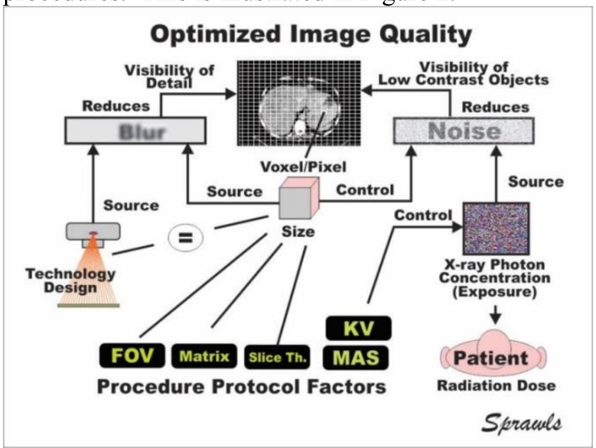

Figure 2. The general relationship of voxel size to image quality.

IV. IMAGE QUALITY OPTIMIZATION

With imaging methods using images in a digital format, quality control and quality assurance take a completely different and expanded approach. Most traditional QC activities involving equipment performance testing generally focus on each individual image characteristic--contrast, blurring (resolution), artifacts, etc. With the methods using digital images the requirement is for *image quality optimization.* This occurs when selecting and adjusting the technique or protocol factors for each imaging procedure, not with the testing of the equipment.

Image quality optimization is very different from traditional image quality control and is a complex process. It is an activity in which medical physicists can make significant contributions to the quality of medical imaging procedures.

V. THE EXPANDING ROLE OF MEDICAL PHYSICS IN CLINICAL MEDICAL IMAGING

An overview of medical physics activities to contribute to high-quality medical imaging procedures is illustrated in Figure 3.

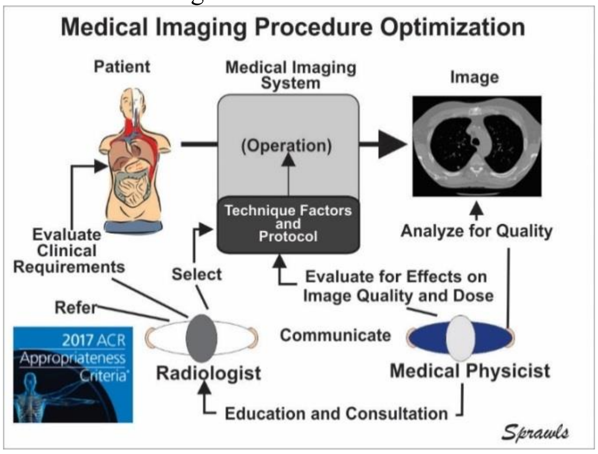

Figure 3. An overview of the collaborative process for optimizing image quality in clinical procedures. (Compare to Figure 1.)

This requires knowledge and experience beyond that needed to perform the traditional QC and QA procedures. A significant factor is that it involves interactions with other medical professionals, especially radiologists, in both educational activities and ongoing consultations.

Because of the extensive capability and complexity of modern medical imaging methods the radiologist or other physician is challenged with selecting the most appropriate protocol for each specific clinical case. This is usually done based on personal experience or consultation with colleagues but also based on recommendations published in *Appropriateness Criteria* by professional organizations, including the ACR. This provides guidance for selecting imaging methods but not some of the details with respect to image quality and radiation dose, if that is a factor.

It is the medical physicist who can evaluate images with respect to quality characteristics and relate these to the selection of technique factors and the protocol used for a specific procedure. To be most effective in this and provide the greatest value to clinical medical imaging, medical physicists must have a comprehensive knowledge in three related areas as illustrated in Figure 4.

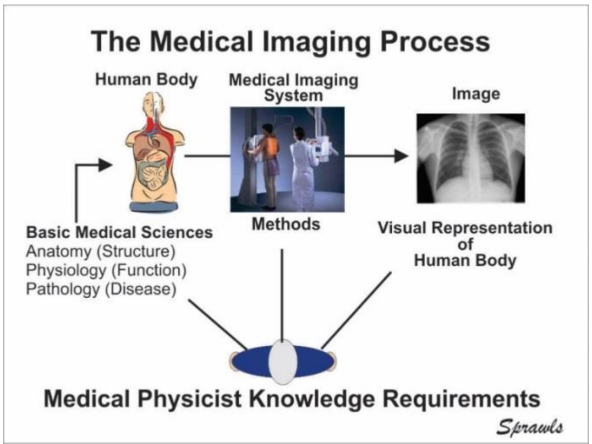

Figure 4. Areas of knowledge required for effective medical physics contributions to high-quality medical imaging procedures.

A major objective of this article is to identify the educational needs for expanding medical physics activities and consider models for effective educational activities to meet those needs. This requirement for medical physics education with more clinical medical science content is now recognized by various organizations including the American Board of Radiology (ABR) in the certification of medical physicists.

VL. IMAGE FOCUSED MEDICAL PHYSICS EDUCATION

The medical image is a unifying factor in effective medical physics education. It is the physical object physicists evaluate with respect to image quality characteristics and then make recommendations on producing images appropriate for specific clinical applications. Beyond knowledge of the physical characteristics of images (contrast, blur, noise, etc.) there is the need for knowledge of both the conditions within the human body and the imaging process that "connects" the image to the body. Figure 4 illustrates medical images that provide visualization of the three basic clinical sciences that are significant for medical imaging: anatomy (structure), physiology (function), and pathology (disease).

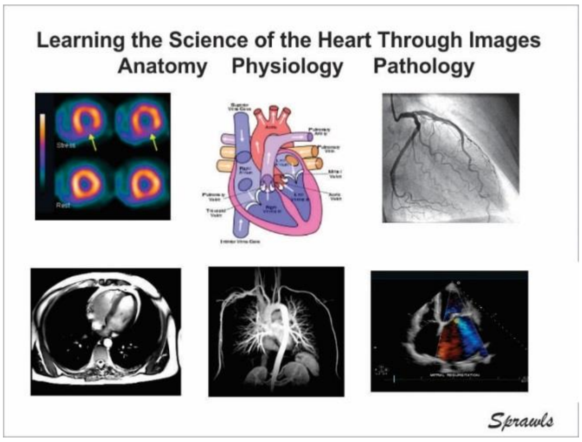

Figure 4. Medical images that provide visualization of the clinical conditions associated with the heart.

Using clinical images within the context of medical physics education activities adds significant value. It provides a basis for learning the three medical sciences in a form that directly applies to the physics of medical imaging. This can be provided with a combination of at least three different learning resources and activities or models. Here each will be considered in terms of its effectiveness and its efficiency.

VII. MODELS FOR LEARNING ACTIVITIES

Effectiveness

The *effectiveness* of a learning activity is its ability to produce knowledge that supports specific functions. Of special interest here are the functions illustrated in Figure 3. The effectiveness is the major goal of a learning activity. If it is not effective it has limited value.

Efficiency

The *efficiency* of a learning activity is determined by the effort, resources, and other costs needed to provide it. Efficiency is often a limiting factor that makes some potential learning activities unavailable or not practical.

Textbooks

Text and reference books primarily for other medical imaging professionals, especially technologists, are useful for medical physics education. Kowalczyk (1) is an example that correlates the three medical sciences and related imaging methods. It is a valuable resource for medical physicists and students for self-study and reference in combination with other activities. The use of appropriate textbooks is both effective and efficient providing extensive information at a relatively low cost.

Radiology Clinical Involvement and Conferences

When medical physicists, students, or residents are directly involved in clinical radiology or academic departments attending discussions and conferences, there is an opportunity to learn the various imaging procedures and the pathological conditions where they are applied. While this provides valuable exposure to clinical activities it is somewhat limited with respect to both effectiveness and efficiency. The focus on most presentations and discussions is for physicians and not medical physicists.

Clinical Science and Imaging Methods Education within Medical Physics Programs

The most effective learning activities covering the medical sciences and imaging applications are those developed and provided within medical physics academic programs as illustrated in Figure 5.

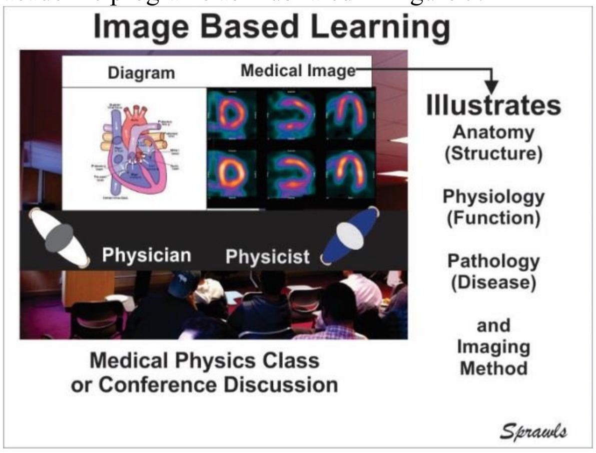

Figure 5. A highly effective learning activity for medical physics students.

A very effective learning activity to prepare medical physicists to contribute to improved and optimized image quality in clinical procedures includes several features as illustrated. A major factor is correlating medical images with the characteristics of the human body and using the images to learn the basic medical sciences.

This can be most effective when the discussions are conducted by a physicist and physician working together. It provides both physics and clinical perspectives of the imaging process. There is also value in experiencing the communication process between physicists and physicians.

While this type of class or conference is highly effective it has some limitations and challenges with efficiency. Considerable effort is required to produce the curriculum and visuals. There is the opportunity for this to be done as a collaborative and shared effort among educators, organizations, and even institutions. One purpose of this publication is to illustrate the characteristics and need for these educational resources and encourage their development.

Most radiologists or other physicians within an institution have limited time to devote to teaching within physics programs. In institutions with radiology residency programs there is the opportunity for some residents to participate as discussion leaders on a rotating basis. They benefit from enhancing their teaching skills and perhaps learning some physics in the process. Another possibility is to engage retired physicians giving them the opportunity to share their extensive knowledge and experience and contribute to the education of young scientists.

VIII. SUMMARY AND CONCLUSION

Physics is the foundation science of all medical imaging methods and physicists are the scientists who make major contributions to effective and safe imaging procedures through a variety of professional activities. With most modern imaging methods the variations and possible deficiencies in image quality now depend more on the procedure factors and protocols than on the performance characteristics of the equipment. To contribute to high-quality and optimized image quality medical physicists need education that includes the three basic medical sciences, anatomy, pathology, and pathology, along with an understanding of the imaging methods that provide visualization of these body and tissue characteristics.

There are several different approaches, or models, for including this in medical physics education. No one model fits all. It is a continuing process in which educators will develop learning activities that are appropriate for their needs and capabilities. There is the opportunity for collaborative efforts in developing and sharing resources to support the expanding roles of medical physicists in the field of clinical imaging.

The ultimate goal is medical physicists with the education and experience to contribute to the production of medical images with the quality characteristics required for highly-effective clinical procedures using the advanced technology and methods that are the foundation of modern medicine.

REFERENCES

1. Kowalczyk, Nina. *Radiologic Pathology for Technologists*.6th. Edition. Elsevier Mosby. Maryland Heights, MO 63043

Contacts of corresponding author:
Perry Sprawls
Sprawls Educational Foundation
www.sprawls.org
sprawls@emory.edu