VIEWPOINT

Molecular Imaging and PACS

Where we are now and where we are going

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In this installment of Examine | PACS, we take a look at PACS solutions for molecular imaging, including what's out there now and what needs to be for tomorrow.

Multimodality PACS/RIS with comprehensive support for radiology, cardiology, and molecular imaging

FOR MOST HEALTHCARE institutions that provide diagnostic imaging services, PACS have been part of their daily life for general radiology modalities (i.e., CT, MR, X-ray, general ultrasound, etc.). However, professionals in these institutions, from physicians, technologists, and administrators, to PACS/IT staff, have also been feeling the pain of not having proper PACS solutions for a range of different modalities. The most under-served modalities by PACS are the molecular imaging modalities, including PET-CT, SPECT-CT, nuclear cardiology, and general nuclear medicine.

Although molecular imaging is relatively small considering the number of exams performed per year, its importance is not to be underestimated, both clinically and financially. PET-CT has been proven to be the *de facto* modality when it comes to cancer diagnosis. Nuclear cardiology has been the modality of choice for noninvasive cardiology. General nuclear medicine provides many functional imaging applications that no other modalities can match. Financially, PET-CT and nuclear cardiology are still among the highest reimbursed procedures in diagnostic imaging.

What makes molecular imaging different from general radiology modalities is that the former images the functions of the body, while the latter images the anatomy of the body. This is why molecular imaging is sometimes also referred to as metabolic imaging. In order to analyze the functions of the body from the images acquired, special viewing and analyzing tools are required. These tools are exactly what are missing from the majority of the PACS today.

THE BREAKDOWN

For PET-CT, since a study contains both PET and CT images, PET provides the metabolic information, and CT provides the anatomic information. In order to perform an accurate diagnosis, physicians depend on tools to fuse PET and CT images together to overlay functional images on top of anatomic images, and to be able to manipulate and perform various measurements on the fused images.

In most institutions with PACS, the fused images are generated on a modality workstation and then saved as screen captures to be sent to PACS. Physicians will then have to interpret from the saved screen captures, with no ability to manipulate or measure these screen captures. If a physician desires the ability to manipulate and measure on the fused images, then they will have to perform it on a modality workstation.

For SPECT-CT, the situation is similar to PET-CT. The only difference is that PET images are now replaced by SPECT images. The requirements and the shortcomings of most PACS are the same.

For nuclear cardiology, after a series of image processing, a four-dimensional image dataset of the patient heart is obtained. To help make an accurate diagnosis, physicians will need special tools to visualize the heart in motion (beating), analyze the blood supply to the myocardium (perfusion analysis), and analyze the heart's ability to pump blood (wall motion analysis). From time to time, physicians will also need to re-reconstruct the four-dimensional image data from a series of raw two-dimensional data, particularly if the physician is not satisfied with the four-dimensional data presented to them. In most institutions, the processing and analyses are done on modality workstations. The results are saved as screen captures and sent to PACS. Physicians have to interpret solely based on the screen captures.

General nuclear medicine is relatively easy, compared to PET-CT, SPECT-CT, and nuclear cardiology. Many general nuclear medicine procedures only require static images, and screen captures are often adequate for these types of studies. However, many other procedures require dynamic images and special analysis tools. For these types of studies, screen captures are inadequate. In most institutions, general nuclear medicine images

are processed on modality workstations and screen captures are sent to PACS. Physicians will then interpret solely based on the screen captures.

The ability to view molecular images with proper colors is also very important in order to make accurate diagnosis. Most PACS do not have the ability to display such raw data in colors.

In summary, currently most PACS only display screen captures for molecular imaging modalities, and this is the only option available for physicians to interpret molecular imaging studies on PACS.

CHALLENGES WITH MOLECULAR IMAGING

So why is molecular imaging so complicated? The complications come from all aspects that make molecular imaging work.

First of all, as mentioned earlier, molecular imaging is functional imaging, which makes the modality intrinsically difficult. For functional imaging, obtaining images is only the first step; the more important steps are how to process and view the images in meaningful ways, and how to analyze the images. Unlike most other modalities, for which you just need to acquire images and present them as-is on PACS, molecular imaging requires comprehensive tools found in modality workstations to be available on PACS to allow accurate diagnosis.

Secondly, molecular images are formed by collecting radiation from patients generated by radioactive isotopes administered to them. Compared to other modalities, information available to form images is very limited. In order to improve image quality, manufacturers devised their own special technologies to make their images look better.

These special technologies often result in proprietary information that no other vendor can support. Therefore, being able to handle all vendors' data and make them compatible with each other is a must.

Thirdly, many institutions still use nuclear medicine equipment from the '80s or '90s, which do not support DICOM. For such old equipment, it is simply impossible to send images to PACS. Even the devices that claimed to be DICOM-compatible would only support sending screen captures, at best. Connecting these legacy devices to PACS is a major obstacle to overcome.

Lastly, being able to store raw molecular image data on PACS and being able to bring it back to modality is a major challenge for most PACS. Most PACS either would not accept raw data, or when you retrieve the raw data, it is no longer usable. The majority of institutions do not use PACS for long-term archiving of molecular imaging data. The majority of nuclear medicine departments still maintain their own archive on CD/DVD, MOD, or mini-PACS.

SPECIALIZED SOLUTIONS

Since the mid- to late-'90s, various vendors have been developing specialized solutions to address the needs of molecular imaging. As a result, there were a few nuclear medicine mini-PACS available, primarily to address the connectivity and data storage issues. In such implementations, modality workstations were still required to provide the clinical tools. As enterprise PACS were being implemented, institutions tended to discourage such mini-PACS solutions, since the cost for maintaining such storage solution could no longer be justified.

The three major molecular imaging modality vendors all have significant presence in the PACS market. Especially since purchasing Stentor, Philips Healthcare, based in Andover, Mass., has been a major player in the enterprise PACS market. All three vendors try to sell their modality workstations as special-purpose PACS workstations; some are even integrated with their PACS platforms. However, the success has been rather limited. The main reason is that modality workstations are primarily designed for technologists to do processing. They are too cumbersome to be used by physicians as PACS workstations, simply because they do not possess the dataflow and workflow required of PACS workstations. The even bigger limitation with such solutions is that they may not work with images from their competitors' equipment at all.

Some other major PACS vendors integrated third-party nuclear medicine workstation solutions into their PACS platforms, hoping to provide some necessary clinical tools on their PACS. However, the following key issues were left unaddressed:

Connectivity. As mentioned earlier, getting data from nuclear medicine equipment to PACS and maintaining the data integrity is one of the biggest challenges. If data cannot get to PACS properly, the integrated workstation can provide very little value.

Lack of the ability to be vendor- and device-neutral. Since the responsibility of connectivity falls on PACS, it would not have the ability to handle the many types of images and the specifics of each molecular imaging device. Data from some vendors' devices may work, while others may not.

Lack of diagnostic tools for physicians. Often, such workstations are designed for technologists for processing. Physicians normally find them unusable as diagnostic tools in PACS.

Lack of efficiency. Since such workstations were designed as technologists' processing workstations, PACS dataflow and workflow were not part of the design. You may be able to pass data to it and launch it, but there is no bi-direction interaction with PACS. It is basically a dead-ended application.

Lack of the ability to send data back to modality. Because of the special features that each vendor implements to improve image quality, certain processing can only be done on modality workstations. In case data needs to be brought back to a modality workstation for further processing, PACS most likely would not have the capability to do so for many of the image types.

THINKING SYSTEMS **ThinkingPACS/ThinkingRIS**

Thus far, we have discussed the solutions that work in limited fashion. So, what are the requirements for a solution that really works? The solution has to be able to do the following:

- Communicate bi-directionally with any vendor's modality devices, through either DICOM or proprietary communication protocols, and be able to receive, retrieve, and send all image types in true DICOM or proprietary formats without losing any vendor specific information.
- Communicate bi-directionally with enterprise PACS for all image types and ensure that all data sent to PACS can be retrieved back without losing any device-specific information.
- It is a true PACS product, designed and optimized for the dataflow and workflow in an enterprise environment.
- The clinical solutions are seamlessly integrated with enterprise PACS as plug-in or add-on, and the clinical solutions cover all areas, specifically: PET-CT fusion; SPECT-CT fusion; nuclear cardiology processing and quantifications; and general nuclear medicine view, processing, and quantifications.
- The clinical solutions are available enterprise-wide through either thick-client or thin-client.

THE FUTURE OF MOLECULAR IMAGING AND PACS

Molecular imaging modalities have been among the fastest growing modalities in the industry, especially the hybrid modalities, such as PET-CT and SPECT-CT, which combine functional imaging and anatomical imaging together. Molecular imaging has been playing crucial roles in healthcare, especially in oncology and cardiology. According to industry analysis, including the recent *Forbes Wolfe Emerging Tech Report* project released in January, molecular imaging is one of the technologies expected to make a significant impact in the next decade.

Even though the major enterprise PACS vendors continue to downplay the importance of molecular imaging, they all realize that they cannot continue to bury their heads in the sand much longer. They realize that molecular imaging is now, more than ever, a deciding factor in the selection process of new PACS purchase, PACS upgrade, and PACS replacement. Whichever of these vendors comes up with comprehensive solutions for all modalities first, especially for molecular imaging and cardiology, will most likely dominate the market for years to come.

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