Data, Metrics, and Analytics in Medical Imaging

By Raif Erim

The Patient Protection and Affordable Care Act (ACA) was signed into law in March of 2010. Healthcare reform and changes to the delivery system are beginning to move at a dizzying pace compared to the last two decades. Accountable care organizations, population health, capitated contracts, commoditization, reimbursement, bundling—as these buzzwords circulate, medical imaging faces the daunting dichotomy of providing state of the art diagnostic care as cheaply as possible. To continue down this continually redefined path while making use of and leveraging existing resources, the key to success is utilizing Big Data.

What exactly is Big Data, and how is the healthcare market on a macro level, and medical imaging on a micro level, making use of it to transform how business is conducted? To answer these questions, one must explore what is contained in the millions of terabytes of information residing on the servers of healthcare providers and equipment manufacturers across the country. The information that is there has to be defined, and then it needs to be determined how to utilize it within a facility's operations.

The term Big Data was coined around the idea of datasets that are so large they are beyond the ability of common applications and software tools to organize, capture, manage, and process in an acceptable amount of time. The challenge around datasets this size is that it becomes nearly impossible to transform the data into any sort of meaningful output. To put the size of these datasets into perspective, in 2012 "exabytes" became a commonly used term, which means millions of terabytes—that's one million terabytes, which in turn is one million bytes of data. The average hard drive on today's desktop computer is usually around 500 gigabytes, or one half of a terabyte. It can be seen why there might be problems analyzing the data. In 2012, worldwide, 2.5 exabytes of data were created *every day*!

When considering the massive amounts of data being generated daily, and then thinking about the systems, images, patients, and operations of hospitals, medical imaging departments, and imaging centers, it becomes clear that the US healthcare system has some data challenges. Business intelligence (BI) and data analytics firms have begun to flood the marketplace with software solutions to help mine and make use of all of the patient information, diagnostic data, lab and pathology data, clinical response data, report information, demographics, etc. If there are data fields that exist, there is a software tool available to transform them. It's this transformation that is the holy grail of data analytics. At its core, the individual data fields and all of the associated information contained in these databases mean very little. Not much can be done with them because they don't reveal anything on their own. Most providers have been collecting and storing millions and millions of patient records and all the associated data for years, but very few organizations have implemented the necessary means to transform that data into usable, actionable information. A "data warehouse" that combines the data elements from all these systems is essential to extracting usable information into real time dashboards and performance metrics.

Medical imaging is the diagnostic gateway for clinical care and patient health and has become such an integral part of the continuum of care that it can often be taken for granted how advanced the diagnostic tools have become over the past 20 years. As it relates to Big Data, think about the number of systems involved when a patient gets imaged: HIS, RIS, PACS, reconstructions, reporting, billing, EMR, CRM. Each of these systems has its own database full of data that applies to the patient, attending physician, referring physician, radiologist, procedure room, equipment, specific procedure, payor, etc. When this is applied to an insured population of about 265.3 million, this certainly qualifies as Big Data. So the question that inevitably follows is: "So what?"

Gleaning Information

Oracle, Sequel, SAS, and other database engines, are all valuable for tagging, storing, and sorting the data. They are absolutely necessary tools in the process of data creation and management behind the scenes, but they are limited in their usefulness when it comes to analytics. The solution that is needed is a true BI platform, and there are many of them

that are reasonably well suited for the task. Two of the key elements that anyone should look for in a BI or data analytics tool are: 1) The ability to seamlessly navigate across databases from any number of sources and perform analytics and computations across those platforms; and 2) The ability to mine and report on that data in real time.

The first element is fairly self-explanatory: data is needed from the scheduling system, RIS, and PACS to be compared against each other. Management needs to be able to easily measure and report on when a patient was scheduled, how long they have been in the waiting room, when the exam started, when it ended, who was the reading radiologist, when was the report dictated, and when was it signed. With all of that information on every patient coming through a department or imaging center, an empirical, data driven understanding of workflow and operations will start to take shape. Now that everything about the patient procedure is known, it also needs to be cross referenced with the RIS/PACS and billing systems to measure if the exams that were performed are consistent with the exams that are getting billed. And once they're billed, it can be checked if the facility is getting paid what the insurance payor has contracted to pay. From there, the contact management CRM system can be tied in, and the productivity of marketing staff or the financial value of certain referral sources can be measured.

Consider hospital financial systems as another example of where the intelligent mining and analysis of data can transform operations. Every day, in hospitals and healthcare systems, managers, financial VPs, and CFOs are making decisions about the performance of their employers without any real transparency into the costs associated with various services. For example, how simple is it to get an accurate report of what it costs per procedure for an MRI of the brain, or a CTA of the heart, or a PET study and the accompanying radiopharmaceuticals? There are certain individual cost items one can get hold of, but how easy is it to share cost per procedure? A facility should know how profitable its services are. By applying BI solutions across platforms to include all of the financial data for the system, all the necessary integrations, analyses, and metrics can be built that will provide accurate and factual reporting on all of the financial aspects of operations, both in medical imaging and throughout the system.

A facility can go from having millions of lines of data and no way of using it, to having clear and concise information that is specifically related to the task at hand as department managers and group administrators. There is now actionable intelligence that is evidence based and backed by all of the history contained in the database systems. Healthcare is no longer trying to run its businesses looking in the rearview mirror and, as a result, facilities have more efficient and productive staff and, if managed properly, more satisfied patients and referring physicians. And when referring physicians are satisfied, volumes can increase. This is how greater value and improved patient outcomes will be created, which are essential to demonstrate under ACO or population health reimbursement models.

Transforming data into information is not easy. But if the medical imaging industry is going to protect itself from the challenges and be proactive to meet the changes ahead, there has to be a directive to take control of and make use of the data that's already available. BI tools are the first step towards making that transformation because once a tool can "touch" and mine all of the required data elements, the extraordinarily difficult task is reduced to a much simpler series of algebraic equations. And if the equations can be appropriately defined, the BI tool can fill in the variables.

Metrics and Analytics

Metrics define an organization's behavior and performance; it should support a range of stakeholder needs from customers to shareholders to employees. Analytics is the discovery and communication of meaningful patterns in data; relies on the application of statistics, computer programming, and operations research to quantify performance.

These two terms are definitively interwoven. Without analytics, there can't be metrics. Without metrics, there is no adequate way to measure the performance of an organization or department. William Thomson, also known as Lord Kelvin, one of the premier mathematical physicists and engineers of recent time (born 1824) made this declaration on metrics:

> *"I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind."*

And more summarily, he stated:

> *"If you cannot measure it, you cannot improve it."*

While the absolutism that Lord Kelvin surmises can be debated, there is a certain truth in the second quote. If any variable within the healthcare delivery system cannot be quantifiably measured, how can that variable be improved? And yet many providers continue to operate on anecdotal and reactive responses rather than empirical proactive processes.

Analytics—meaningful patterns in data—will drive healthcare as change is navigated over the next 20 years and more: identifying meaningful patterns, understanding what they mean, communicating them, and then changing the necessary behavior to improve on the defined metrics.

Historically, medical imaging has been measured by a few different statistics. Performance is measured based on patient wait times, report turnaround times, procedure volume, revenue, staff, and radiologist productivity. Sometimes, if the ability is there, cost per procedure or revenue per procedure is measured. Occasionally, referring physician or patient surveys are used to try and measure customer

satisfaction. While each of these key performance indicators (KPIs) are important, and each of them should continue to be measured and improved upon wherever possible, they are not complete. They don't provide any cross platform comparisons. They don't offer any insight into the overall performance of the department. And perhaps the biggest shortfall—none of these KPIs has anything to do with clinical patient outcomes.

Many are unsure how quality and clinical outcomes can be tied into this data stream. But, from an enterprise perspective, it's coming. Finding an enterprise solution that includes imaging will put any organization at a significant advantage. For example, a patient presents with a specific ICD code. The primary care physician is uncertain whether to order a pulmonary exam or a CT of the lungs. What if she was able to pull up all of the patients with similar health histories and the same diagnosis and see that the CT is far more cost effective in diagnosing and treating the patient? So she orders the CT. Then the radiologist reads the images and sees something that may or may not be a nodule related to the primary diagnosis. He pulls up a search engine to look for comparable images and, in seconds, he can compare his patient's images to that of hundreds of others with the same diagnosis. He can now issue his report with far more certainty.

Now herein lies a problem—the patient leaves the facility, his primary care doctor orders a biopsy of the mass they found on the CT. How does the radiologist know whether he made the correct diagnosis or not? Currently, there is no feedback loop, but there will be. There are technology and analytics platforms available today that tie into the pathology information systems to provide accurate feedback to any of the physicians involved in the patient's care. As that feedback loop continues to get populated with more and more empirical data, the information comprised of that data becomes more and more meaningful to the treatment of the patient. The next time the radiologist is presented with a similar image, he knows that the mass is benign and the biopsy is an unnecessary expense for the patient and the system. Every patient who is entered into the provider's database, every data point related to age, health, family history, diagnosis, treatment, medications, outcomes, re-admittance, complications, and more is included in a comprehensive integration engine that can provide real time, evidence based, and outcome backed decision support around any patient that presents to the provider. Certain providers are all making use of some early adoptions of technology that allow them to use natural language processing and analyze free text streams and unstructured data contained in radiology reports. With a system that can translate free text into minable data, there are capabilities to provide real-time automated recommendations, diagnostic comparisons, and ultimately more accurate diagnostic results. These same tools can cross reference the data contained in a patient's EMR to help ensure quality and appropriateness of care based on the presenting conditions and observations of the clinicians involved in the patient's continuum of care. Now the health of the patient is being treated rather than merely trying to resolve the symptoms.

This is where healthcare BI and data analytics are headed, and medical imaging is a vital component of it. As the shift is made towards population health and value based reimbursement, the ability for the clinical decision makers to safely, accurately, and appropriately recommend the correct treatment path for patients, the more successful and sustainable the healthcare provider will be. And by having the evidence based resources to make the appropriate decision first, unnecessary spending is eliminated in a system that has very little margin with which to fund inappropriate patient care.

Data Driven Changes in Operations

Armed with a better understanding of what Big Data is, and how it applies to healthcare, the next challenge is figuring out what to do with it. Healthcare providers are notorious for being behind the curve when it comes to the acceptance, adaptation, transformation, and utilization of timely and accurate information about operations. For years, the industry has continued to utilize antiquated processes to manually create spreadsheets and reports to measure how performance last month, last quarter, or last year. Administrators spend countless hours each month getting the data they need from their systems, transforming that data into something useable, and then populating reports or spreadsheets that they have used for years.

The problem with this process is that because of how manual the data transformation is, there are definitive limits on how much data can be mined and what metrics can be created. The challenge is this—if the metrics being used cannot provide actionable information with which to govern operations, then the wrong metrics are being looked at. Instead of looking at volume for last month, look at volume, work RVUs, and allocated staff and physician resources for today. Instead of marketers looking at volume by referring physician, they should be analyzing the net revenue generated from each physician by payor. While seeing what collections look like for the trailing twelve months is nice, wouldn't it be preferable to see which exams were performed that never got billed, and which payors are short paying based on contracted rates? Now consider how useful it would be to have all of that available right now, in real time. What if BI tools were set to generate automatic notifications when certain referral sources fell below expected levels on their "loyalty index?" What if a perceived issue could be fixed with a referral source before it became a real problem?

The data and information contained in the myriad systems at any provider can be instrumental in changing workflow and processes. For example, patient wait times can be measured by recording and reporting when they check in, when they are called back in the department, and

when they are logged in for their exam—this provides the ability to alter the process as these time stamps are measured. Imagine an automated notification when wait times by modality increase beyond an acceptable limit. Perhaps even more importantly, it would allow the ability to monitor any implemented changes and determine effectiveness.

A common inefficiency in hospitals revolves around appropriate levels of staffing for imaging services. While a provider has to be able to manage sick time and peak service times, over staffing doesn't have to be an inevitable result. Instead, study the schedule, both prospectively and retrospectively, to understand what the staffing needs are. Study the employee time stamps on the RIS and match them up with the time clock. With the right BI tools, this can be done automatically, with unwavering accuracy, so staffing no longer takes place for things that might happen, but staff are being managed for what is known will happen—by the day, hour, and modality.

With all of the information that can be gleaned from the millions of bytes of data, there are certain pitfalls that exist. BI and data analytics cannot be created in a vacuum, as there is the risk of making changes that can negatively impact satisfaction, patient care, and outcomes. This is why the analytics themselves and the data transformation are so vital. The correct analytics have to be applied with the consideration of all aspects of the continuum of care that may be affected. Using the previous example of staffing, wholesale changes to the staffing model should not be made if some of the "redundant" staff are providing other services in the department that may impact patient satisfaction. In general, do not become myopic with regard to the numbers and charts that the BI tool is providing on a daily basis. The goal of a good BI solution should be to complement the people that are managing the services. Never presume to take the human element out of the management and decision making process. However, providing managers with the necessary tools and information to satisfy operational requirements can inevitably lead to a more efficient, and ultimately more cost effective, department.

It is also possible to get handcuffed by the data. Sometimes, when there is unfettered access to excessive amounts of data, it's difficult not to dice it in so many ways that results end up contradicting previous conclusions. This is where it becomes paramount to define performance indicators and metrics. If the measuring stick is established first, and all expectations are controlled accordingly, then it is much less likely to get lost in a sea of data.

Capitalizing on New Information

In order to truly capitalize on access to new information, it's important to focus not just on the elements being used to measure, but new metrics that have previously been untapped. The following is some of what could be impacted by appropriate use of BI solutions:

- Peer review and benchmarking, both internal and external
- Utilization management and appropriateness
- Productivity standards for staff and equipment utilization
- Department performance
- Financial performance including cost per procedure or modality
- External department relationships
  - Credentialing
  - Billing and collections accuracy and performance
  - Clinical findings feedback loop
  - Secondary findings follow up
  - Referring physician tracking and education
- Demonstrate medical imaging's profitability
- Radiologists' performance indicators

Through documented processes, complex data analytics, information driven changes, and accurately measured results, it becomes possible to demonstrate the true value of medical imaging in the healthcare continuum. Under fee for service (FFS) models, the value seen in medical imaging is often measured in contribution margin. How much money does medical imaging bring to the bottom line of most hospital providers? If a department is providing less than a 50% contribution margin for the provider, then there is probably good reason to investigate costs and departmental efficiencies. Medical imaging and ambulatory surgery are the two most profitable divisions for hospitals these days. What happens to that profitability when the healthcare system evolves away from the traditional FFS based healthcare? It is paramount that, as an industry and a critical piece of the diagnostic care for patients, medical imaging finds a way to demonstrate the value of the services performed. The only way to do that is through accurate metrics and critical analysis through BI and an appropriate use of Big Data.

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