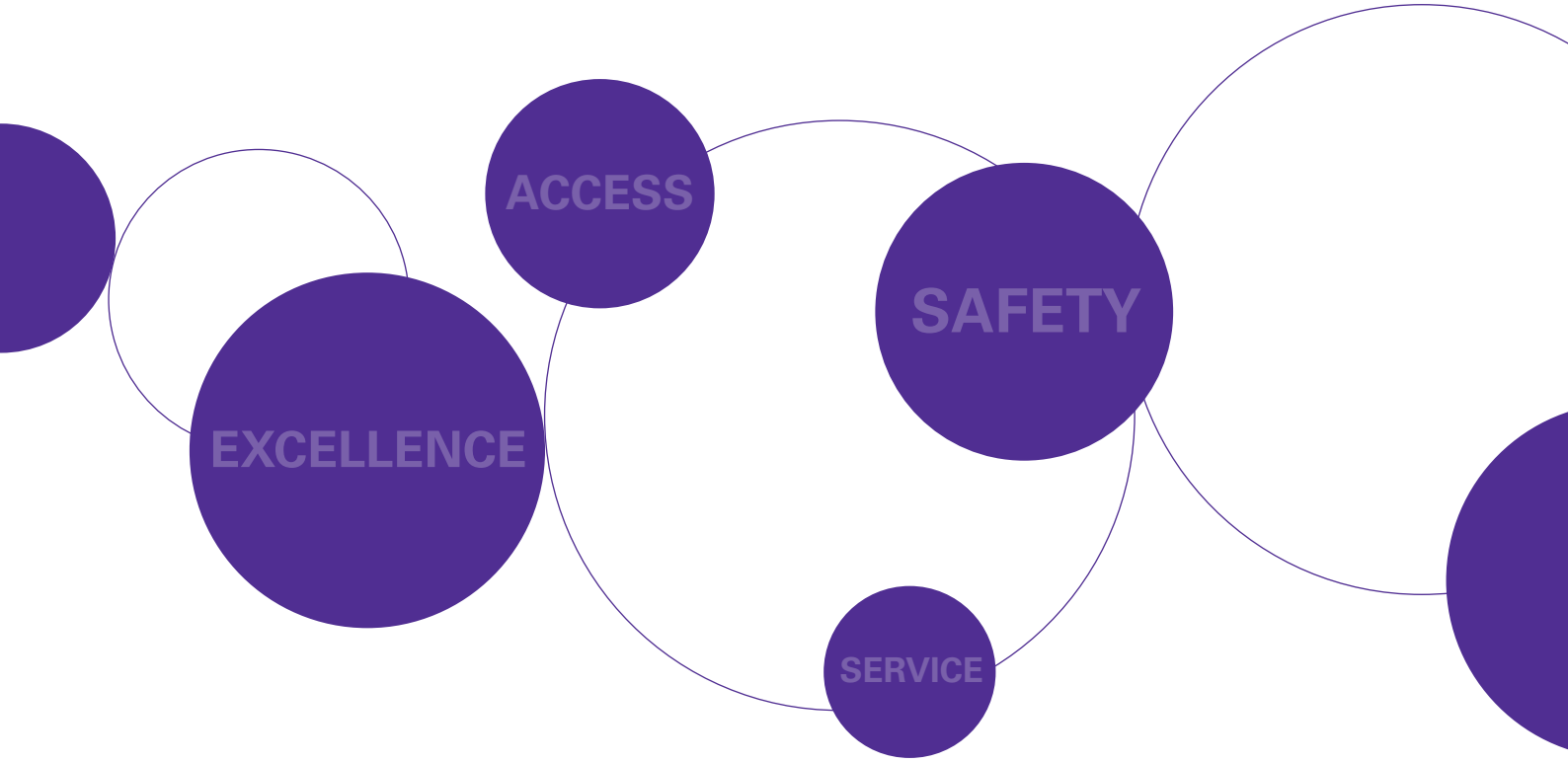
NYU Langone
MEDICAL CENTER

DEPARTMENT OF RADIOLOGY

2012 QUALITY REPORT



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A Message from the Dean and CEO

Guided by a clear vision and a series of measurable performance goals, NYU Langone Medical Center is uniquely positioned to drive its tradition of excellence into all aspects of our growth. As public interest in healthcare quality and accountability grows, we continue to define best practices by building upon our strong tradition of excellence in patient care, education and research.

With quality and safety at its core, our model of patient-centered care includes a highly focused program of process improvement along with the ongoing investment in the technology and resources necessary to sustain success.

Radiologic imaging plays an essential role in supporting all of the medical and surgical specialties at NYU Langone and throughout the community. It provides critical information and helps inform the key medical decisions made every day.

NYU Langone's Department of Radiology is passionately committed to this broad scope of responsibility. In the pages of this report, you will see evidence of their commitment to quality along with concrete examples of the progress we are making. I think you'll be impressed by the steps that have been taken to understand and address the level of excellence required in the areas of quality, safety and service, not only from the perspective of our patients, but from those of our physicians, students, and other key stakeholders as well.

As a radiologist myself and former chair of the Department of Radiology, I am particularly proud of the work of the department under Chair Michael P. Recht, MD, The Louis Marx Professor of Radiology, and am pleased to present you with the Department of Radiology 2012 Quality Report.

ROBERT I. GROSSMAN, MD
The Saul J. Farber Dean and Chief Executive Officer
NYU Langone Medical Center

A Message from the Chair

Over the past several years, innovative imaging modalities have been developed, including multichannel computed tomography (CT), high-field multichannel magnetic resonance (MR), positron emission tomography-CT (PET-CT) and most recently, PET-MR and minimally invasive imaging-guided interventional procedures. These new modalities have had significant impact on medical practices and have allowed physicians to more accurately and rapidly diagnose and treat pathology.

Not surprisingly, they have also led to rapid growth in the volume of imaging procedures performed. This has had a significant effect on health care spending, and has also led to concerns regarding patient's radiation exposure. It is imperative that radiologists and radiology departments take steps to ensure that medical imaging is performed appropriately, with the least amount of radiation necessary, and with maximum positive impact on patients' clinical outcomes.

Over the past year, the Department of Radiology at NYU Langone Medical Center has embarked on several initiatives to ensure that our department will play a leading role in this effort. Moreover, we have implemented several new programs to make patients' visits and stays in our department as quick, pleasant and safe as possible. This effort has been led by Danny C. Kim, MD, our director of quality and patient safety; Jill E. Jacobs, MD, FACR, our associate director of quality and patient safety; and Kirk Lawson, MBA, our administrative director of radiology. A task of this importance and magnitude, however, requires widespread involvement and investment by the entire department in order to be successful, and I am pleased that this has happened in radiology. Staff from all areas of our team—technologists, receptionists, nurses, physician assistants, ombudsmen, residents, fellows, basic scientists and faculty radiologists—have all contributed significantly to our effort. In the following pages, several of our initiatives and their results on our performance will be presented. I am proud of the progress we have made in the past year and can assure everyone that our entire department is committed to continuing to be a national leader in this effort.

MICHAEL P. RECHT, MD
The Louis Marx Professor of Radiology
Chair of the Department of Radiology

Welcome to the Department of Radiology 2012 Quality Report.

1

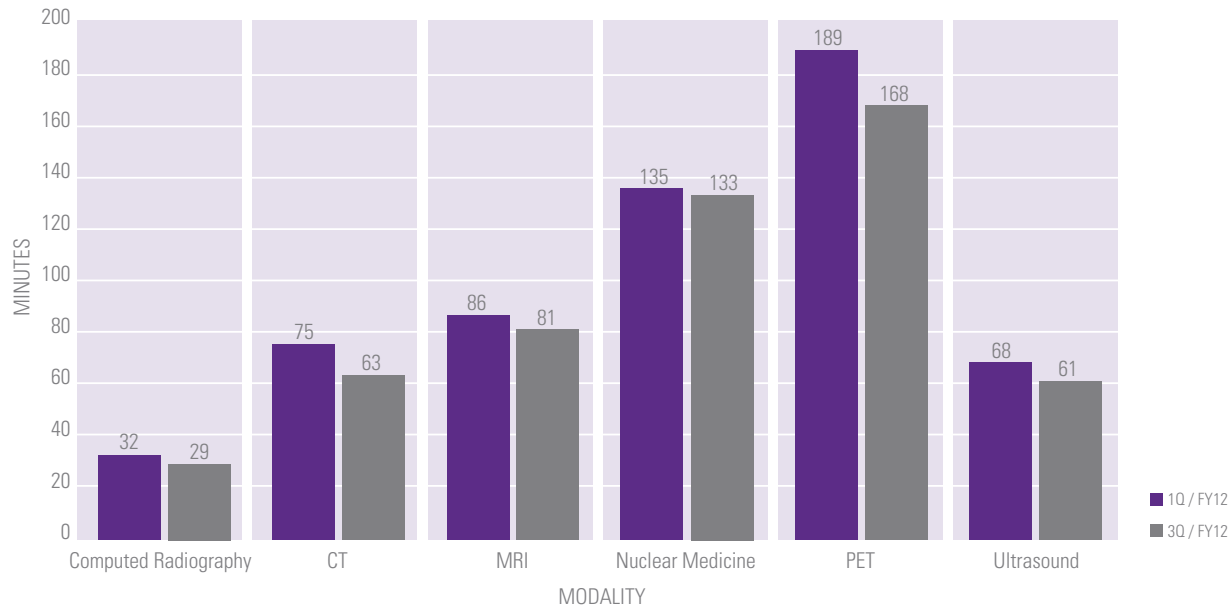
Departmental Performance Measures

Departmental Performance Measures

Recognizing the importance of time to patients and physicians, we're making progress in reducing the amount of time patients need to spend in our department.

Average Time Spent by Patients in the Department is defined as the time duration between the patient arrival time and the "end procedure" time stamp entered by the technologist.

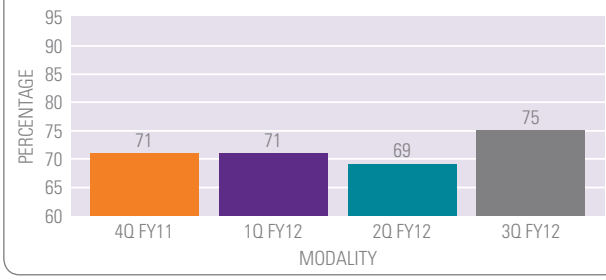
Average Time Spent by Patients in Our Department by Modality



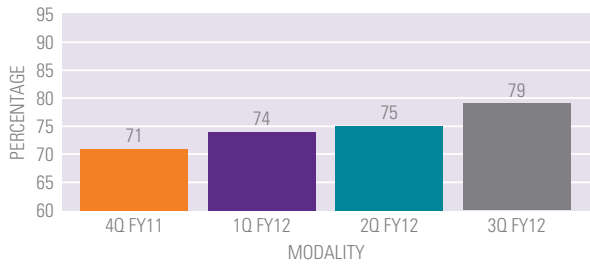
Simultaneously, our on-time performance record continues to improve.

On-Time Performance is defined as the percentage of cases starting within 30 minutes of the appointment time.

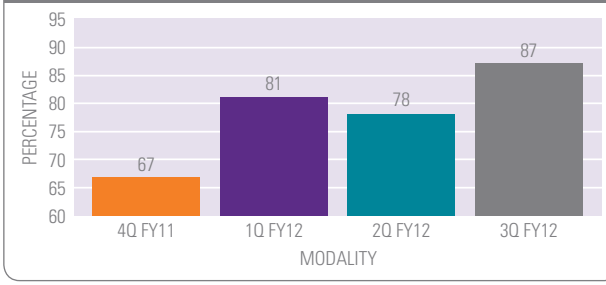
On-Time Performance: Outpatient CT



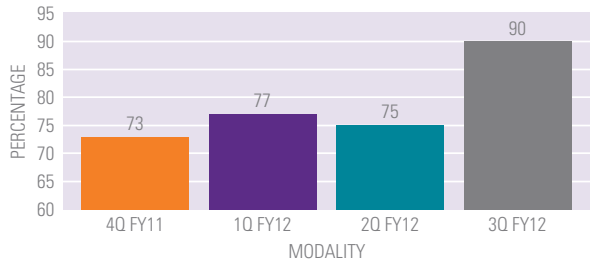
On-Time Performance: Outpatient MRI



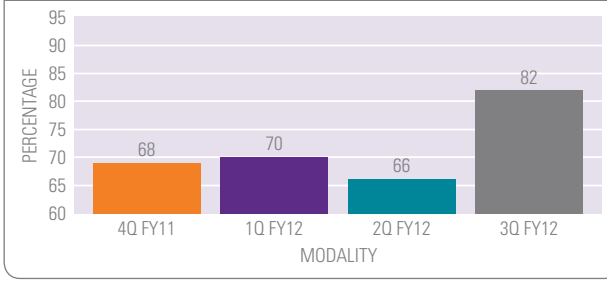
On-Time Performance: Clinical Cancer Center MRI



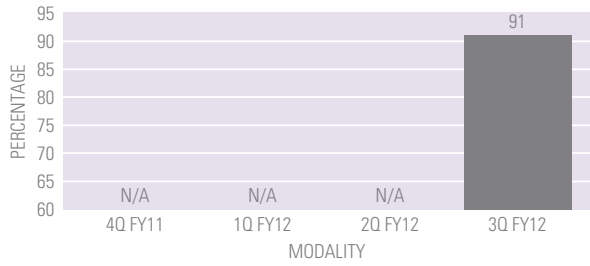
On-Time Performance: Outpatient Ultrasound



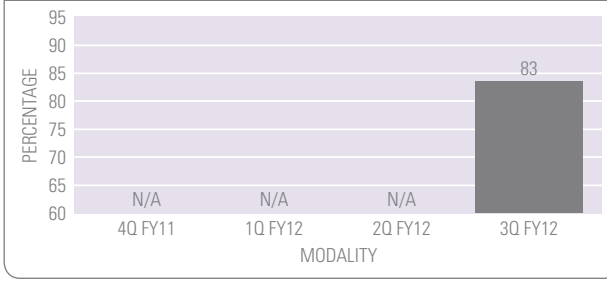
On-Time Performance: Screening Mammography



On-Time Performance: CMC* MRI



On-Time Performance: Outpatient PET

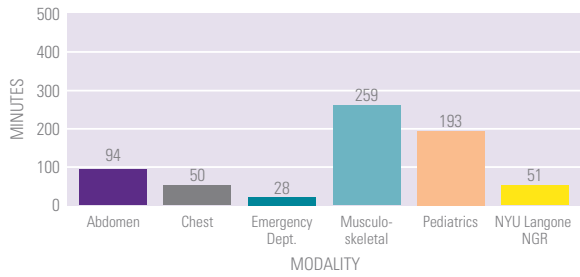


*Center for Musculoskeletal Care

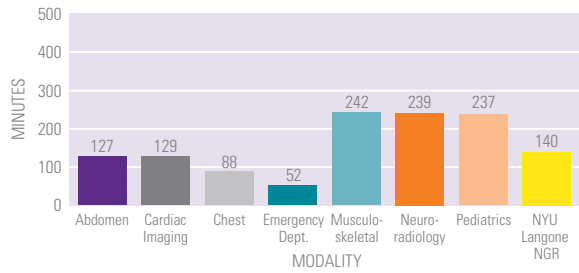
Our commitment to reducing turnaround time continues across all modalities and sites.

The definition of Average Turnaround Time is defined as the time duration between the "end procedure" time stamp entered by the technologist and the time when the report is signed by the attending radiologist. Graphs below are based on 3rd quarter FY 2012 data.

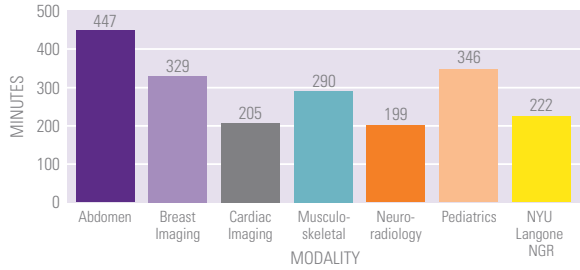
X-ray



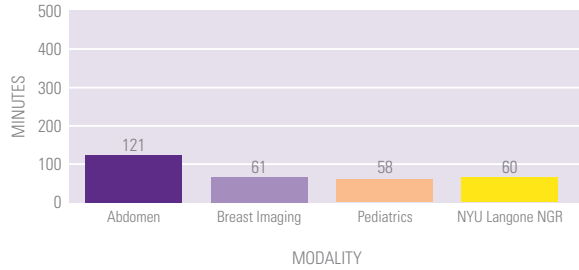
CT



MRI



Ultrasound



2

Radiation Dose Optimization Program

Radiation Dose Optimization Program

The safe use of radiation in imaging examinations is one of the most important challenges confronting the Department of Radiology. CT examinations account for nearly 70% of the radiation exposure delivered by our department. While the information gained from CT examinations contributes greatly to patient care, we must acknowledge the small risk of deleterious effects, including the risk of developing cancer. To date, the risk of developing cancer from small doses of radiation delivered in typical imaging examinations remains uncertain. Although controversial, currently accepted risk estimates derive primarily from extrapolations based upon surveillance of the atomic bomb survivors in Japan. While these risks are rather small compared to the population's baseline risk of developing cancer, the increasing use of CT examinations and the multiplicity of use in many patients warrant the careful use of radiation for the individual patient and the entire patient population.

A Commitment to Safety

Our department adheres to the principle of ALARA (as low as reasonably achievable) when performing CT examinations. This principle includes two major components: justification and optimization. First, the examination must be medically indicated. Second, the examination must be performed with radiation dose as low as reasonably achievable for the diagnostic task. Our department is taking steps to be fully accountable for appropriate CT radiation usage by creating a CT Radiation Dose Optimization Program. We will formally address other imaging modalities soon. Our department has affirmed our efforts to optimize radiation dosage in imaging pediatric and adult patients by pledging to the Image Gently® and Image Wisely® public campaigns.

Standardizing Protocols

In our department, the first step in our CT Radiation Dose Optimization Program was standardization of the imaging protocols used to scan patients for specific clinical indications. For example, a CT scan for hematuria is performed in the same manner no matter which radiologist is performing and interpreting the examination or where in the medical center it is performed. A departmental CT protocol committee meets regularly to ensure that imaging protocols are up-to-date with the standard of care, and to ensure that they incorporate the latest technological advancements from the equipment vendors to optimize our examinations.

Reducing Variation

The second step in our CT Radiation Dose Optimization Program was to standardize the radiation dose exposure for all the departmental CT scanners for each protocol. The department installed a database to collect CT radiation dose indices from our CT scanners for each protocol. These data were analyzed to ensure that the radiation dose exposure was similar across our CT scanners and imaging protocols. Through this evaluation, as an example, we found that the average radiation dose index, Computed Tomography Dosage Index (CTDI) (vol), for a CT scan of the sinuses was higher on two of our scanners compared to the third from 5/1/2011 to 9/1/2011 **(Figure 1)**.

After confirming that the CT scanner with the lower dose index was producing diagnostic-quality examinations, we compared the scanner parameters and found the settings to be unnecessarily higher on the first two scanners. When we adjusted the parameters to similar levels as the third scanner, we achieved an approximately 40% decrease in radiation dose on the first two scanners without sacrificing diagnostic quality. Since that change, the radiation dose indices have been similar across the three scanners from 10/1/2011 to 5/1/2012 **(Figure 2)**.

Figure 3 below demonstrates our efforts in the standardization of CT radiation dose indices for four of our most common CT examinations performed in our department on our five CT scanners for the first half of the calendar year 2012. Small differences in the mean dose indices may be secondary to multiple factors. In addition to patient body habitus, scanner parameters and hardware and software differences are important factors. We are continually analyzing the data to ensure that our scanner settings are optimized to achieve diagnostic quality images and deliver similar radiation dose.

Figure 1. Average CTDI (vol) 5/1/2011 to 9/1/2011 Baseline

SCANNER 1	SCANNER 2	SCANNER 3
16.3 (n=118)	16.0 (n=118)	11.5 (n=44)

Figure 2. Average CTDI (vol) 10/1/2011 to 5/1/2012 Post-Optimization

SCANNER 1	SCANNER 2	SCANNER 3
10.3 (n=182)	9.9 (n=176)	9.0 (n=135)

Figure 3. CTDI (vol) 2012 Comparison

	SCANNER A		SCANNER B		SCANNER C		SCANNER D		SCANNER E	
MEASURE	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD
Brain Non-Contrast	57.49	5.63	62.92	0.08	59.40	0.15	61.94	1.94	62.67	2.91
Chest Non-Contrast	11.28	3.94	10.37	4.44	8.83	4.12	10.58	3.86	11.72	3.26
Oncology	15.89	4.42	13.50	4.91	11.35	4.28	12.85	5.87	16.04	5.14
Sinus	9.45	1.55	8.99	1.15	8.80	1.32	—	—	—	—

Benchmarking Our Data

The third step in our CT Radiation Dose Optimization Program was to submit our CT dose indices into a national database, the American College of Radiology's Dose Index Registry, to compare our departmental dose indices against national benchmarks. Thus far, we have received some preliminary reports but await more comprehensive information from this program. These results will allow us to compare our radiation dose indices to benchmarks and help us to identify examinations that potentially may be performed with lower radiation doses.

Reducing Exposure

The fourth step in our CT Radiation Dose Optimization Program is to identify opportunities to reduce radiation dose without compromising diagnostic capability. Our clinical sections that utilize CT have already been investigating numerous opportunities to reduce radiation dose.

One of our noteworthy accomplishments has been a collaborative effort with the Institute of Reconstructive Plastic Surgery to reduce radiation exposure in pediatric patients, who are the most susceptible to the potential deleterious effects of radiation. Their evaluation of patients with craniosynostosis necessitates performing a CT scan to determine their therapeutic strategy. We realized that low-dose scout exams performed during other neurological examinations produced good quality images of the skull. We therefore consulted with our colleagues to determine if these low-dose images would be satisfactory for their evaluations. **Figure 4** shows a skull image comparison of a previous CT scan versus the new low-dose CT scan. After getting their approval, we adopted this lower dose CT scan for these pediatric patients, enabling a reduction in radiation exposure by 60% without compromising diagnostic image quality (**Figure 5**).

Figure 4. High-dose CT skull image on the left and low-dose CT skull image on the right.

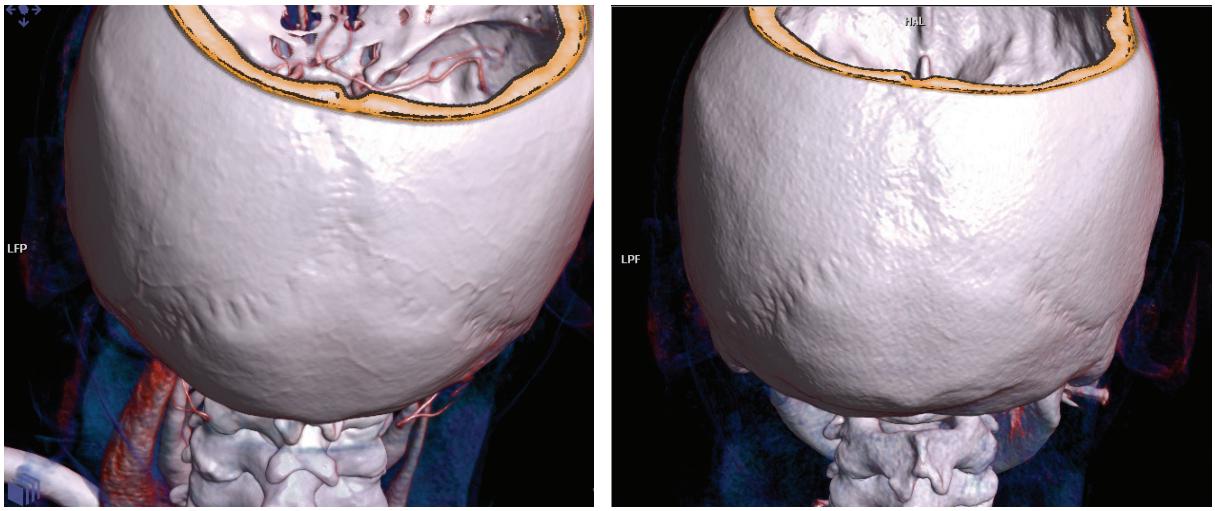
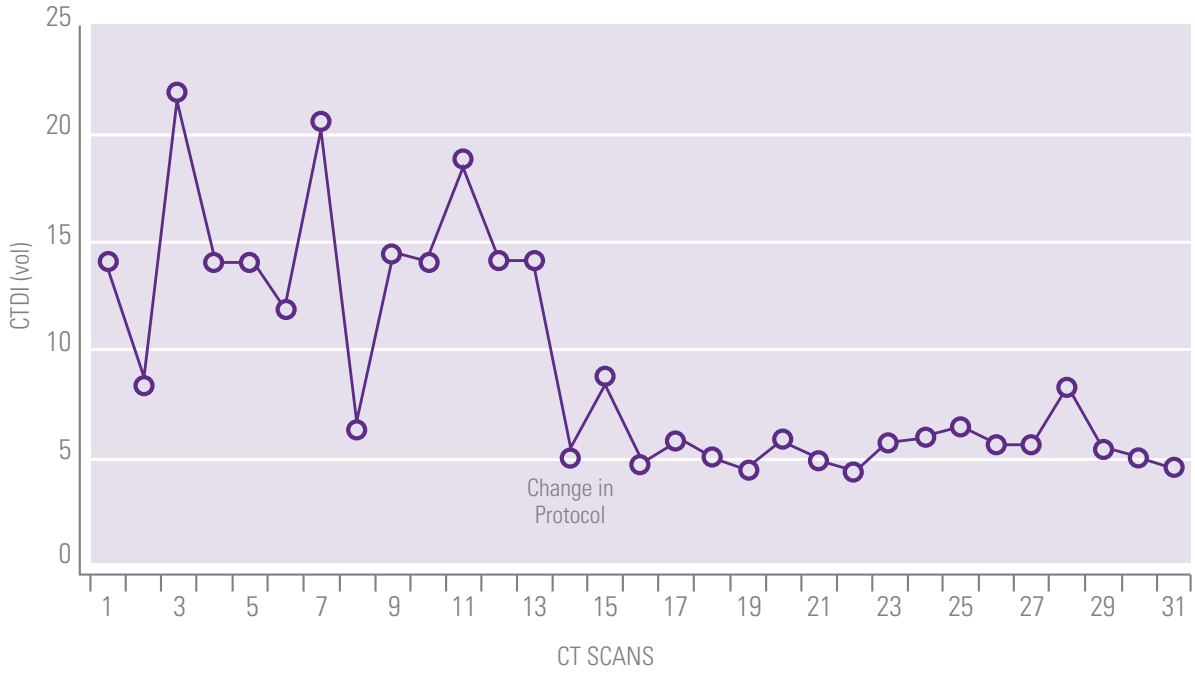


Figure 5. This graph shows the CT radiation dose index, CTDI (vol), for our last 31 CT scans performed for craniosynostosis:



Using a similar methodology, we have been able to reduce radiation dose for lumbar spine CT scans. We realized that low-dose CT scans of the abdomen and pelvis produced good quality images of the lumbar spine. Our musculoskeletal radiologists reviewed these images and found the image quality sufficient for making a diagnosis. Since then, we have implemented this low-dose lumbar spine CT scan protocol.

Increasing Collaboration

Our department also works closely with our equipment vendors to employ the latest hardware and software advancements that enable us to further optimize radiation dosage without compromising image quality. Several new products are currently being incorporated into our routine clinical practice and are described later. Beyond optimizing CT scanning protocols and incorporating new technology, we are collaborating with our referring clinicians to perform only clinically indicated examinations, with the assistance of established imaging guidelines published by the American College of Radiology known as the Appropriateness Criteria®. We also collaborate with our referring clinicians to identify opportunities to utilize non-radiation imaging examinations, such as ultrasound and MRI, to answer the clinical question. This close collaboration between the clinical departments and our department will be vital to achieving the goals of performing high-quality diagnostic imaging while utilizing the lowest radiation dose to aid clinical diagnosis.

DANNY C. KIM, MD
Assistant Professor
Director of Quality and Safety

Our department adheres to the principle of ALARA (as low as reasonably achievable) when performing CT examinations.

3

Quality Improvement Committee Projects

Quality Improvement Committee Projects

One of the key components of healthcare delivery is diligent monitoring and assessment of patient care, safety and adverse outcomes. The radiology department at NYU Langone Medical Center has demonstrated its high level of commitment to this process by creating the Quality and Patient Safety Program. The two main facets of this program are committees charged with quality improvement and those charged with patient safety.

Subcommittees of the quality improvement component include the Quality Improvement Committee, whose charge is the development and measurement of initiatives addressing standardization of patient care, performance outcomes, and outcomes management; the Outcomes Management Committee, whose duty is continual assessment and analysis of radiology reporting outcomes; and the Best-In-Practice Committee, whose concern is modality-based education of scanning techniques and safety policies for physicians, nursing personnel and technologists.

Subcommittees of the safety component include the Patient Safety and Policy (PSP) Committee, charged with continual monitoring and analysis of procedural complications and adverse outcomes, as well as the establishment of policies ensuring continued patient safety and decreased patient risk. Subdivisions of this committee include the MRI Safety Committee, responsible for developing and monitoring MRI safety policies, and the Contrast Safety Committee, charged with the development and monitoring of policies to ensure standardized, safe delivery of intravenous and oral contrast media. Toward this end, an additional subcommittee of the PSP Committee is the Simulation Training in Patient Safety and Contrast Reaction (SIMS) Committee, responsible for training physicians and technologists to accurately recognize and optimally treat contrast reactions.

As the exposure of the United States population to medical radiation continues to rise, another key component of the PSP committee is the Radiation Monitoring Committee. This committee focuses on the continued analysis, standardization and optimized reduction of radiation dose delivery for all of the patients served by our department.

Improvement of patient safety, decreasing patient risk and adverse outcomes, and lowering radiation dose are of paramount importance to all of the NYU Langone radiologists. We hope the work of these Quality and Patient Safety Programs demonstrate our commitment to the physicians and patients we serve.

Following are some of our ongoing quality initiative and outcomes projects.

JILL E. JACOBS, MD, FACR
Professor
Associate Director of Quality and Safety

Quality Improvement and Measuring Outcomes: Radiologic-Pathologic Correlation in Acute Appendicitis

Problem:
No standardized model exists that completely and accurately measures performance, accuracy and outcomes of radiologic diagnoses.

Project goal:
Evaluate accuracy of radiologic diagnosis of acute appendicitis using radiologic and pathologic correlation with a long-term goal to establish a standardized, reproducible model to measure performance and outcomes of various radiologic diagnoses in real time.

Team members and roles:
- Martin Kopec, MD–Radiology Resident, Quality Improvement Committee member
- Courtney Cunningham–MSIV, NYU School of Medicine
- Danny C. Kim, MD–Director of Quality and Safety

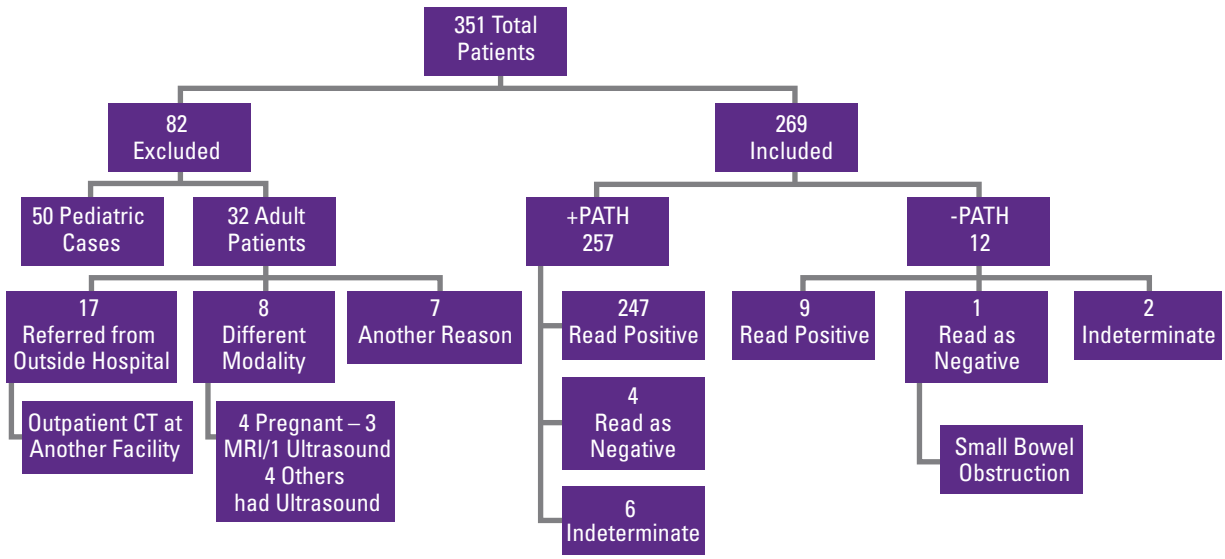
Methods/Interventions:
- Data collected on 351 adult patients, of which "appendix" was primary submitted specimen to pathology from 1/1/2011 to 12/31/2011.
- Primary data points: pathology specimen designated as positive or negative and CT report impression designated as positive, negative or indeterminate.
- Secondary data points: patient demographics and associated findings reported on pathology and CT reports.

Progress to date:
The positive predictive value of the CT diagnosis of appendicitis is 96%.

Lessons learned:
- Creating a system to perform follow-up on all patients imaged for suspected appendicitis is difficult.
- Using a single variable for evaluating true performance is incomplete.

Next steps:
Refine data collection process.

Patient Outcomes



Standardization of Radiology Reports from NYU Langone Musculoskeletal Imaging Specialty

Problem:
Every radiologist in the Department of Radiology's Musculoskeletal (MSK) Imaging Specialty generates a uniquely styled, dictated report for MRI examinations. Regardless of which radiologist is producing the report, the report provided to the referring clinician should be similar.

Project goal:
Standardize the radiology report delivered from NYU Langone MSK Imaging Specialty.

Team members and roles:
- Luis S. Beltran, MD–Project Leader
- Danny C. Kim, MD–Director of Quality and Safety

Interventions:
- Survey NYU Langone Medical Center MSK referring clinicians to collect and analyze information about the desired structure of MRI radiology reports.
- Create MRI report templates for individual body parts based on survey results to deliver similarly dictated reports for every radiologist.
- Resurvey NYU Langone Medical Center MSK referring clinicians to collect and analyze information about their satisfaction with the standardized MRI radiology reports.
- Readjust MRI report templates as needed based on survey results to achieve optimized standardized reporting for our referring clinicians.

7. Which of the following do you prefer?

	Response Percent	Response Count
Standardized radiology reports for all modalities including MRI, CT, radiographs, ultrasound, etc.	71.4%	20
Standardized radiology reports only for cross-sectional modalities (MRI, CT)	10.7%	3
Non-standardized radiology reports for all modalities (i.e., let the radiologist decide what he/she wants to describe in the report)	17.9%	5

Progress to date:
The answers from the NYU Langone Medical Center referring clinicians for one of the most significant questions asked in the initial survey are displayed in the chart.

Lessons learned:
The majority of the NYU Langone Medical Center referring clinicians sampled in the survey prefer standardized reports.

Next steps:
- Implement standardized reports in clinical practice.
- Resurvey referring clinicians.
- Readjust report templates based on survey results as needed.

Referring Physician Survey (January 2012)

1. In which division/subspecialty do you work?		
	Response Percent	Response Count
Orthopaedics	69.0%	20
Rheumatology	17.2%	5
Rehabilitation	6.9%	2
Other (please specify)	6.9%	2
2. Which of the following best describes what you prefer to read in the "Findings" section of the radiology report?		
List everything, including pertinent and non-pertinent positive and negative findings	69.0%	20
List only pertinent positive and negative findings	24.1%	7
List only pertinent and non-pertinent positive findings	6.9%	2
List only pertinent positive findings	0%	0
3. Which of the following best describes what you prefer to read in the "Impression" section of the radiology report?		
List everything, including pertinent and non-pertinent positive and negative findings	10.7%	3
List only pertinent positive and negative findings	53.6%	15
List only pertinent and non-pertinent positive findings	10.7%	3
List only pertinent positive findings	25.0%	7
4. Which of the following is the most important to you when reading the radiology report?		
Attention to all details, including those that do and do not affect treatment decisions	62.1%	18
Attention only to details that affect treatment decisions	37.9%	11
5. Which of the following examples of a hypothetical text describing a normal meniscus on MRI would you prefer in the "Findings" section of the radiology report?		
Menisci: within normal limits	27.6%	8
Menisci: no evidence of tear or degenerative change	31.0%	9
Menisci: no evidence of tear, degenerative change, extrusion, or parameniscal cyst	41.4%	12
6. In which of the following methods do you prefer the "Findings" section of the radiology report to be structured?		
By compartment (e.g., Medial compartment of the knee: within normal limits)	60.7%	17
By tissue type (e.g., Cartilage: within normal limits)	21.4%	6
Free text (i.e., no specific structure)	17.9%	5
7. Which of the following do you prefer?		
Standardized radiology reports for all modalities, including MRI, CT, radiographs, ultrasound, etc.	71.4%	20
Standardized radiology reports only for cross-sectional modalities (MRI, CT)	10.7%	3
Non-standardized radiology reports for all modalities (i.e., let the radiologist decide what he/she wants to describe in the report)	17.9%	5
8. Would you like to be a representative of your division or group practice in a multidisciplinary committee designed to create standardized radiology reports?		
Yes (please e-mail luis.beltran@NYUMC.org if you are interested)	14.3%	4
No, thank you	85.7%	24

Evaluation of Ultrasound for the Diagnosis of Appendicitis in Children

Background:
CT is the gold standard for imaging of appendicitis in adults. However, in children, due to the concerns and risks of ionizing radiation, first-line imaging at our institution begins with an ultrasound, reserving CT for inconclusive cases. This imaging strategy adheres to the As Low As Reasonably Achievable (ALARA) principle and the American College of Radiology (ACR) recommendation for imaging of appendicitis in children.

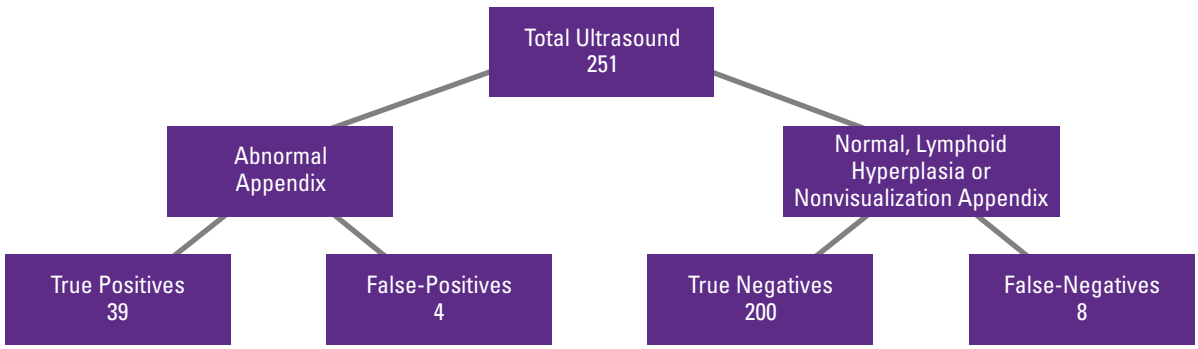
Project Goal:
To assess the diagnostic accuracy of ultrasound for appendicitis in children and to identify the limitations of this modality at our institution.

Team members:
- Shailee V. Lala, MD–Assistant Professor
- Lynne P. Pinkney, MD–Assistant Professor
- Nancy R. Fefferman, MD–Assistant Professor, Section Chief Pediatric Radiology

Methods:
We performed a retrospective review of ultrasounds performed by a sonographer and a pediatric radiologist during daytime hours for acute abdominal pain in patients from ages 1-17 (1/2010-4/2012). A total of 251 cases were reviewed. Ultrasound diagnosis, and if performed, a CT diagnosis, was recorded. Surgical pathology and patient disposition were also noted. Pathology was used as our reference standard for a positive diagnosis. Patients with a nonvisualized or normal appendix on ultrasound, and who were also discharged, were used as our negative reference standard.

Results:
Patient outcomes are outlined below.

Patient Outcomes



Discussion:
Of the 251 cases scanned for acute appendicitis, 47 cases were positive for appendicitis. Forty-six cases were pathologically proven to be appendicitis. One case went on to CT, showing perforated appendicitis with abscess, which was drained. This patient was lost to follow-up. At our institution, the sensitivity and specificity of ultrasound for the diagnosis of appendicitis was found to be 83% and 98% **(Table 1)**, respectively. The literature reports a range of sensitivities and specificities, with a recent meta-analysis quoting a sensitivity and specificity of 88% and 94%, respectively.[1]

Eight false-negative ultrasound cases were identified; eight out of eight false-negative cases went on to CT. Of these:

- Two were retrocecal appendices
- One appendix was located deep in the pelvis, posterior to the uterus
- One patient was morbidly obese

Of the 251 patients scanned for acute appendicitis, 30 (12%) went on to CT. Of the 10 patients who had CT scans positive for acute appendicitis, two were correctly diagnosed on ultrasound as perforated appendicitis, and CT was performed for abscess characterization. The remaining eight CT scans were performed in our false-negative cohort **(Table 2)**.

Practice modifications:
A known pitfall of ultrasound is the presence of a retrocecal appendix, which can be difficult to visualize. When the appendix is not visualized anterior to the psoas, we will attempt to scan posterolaterally to attempt to identify a retrocecal appendix. Utilization of lower frequency transducers may improve visualization of an abnormal appendix, which may be located deep in the pelvis or in another atypical location. Patient obesity remains a challenge and limitation of this imaging modality. We still attempt to diagnose appendicitis in these patients, accepting a lower sensitivity given that this modality presents no risk to the patient, and reserving CT or MRI for those patients with an equivocal or nondiagnostic ultrasound.

Table 1. Ultrasound Performance

Sensitivity	83%
Specificity	98%
PPV	91%
NPV	96%
Accuracy	95%

Table 2. CT Scans Performed

Normal	13
Positive	10 (acute and perforated)
Alternative Diagnosis	6*
Equivocal	1 (admitted for observation and discharged)

[1] Doria AS, Moineddin R, Kellenberger CJ, et al. US or CT for Diagnosis of Appendicitis in Children and Adults? A Meta-Analysis. *Radiology.* 2006 Oct;241(1):83-94.

**Mesenteric adenitis, UTI, pancreatitis, epiploic appendagitis, pneumonia, and perforated Meckel's diverticulum.*

Radiology Patient Safety Interdisciplinary Seminars

Background:
There has been increasing emphasis on patient safety in radiology. Many times, the audience for patient safety education is composed of radiologists—not the clinicians who order the exams.

Project goal:
Giving a seminar to emergency medicine (EM) physicians regarding radiology patient safety.

Team members and roles:
- Nathaniel Evin Margolis, MD–Radiology Chief Resident
- Mark P. Bernstein, MD–Emergency Radiology Attending

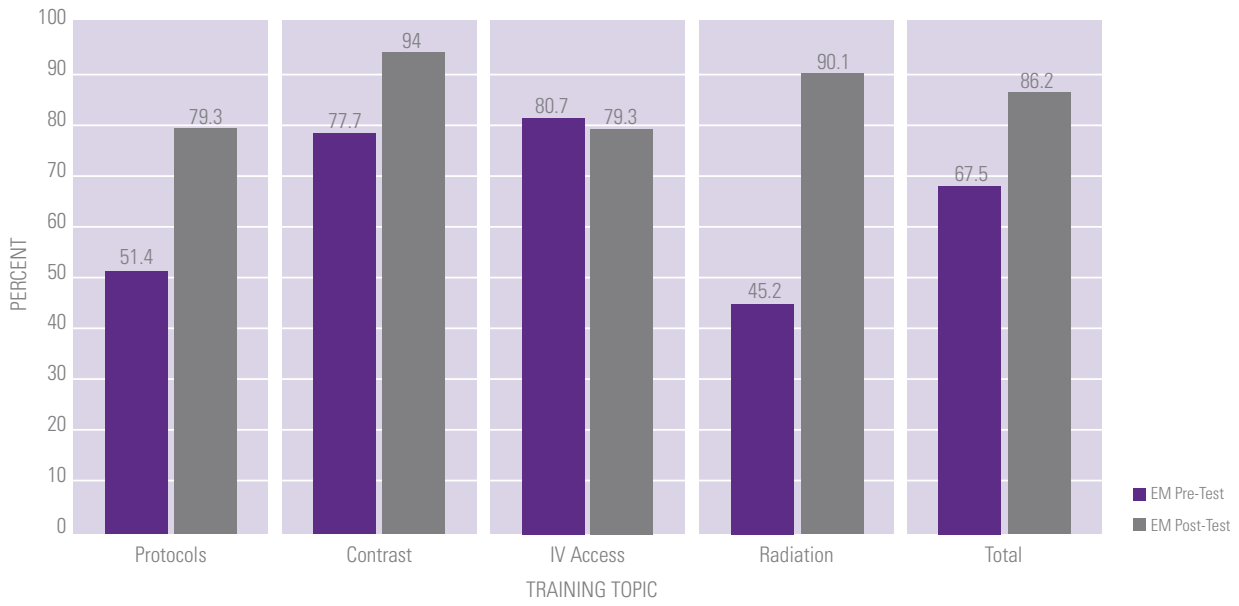
Interventions:
- A patient safety seminar was developed with sections on appropriate imaging protocols, IV contrast safety, IV access required for contrast administration, and radiation dose.
- Radiologists gave the seminars to EM physicians of all levels of training, including faculty (n=28), medical students (n=19), and first-year radiology residents (n=9).
- Pre- and post-tests were distributed before and after the seminars.

Progress to date:
There was marked improvement in four out of five scores for all three groups: EM physicians (+18.7%, $p<0.0001$), medical students (+34.2%, $p<0.0001$), and first-year radiology residents (+21.7%, $p<0.0001$).

Lessons learned:
Interdisciplinary seminars are an effective way to educate referring clinicians about radiology patient safety.

Next steps:
Give radiology patient safety seminars biannually, using pre- and post-tests as a continuous quality improvement project.

EM Test Scores



Recommendations for Additional Imaging on Emergency Department (ED) CT Examinations

Problem:
Previous studies have observed a high frequency of recommendations for additional imaging (RAI) on ED CT examinations, which in turn has been identified as a source of increased healthcare costs. Therefore, awareness of factors associated with RAI in the ED setting is warranted. Follow-up for many RAI studies requires specialized prep, which is often better suited to an outpatient setting rather than within the ED.

Project goal:
To compare patterns of RAI within the ED setting between ED-based and organ-based subspecialty radiologists.

Team members and roles:
- Andrew B. Rosenkrantz, MD–Assistant Professor of Radiology
- John M. McMenamy, MD–Assistant Professor of Radiology
- Mark Foran, MD, MPH–Assistant Professor of Emergency Medicine
- Brent Matza, MD–Research Assistant

Steps:
- Identified 100 consecutive ED CT studies performed in six different categories:
  - Brain, chest and abdominal CT studies, interpreted by both ED-based and organ-based radiologists.
- Identified frequency of RAI in all categories.
- Tabulated RAI in each category in terms of specific imaging findings, leading to the recommendation.

Findings:
- The frequency of RAI was 21.5%, 13.5% and 5.5% for CT examinations of the chest, abdomen and brain, respectively.
- There was a significantly higher frequency of RAI for chest CT studies interpreted by chest radiologists than by ED radiologists (28.0% vs. 15.0%, respectively), largely due to a higher rate of RAI for incidentally detected lung nodules and masses, as well as other pulmonary parenchymal abnormalities by chest radiologists.
- Although there was no significant difference in RAI on brain or abdominal CT studies between ED-based and organ-based radiologists, only ED-based radiologists provided RAI on abdominal CT studies for abnormalities related to the bowel or uterus.
- Three most common subspecialty areas of RAI include lung nodule or mass, other pulmonary parenchymal abnormality and bowel-related abnormality.

Future work:
- Compare RAI with available practice guidelines.
- Assess outcomes of follow-up imaging actually performed.
- Assess impact of RAI on overall costs.

RAI Frequency

	Overall	ED-based Radiologist	Organ-based Radiologist	P
Chest	21.5% (43/200)	15.0% (15/100)	28.0% (28/100)	0.036
Abdomen	13.5% (27/200)	16.0% (16/100)	11.0% (11/100)	0.426
Brain	5.5% (11/200)	6.0% (6/100)	5.0% (5/100)	1.0

Monitoring Image Quality

Problem:
Image quality issues are reported in several different ways, hindering identification of systemic issues and the implementation of appropriate solutions.

Project goal:
To create a comprehensive system to monitor image quality issues and identify areas for quality improvement.

Team members and roles:
- Thomas P. Mulholland, RT–Training and Applications Specialist
- Joseph J. Sanger, MD–Faculty Practice Radiology
- David Chen–MRI Manager
- Jeanique M. Pierre, MPH–MRI Evening Supervisor
- Tom P. Callahan–MRI Day Supervisor
- Danny C. Kim, MD–Director of Quality and Safety

Interventions:
- Created a team to monitor image quality issues and perform quality improvement initiatives.
- Created a single online tool for radiologists to enter specific image quality issues (tickets), as they occur.
- Created an electronic database to analyze the compilation of image quality issues.

Progress to date:
A unified system of entering and monitoring image quality issues has been created within the radiology informatics architecture. Thus far, image quality issues in MRI are being systematically monitored and analyzed.

Lessons learned:
A unified system to monitor image quality is vital to the identification of areas for quality improvement initiatives that attempt to improve the overall image quality in our department.

Next steps:
- Encourage consistent use of this system to identify image quality issues that occur in our department.
- Systematically monitor and analyze image quality issues in other imaging modalities, such as X-rays and CT scans.
- Provide progress reports on the results of specific quality improvement initiatives to the entire department.

Quality Problem Reporting Categories

Problems:

MRI-Specific
- ☐ Deviation from Protocol
- ☐ Post-Processing Error
- ☐ Incomplete Exam
- ☐ Poor Image Quality
- ☐ PACS Issue
- ☐ Insufficient Visualization of Contrast
- ☐ Insufficient Anatomic Coverage

CT Examination Contrast Extravasation Reporting

Problem:
Contrast extravasation (CE) is a potential complication of intravenous injections for CT examinations. Although extravasation is uncommon, accurate documentation of its occurrence in the radiology report is of paramount importance.

Project goal:
To assess the CE reporting rate in dictated radiology examinations, and to initiate process improvement strategies to achieve 100% reporting compliance.

Team members and roles:
- Jill E. Jacobs, MD, FACR–Associate Director of Quality and Safety
- Danny C. Kim, MD–Director of Quality and Safety

Interventions:
- Create a standardized location in the Primordial and EPIC technologist notes for documentation of an extravasation event.
- Create a reporting template in Primordial and EPIC to ensure standardized and complete extravasation data documentation by the technologist.
- Educate the technologists and radiologists about the importance of accurate documentation and reporting of all CEs.

Progress to date:
The contrast extravasation reporting rates for 2010-2011 have been evaluated (see table below).

Lessons learned:
CE reporting rates are currently suboptimal. Process improvement strategies need to be initiated to ensure 100% reporting compliance.

Next steps:
- Implement process improvement strategies.
- Monitor radiologists' dictated reports to reassess contrast extravasation reporting rates following initiation of the process improvement strategies.
- Radiology Patient Safety and Policy Committee approval of departmental policy for the recognition, evaluation and treatment of IV contrast extravasation and outpatient discharge information sheet.
- Collect data utilizing updated, detailed CT IV contrast extravasation incident report.

Extravasation Reporting

	2010	2011	Total
# Contrast Extravasations	11	23	34
# Unreported Contrast Extravasations	6	14	20
% Unreported Contrast Extravasations	55	61	59

The Commitment to Process Improvement Continues

Future projects will include:

- Assessing the needs of our referring clinicians in the Breast Imaging Section
- Developing and implementing benchmarks for the Breast Imaging Section
- Standardizing and decreasing pediatric radiation dose from NYU Langone Medical Center PET/CT scanners

4

Process Improvement

Impacting Key Performance Indicators in Our MRI Section through Process Improvement

Process improvement (or reengineering) is the process of collecting, analyzing and evaluating data with the goal of achieving an improved workflow process. Over the past year we undertook a process improvement project in our MRI section. We measured several key performance indicators prior to the reengineering event, including: daily inpatient backlogs; on-time performance for all outpatient exams; scan duration relative to time allotted for the exam; and appointment backlogs for pediatric examinations requiring anesthesia. We found that through our process improvement efforts, performance in our MRI section significantly improved in every area measured.

Key members of our team were invited to participate in this reengineering project. The personnel chosen included members from all aspects of MRI delivery: MRI technologists, nurses, schedulers, front desk receptionists and physician and non-physician members of section administration. Personnel were chosen from each of the four locations in which we provide MRI services.

Process Improvement

Reengineering workflow was accomplished utilizing data from several sources. First, historical data from the four months prior to the reengineering process were gathered on: inpatient backlogs, on-time performance for all outpatient exams, scan duration relative to time allotted for the exam, overall examination volumes, and appointment backlogs for pediatric examinations requiring anesthesia.

Second, for the study period, we developed an in-depth tracking sheet to monitor all patients arriving in our section from the time they checked in at the front desk until the time they completed their examination. These tracking sheets were filled out by a combination of MRI expeditors and technologists to ensure that all data points during a patient's visit were accurately captured. The data from the worksheets were reviewed on a daily basis by the entire reengineering group the following day to determine where process improvement was possible. Finally, changes to MRI workflow were implemented based on review of the data.

Results and Changes Implemented

An automated telephone message system was implemented in order to notify patients when to arrive for their MR examination. Prior to reengineering, only 56% of patients arrived on time. Because of this low compliance, we implemented a live calling system in which a technologist or expeditor called the patient the night before their exam to notify the patient of the arrival time. This not only emphasized to patients the importance of on-time arrival, but also allowed a second screening process for implantable devices that might be MR incompatible. Calling patients the night before the examination resulted in an increased patient on-time arrival of 74%.

Second, we found that the process of getting outpatients ready for their examination often exceeded the time allotted. This was due to a number of factors, both on the technologist side and on the radiologist side. Prior to reengineering, we had a single technologist assigned to a room. We implemented a system whereby there are now 1.5 technologists assigned to a room. This enables more efficient patient data entry into magnets, placement of the patient on the MR table, and setting up the appropriate coils. Prior to reengineering, the vast majority of IV lines in patients requiring gadolinium were placed after the patient was on the MR table. By having

1.5 technologists per room, this practice was eliminated and now, IV line placements are inserted prior to the patient being brought into the MR exam room.

Our data revealed that often the first inpatient would not arrive in our section until after 8:00 a.m.; this was related to two primary reasons: issues with transport and inpatient nursing. As a result of our analysis and discussions with our other escort department, we were able to obtain a dedicated escort to have an inpatient in our section by 7:00 a.m. Second, we initiated a system whereby MR technologists notified inpatient nursing the evening prior to an inpatient's scheduled examination, so that patient preparation and coordination could be expedited.

Finally, we found that scheduling in the implementation of our outpatient pediatric anesthesia procedures had led to inefficiency in our section. These examinations were scheduled two days a week, beginning at noon and ending at 4:00 p.m., and two days a week (one a Saturday) beginning at 8:00 a.m. and concluding at 4:00 p.m. The late starts with pediatric anesthesia were found to be unpopular with patients, due to infant feeding schedules and the need for the child to be fasting prior to anesthesia. As a result, our section worked with the departments of anesthesiology and nursing to implement six days per week of early pediatric anesthesia starts, with the first case starting at 7:00 a.m. and the last case finishing at 11 a.m.

Key Performance Indicator Changes

Mean Number of Inpatients Not Scanned Per Day: Daily Backlogs
The mean ± standard deviation of the number of backlogged inpatient MR exams not performed per day was 4.24 ± 4.77 prior to reengineering, and was 1.29 ± 2.25 subsequent to reengineering.

On-Time Performance
Prior to reengineering, 68% of our MR examinations were started on time. Subsequent to reengineering, our percentage of on-time starts has increased to 79%.

Outpatient Anesthesia Backlog
The mean ± standard deviation (median) wait time (in days) was 28.4 ± 21.5 (22) prior to reengineering and 5.9 ± 4.3 (5) after reengineering.

Total MRI Volumes
The mean weekday and weekend daily exam volume before reengineering was 114 and 24 exams respectively. This increased to 136 and 36 post-reengineering.

Percentage of Examinations Completed Within Their Allotted Time Slot
The percentage of exams performed within 30 minutes (table time) increased from 35% to 44%.

Conclusion
We found that reengineering efforts can significantly impact key performance metrics within an MR imaging section, and can make the experience significantly more patient-centric. An article on this topic has recently been accepted for publication by the *Journal of the American College of Radiology*.

MICHAEL P. RECHT, MD
The Louis Marx Professor of Radiology
Chair of the Department of Radiology

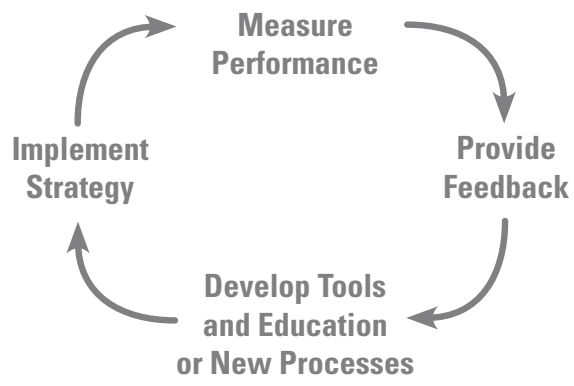
Breast Imaging: Process Improvement and the Power of Change

As NYU Langone Medical Center strengthens its vision as a world-class, integrated, patient-centric academic institution, our breast imaging team is following suit by implementing significant process improvements in patient care and physician collaboration.

Our system and data analysis included developing and measuring key metrics (Balanced Scorecard), comparing against external benchmarks, following industry guidelines (American College of Radiology: ACR), recognizing the unique needs of our patients and referring physicians, and formulating evidence-based decisions. In the process of gathering and analyzing data, we also focused on recognizing and validating each team member's role and contributions for continued team success.

Our plan of action was to reduce the complexity and variability of our process. We recognized that flexibility was the key to success and that attention to the needs of our key stakeholders—patients, physicians and colleagues—would need to remain ongoing.

Process Improvement Cycle



Significant Process Improvement

In addition to hiring additional breast imaging radiologists, we instituted an ongoing set of multidisciplinary meetings to focus on process improvement. With the invaluable insights and support of the team, Department Chair Michael P. Recht, MD, the Louis Marx Professor of Radiology; radiologist Cory I. Singer, MD; and Administrative Director Kirk Lawson, MBA, we measured key performance indicators including on-time starts for mammogram and breast ultrasound exams, and the length of time for each step from the time the patient presented at the reception desk to departure. We also created flowcharts of key processes such as scheduling screening and diagnostic mammograms, and documented the process flow for needle localization. Historical system data, provider feedback and expediter and technologist tracked time stamps helped paint a clearer picture of our customer service profile.

Changes Implemented

With support from additional staff resources, starting in 2010 we implemented:

- Enhanced scheduling options:
  - daily 7 a.m. needle localization appointments
  - expansion of screening mammogram appointments beyond weekdays to also include full-day Saturdays, as well as Monday, Tuesday, Wednesday and Thursday evenings
  - the option for patients to schedule any follow-up exams as well as their next appointment at the time of their current appointment
  - reserved daily appointment slots to accommodate add-on exams

- Faster turnaround time:
  - 48-hour report turnaround time for outside consultations, with the follow-up from these reports scheduled by the Breast Imaging Section, as opposed to the breast surgery staff
  - second-look breast MRI evaluations completed within 24–48 hours

In January 2012 and April 2012 we implemented the following changes:

- Results at time of visit support real-time peace of mind:
  - the option of real-time reads (RTR) for screening mammograms and, if additional imaging is needed, the option to have it done the same day

- Greater efficiency:
  - installed two wall-mounted monitors outside the exams rooms to improve room utilization
  - scheduling diagnostic mammograms and diagnostic ultrasounds one hour apart
  - established standardized exam start and end times

We are especially proud to have implemented these changes while maintaining our status as an ACR Breast Imaging Center of Excellence. We also passed our annual Food and Drug Administration (FDA) and State MQSA inspections with no deficiencies.

Key Performance Indicators:

On-Time Performance
Pre-process improvement: 46% of our mammogram exams were started on time.

After process improvement: our on-time starts increased to 77%.

Total Exam Volume
Our overall exam volume increases are approximately 17% from the previous year.

At the end of August 2012, the volume for September 2011 to August 2012 of 30,242 exams exceeded the prior year's total volume of 25,857 exams.

Conclusion

A leader's job is to look into the future and see things not as they are, but as what they can become. Our 2010 process improvement program harnessed the Power of "Yes" and truly transformed the Breast Imaging Section. Breast imaging played a significant role in the Clinical Cancer Center's customer service initiative. The image on page 32 illustrates one of the internal training tools intended to sensitize staff. Our commitment continues as we strive to improve the lives of our patients, referring physicians and staff.

ROSINA S. ALLY
Assistant Director
NYU Langone Breast Imaging Centers

Internal training tool: What we want our customers to say about us

5

Patient Safety Training Program at NYSIM

Assessment and Treatment of Adverse Reactions to Intravenous Contrast Media

A Department of Radiology Training Program in Coordination with the New York Simulation Center for the Health Sciences (NYSIM)

Iodinated contrast media and gadolinium chelates are the major drugs that radiologists administer. Radiologists manage many contrast-related issues, including selection of appropriate contrast type, route and rate of administration, patient allergy history, premedication protocols, and patients presenting with renal failure. Patients who develop adverse reactions to intravenous contrast media present serious management issues for radiologists.

Rare but Serious Reactions

Fortunately, reactions to contrast media are rare—with serious reactions occurring at a rate of 1–2 per 10,000 patients with intravenous administration of low osmolality iodinated contrast, and fatalities occurring approximately one per 179,000 patients. Because contrast reactions are unpredictable and potentially life threatening, the American College of Radiology (ACR) recommends appropriate training and vigilance.

Vigilance and Training are Key

Vigilance is the key word. Although radiologists may practice for years without encountering an adverse contrast event, they are expected and required to be conversant in the management of contrast reactions. Learning from manuals, although valuable, may not be adequate. A simulation training environment (similar to that used by pilots-in-training to manage emergencies) would be an optimal means to learn, refresh and reinforce skills for the management of contrast reactions.

An Innovative Simulation Center

In the fall of 2011, the New York Simulation Center for the Health Sciences (NYSIM) opened at Bellevue Hospital Center, in collaboration with NYU Langone Medical Center and The City University of New York, to train medical personnel using computer-programmable mannequins. The mannequins can be programmed to simulate physiologic responses including changes in vital signs, sweating, coughing, respiratory distress, etc. The NYSIM Center has coordinated with the Department of Radiology (under the aegis of the Education Committee) to train radiologists in assessing and managing contrast reactions using a series of contrast reaction scenarios including anaphylaxis, minor allergic reactions, and vasovagal reactions.

In addition to launching a web-based teaching module based on standardized ACR guidelines we also implemented hands-on training that started with teaching a team of attendings/trainers how to program the mannequins, present contrast reaction scenarios and conduct "debriefing" sessions following training. In March 2012, we initiated this training for the radiology residents.

We will offer reinforcement and/or remedial skill building as resources allow. We plan upcoming sessions with the 10 incoming first-year residents and the incoming fellows. Training for our department's residents and fellows is mandatory. Because interest has been keen, we have also opened up the training to interested radiology attendings.

Our goals are to update and reinforce practical management of contrast reactions using simulated scenarios.

SANDRA MOORE, MD
Assistant Professor

6

Innovation: New Equipment and New After-Hours Access

MRI at NYU Langone

Three recently FDA-approved state-of-the-art MRI systems were installed at NYU Langone in 2012. One MAGNETOM® Skyra 3T scanner was installed at the Bernard and Irene Schwartz Center for Biomedical Imaging (CBI), and one Skyra 3T scanner and one MAGNETOM® Aera 1.5T scanner were installed at the recently opened Center for Musculoskeletal Care (CMC). These most advanced top-of-the-line Siemens MR systems have many features that offer unique and significant improvements over the older systems: a short magnet with 70-cm bore size, dedicated high-density coil with lighter design, improved signal-to-noise ratio and parallel imaging capabilities for faster scanning.

Improved Image Quality

Our initial experience with these systems has been very positive, with improved image quality and efficiency for clinical MRI examinations. The improved image quality partly results from technical advances in hardware, such as shim techniques to improve the magnetic field homogeneity, and also from numerous improvements in specific pulse sequences.

Increased Comfort and Scheduling Flexibility

The large bore size (70 cm) has decreased patient discomfort, improving the likelihood of completing studies, even in claustrophobic patients. Improved system efficiency and faster throughput has allowed us to add on same-day cases with relative ease, which leads to improved patient and referring physician satisfaction. Clinical MRI examinations are scheduled on these scanners through the scheduling department, as determined by the technologists and radiologists.

Facilitating Research

In addition to improved clinical efficiency and patient satisfaction, these new scanners support many advanced work-in-progress research pulse sequences and protocols. This has enabled various investigators in our department to undertake exciting and clinically relevant research projects. Some of the projects listed here provide a flavor of the different types of research projects under way with these new systems. We are testing an advanced 3-D T2 SPACE sequence for prostate and pelvic imaging, which will be a significant improvement over performing multiple 2-D acquisitions in each plane (the current standard of care). Andrew B. Rosenkrantz, MD, in the Abdominal Imaging Section, is exploring advanced diffusion-weighted sequences to improve the detection of prostate neoplasm. Catherine N. Petchprapa, MD, in the Musculoskeletal Imaging Section, is performing dynamic wrist imaging at 1.5T and 3T. Tobias Block, PhD, of the CBI, is working with Christopher Glielmi, PhD, of Siemens Healthcare to utilize moving table technology in combination with advanced MRI pulse sequence to improve the speed of abdomen and pelvis MRI.

These new MRI systems not only improve image quality and efficiency but also open the horizon for translating cutting-edge scientific developments into routine clinical practice.

HERSH CHANDARANA, MD
Assistant Professor

CT Imaging at NYU Langone

Today, CT is a routine part of the imaging evaluation of patients because it provides superb images rapidly, at relatively low cost, and, when interpreted by subspecialty radiologists who are actively engaged with their clinical partners, goes beyond diagnosis by providing information around which clinical decisions are based. However, the widespread use of CT imaging has drawn scrutiny from patients and the media as fears of increased radiation and potential for increased cancer risks have become widespread.

Commitment to Quality

The current state of our CT capability reflects the department's commitment to maintaining the highest possible image quality at the lowest possible radiation dose. An inventory of our current scanners is a reflection of the level of investment that the department has made in response to these challenges. As of this writing, there are three outpatient and three inpatient dedicated CT scanners. Additionally, there is an inpatient scanner at the Hospital for Joint Diseases (HJD) and four scanners at Bellevue Hospital Center.

Technological Enhancements

All of our scanners at all locations have multi-detector CT (MDCT) capabilities that provide high-quality images in any reconstruction plane. Our Faculty Practice Radiology facility has two single-source 128-slice MDCT scanners and a unique dual-source MDCT scanner. All of these scanners are equipped with a variety of tools that can reduce radiation dose. One of these tools changes the way CT image data are reconstructed (iterative reconstruction), which significantly reduces the image noise generated by low radiation dose imaging.

Our newest scanners (just installed at Faculty Practice Radiology and Tisch Hospital) utilize a brand new detector with significantly increased efficiency, allowing for even further dose reductions. Using these tools, we have been able to reduce dose to approximately 60% of that of standard CT examinations. Our dual-source scanner, located in the Rivergate building, has the fastest temporal resolution (<100 msec), enabling superb coronary artery CT and pediatric imaging without anesthesia. This technology allows scans to be performed at a fraction of background radiation doses. Finally, this unique system design provides us with dual-energy CT capabilities, opening a wide variety of clinical applications while eliminating acquisitions such as routine non-contrast imaging, thereby achieving substantial dose savings. The department is excited to report that our workhorse 16-slice scanner in the Tisch Hospital emergency room is scheduled to be replaced with the latest version of the dual-source scanner, which is fitted with the newest detector material.

At Bellevue Hospital Center, we have been able to upgrade two of our scanners to 64-slice capability. Both of these scanners have iterative reconstruction capabilities, allowing for significant dose reduction. The sole single-slice scanner is used only for biopsy guidance. The scanner at HJD has 40-slice capabilities and can produce high-quality images for inpatient work.

All of these scanners are top-of-the-line instruments. Many sites are seeing their CT volumes decline as radiation fear and aggressive utilization management limit access. However, our conscious choice to continue to offer patients and referring clinicians the best possible images at the lowest possible dose will hopefully be seen as reflective of the departmental commitment to offer the highest quality scanning currently available.

ALEC J. MEGIBOW, MD, MPH, FACR
Professor

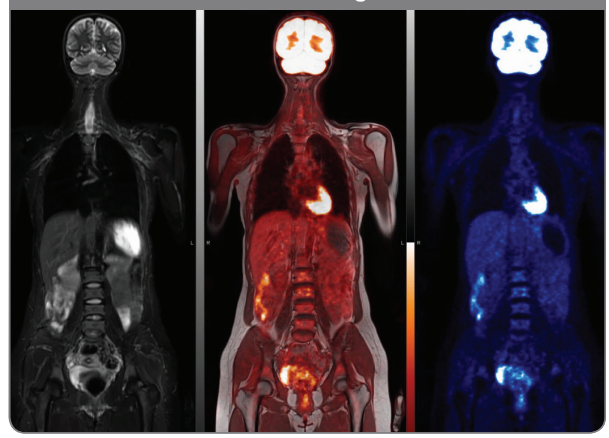
Role of Hybrid Imaging Modalities in Advancing Quality of Care: PET/MR, PET/CT and SPECT/CT at NYU Langone

Radiology departments seeking to improve quality of care for patients must not only refine policy and procedures for existing services, but should make every effort to be at the forefront of emerging technologies. To support this goal, the Department of Radiology at the NYU Langone Medical Center employs the latest generation of SPECT/CT and PET/CT molecular scanners that maximize diagnostic accuracy and minimize radiation exposure. Building upon these powerful tools, the department has partnered with Siemens Healthcare to collaborate on technical and clinical applications development for an exciting new imaging modality: simultaneous PET/MR (Siemens mMR).

Multimodality scanners have revolutionized nuclear medicine by combining highly sensitive, quantitative molecular imaging techniques (SPECT, PET) with high-resolution anatomical maps (X-ray computed tomography). This combination harnesses the strengths of nuclear medicine while allowing for increased specificity, precisely correlating molecular signals with anatomical location and diagnostic information provided by CT.

The new PET/MR imaging service at NYU Langone expands molecular imaging capabilities even further by combining PET scanning with high-resolution MRI, leveraging powerful, precise anatomical sequences and advanced molecular MR techniques including MR diffusion, MR perfusion, spectroscopy, and tractography. The Siemens mMR takes this technology to its nexus by allowing functional PET information to be acquired at the same time as MRI images are generated, enabling clinicians and researchers to view disease processes in multiple ways, with exceptionally accurate temporal alignment.

PET/MR Coronal Fusion Image



PET/MR technology has significant implications for quality of care in radiology. Firstly, patients who suffer from conditions for which there is a clinical indication for both PET/CT and MRI (for example, staging of locally advanced lung cancer) will benefit from a single exam on one machine without having to go to two separate appointments for PET/CT and MRI. Secondly, simultaneous imaging allows for improved spatial correlation between findings on PET and anatomical correlates on MRI, thus improving scan specificity and accuracy for both general lesion detection and guidance of biopsy, or even complex surgical procedures. PET/MR-guided surgery is expected to dramatically improve the surgical treatment of regional metastatic disease—a situation in which the completeness of tumor resection significantly impacts quality of life and disease-free survival. Improved spatial registration may also improve the quantitative accuracy of PET, thus allowing for better assessments of molecular treatment responses. PET will serve to validate quantitative MR techniques as well.

Beyond the improvements simultaneous PET/MR offers in terms of patient comfort and convenience, qualitative and quantitative scan accuracy and surgical guidance, the mMR is expected to improve patient care by allowing clinicians to look at diseases in entirely new ways. Medical conditions characterized by pathological processes that vary over short periods of time can now be measured simultaneously using both PET and MR, allowing clinicians, for the first time, to generate new conceptual frameworks for complex diseases, enabling the development of new therapies.

It is anticipated that neurological and cardiac diseases will be better understood when translational researchers look at these conditions with PET and MRI at the same points in time. Although oncological disease processes may change more gradually at the molecular level, at the time of intervention it is anticipated that novel cancer treatments such as radioembolization may benefit from simultaneous imaging by both PET and MR.

Simultaneous imaging is also expected to allow cancer researchers to cross-validate dynamic PET and MR parameters; such work may reveal synergistic information leading to better diagnoses and improvements in the assessment of treatment response.

In February 2012, a new Siemens mCT PET/CT scanner came online at the Clinical Cancer Center. This state-of-the-art camera, with its high-resolution lithium crystal and 40-slice CT scanner, provides the highest quality images while minimizing radiation dose. Additionally, respiratory and cardiac gating software, LAP lasers for radiation oncology treatment planning, 3-D imaging capabilities, "*syngo*.via" software and time-of-flight image processing all provide state-of-the-art features that advance the role of PET/CT imaging in patient treatment and clinical research.

In the near future, the Siemens Inveon™ microPET/CT scanner will be installed at the NYU Berg Animal Imaging Facility. The high-resolution features of the scanner will support a wide variety of translational research, and, when combined with on-site microMRI, provide an important platform for development of the PET/MR techniques of the future.

Also under construction in the department is an advanced radiochemistry facility. These new tools, in conjunction with the dedicated faculty and staff, will fuel the advancement of patient care and research in the rapidly evolving field of molecular imaging.

KENT P. FRIEDMAN, MD
Nuclear Medicine Section Chief

KAREN A. MOURTZIKOS, MD
Assistant Professor

Breast Imaging at NYU Langone

Many exciting changes are taking place within the Breast Imaging Section. In April 2012, the Joan H. Tisch Center for Women's Health opened on the Upper East Side. This comprehensive center offers same-day appointments for noninvasive cardiac testing, gastroenterology services and women's imaging services. This facility has two state-of-the-art digital mammography units, a state-of-the-art ultrasound unit, and a bone densitometry machine.

In June 2012, the NYU Langone Center for Women's Imaging opened at 221 Lexington Avenue. This center is over 8,500 square feet and features four mammography rooms, two ultrasound rooms, a bone density room, reading and consultation areas, and offices for physicians and staff.

In addition to our rapidly growing clinical practice, we are actively pursuing several research initiatives in an effort to provide innovative technologic tools to our patients. At the NYU Cancer Institute we have installed a 3-D mammography unit. This tomographic unit, the Siemens MAMMOMAT® Inspiration System, acquires multiple low-dose images of the breasts at different angles **(Figure 1)**. These images are reconstructed into a series of thin high-resolution slices. Reviewing breast tissue slice by slice enables the radiologists to identify and characterize abnormalities without the confusion of overlapping tissue. **Figure 2** illustrates that an underlying mass is easily appreciated on 3-D mammography (on the left) compared to conventional 2-D mammography (on the right). Our efforts are geared towards acquiring tomographic images to obtain Federal Drug Administration approval.

We continue to pursue the latest advanced breast MR techniques. The MAGNETOM Trio™, A Tim System is our 3T MRI scanner at the NYU Cancer Institute. Our research efforts have been directed towards acquiring images faster using the latest compressed sensing techniques. Our goals are to achieve higher spatial and temporal resolution in order to better discriminate between benign

Figure 1. Tomographic Unit

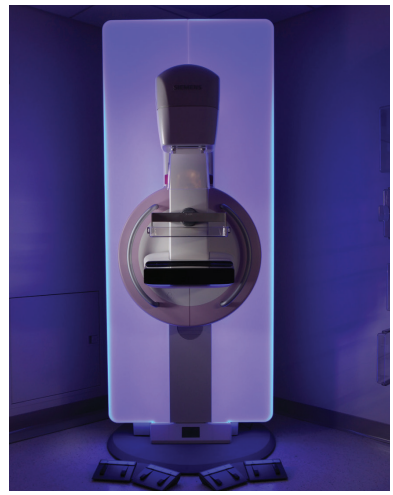
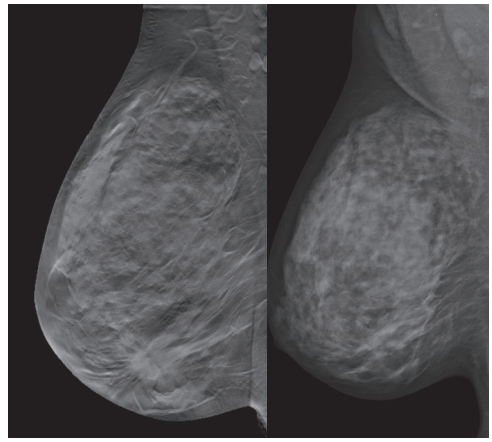


Figure 2. 3-D vs. 2-D Mammography



and malignant lesions. Also, our functional MR imaging research will facilitate our understanding of the biology of breast tumors so that individualized treatment may be offered to women with breast cancer.

The complexity and variety of breast cancer lesions require sophisticated quantitative imaging tools for effective screening, diagnosis and treatment monitoring. One area of active research is diffusion-weighted imaging (DWI). DWI quantifies the random motion of water in biological tissue on the 10 µm scale, typically by an apparent diffusion coefficient (ADC). Since proliferating cellularity reduces the extracellular space, a restricted ADC is a marker of cell density. This sensitivity provides a means for lesion discrimination; however, to capture the full complexity of breast tissue, we must go beyond the single ADC model **(Figure 3)**.

In addition to passive diffusion amongst the tumor cellularity, active incoherent vascular flow is also highly significant in hypervascular lesions. This blood flow causes "pseudo-diffusion" **(Figure 3a)**, which can be captured in an intravoxel incoherent motion (IVIM) framework to provide simultaneous probes of cellularity, vascularity and microvascular flow **(Figure 3c)**. Our group applies IVIM in an ongoing translational study at the synthetic, preclinical and clinical levels of breast cancer and has demonstrated potential for grading malignancy and mapping the tumor microenvironment.

The second complexity is directional diffusion anisotropy, which can be captured in diffusion tensor imaging (DTI) **(Figure 3b)**. Since the ductal tree of normal fibroglandular tissue shows local orientation and anisotropic restriction of ductal fluid, its reduction or absence in breast tissue, assessed via diffusion anisotropy, is suspicious. Several studies have shown diffusion anisotropy as a new biomarker of malignancy and our group is applying novel techniques to maximize this contrast.

One application of DTI in the breast is virtual tracking of the fibroglandular tissue orientation (ductography) **(Figure 3d)**. The combined use of IVIM and DTI in the characterization of breast cancer should increase our diagnostic ability and contribute strongly to individualized treatment. We are submitting NIH R01 grant proposals for our compressed sensing techniques and our diffusion techniques in the fall of 2012.

Finally, the Siemens Biograph™ mMR, a full integration of state-of-the-art 3T MRI and molecular imaging, was installed in July 2012. Our earlier work, performed without the simultaneous PET/MRI scanner, illustrates the potential of this technology. PET/MRI can provide information comparable to that provided by PET/CT at two-thirds the radiation dose. **Figure 4** demonstrates increased FDG uptake, which could represent residual malignancy versus postsurgical change. Fusion with the anatomically detailed T1-weighted post-contrast MR image shows increased uptake localized to a smoothly marginated benign seroma. In addition, PET/MRI may detect brain and hepatic metastases that are occult on PET/CT, thereby allowing earlier and more tailored treatment. PET/MRI data and local metrics may help to monitor treatment response in women with locally advanced breast cancer.

LINDA MOY, MD
Assistant Professor

Figure 3

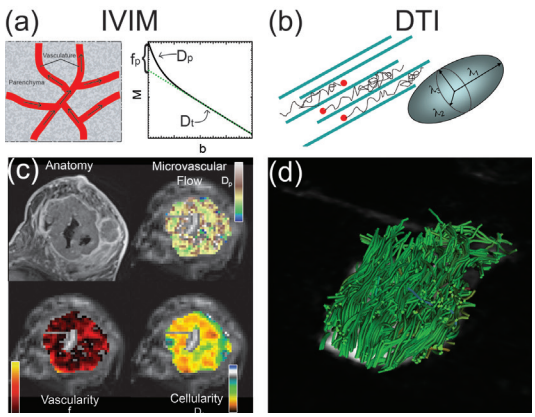
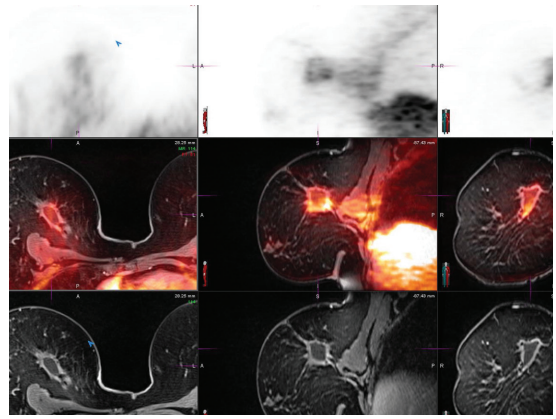


Figure 4



Center for Musculoskeletal Care

The opening of the new Center for Musculoskeletal Care (CMC) at NYU Langone is not only the culmination of a remarkable period of growth and improvement, but is also a landmark in our efforts to reduce unnecessary radiation exposure.

The new EOS orthopaedic imaging machine is the centerpiece of these efforts at the CMC. This standing X-ray unit, which looks a bit like a phone booth, operates in part on Nobel prize-winning detector technology, allowing for the rapid, biplanar acquisition of low-dose, whole-body X-ray images in 25 seconds or less. Special slot scanning technology employing a pressurized gas detector is designed to minimize scatter radiation, ensuring maximum signal-to-noise and allowing for equal or greater image quality at lower doses. In addition, an internal calibration system optimizes the dynamic contrast range over all portions of the images. It is particularly useful for spine and lower extremity imaging in a standing, gravity-dependent position, allowing for accurate estimation of deformities prior to surgical intervention.

Data obtained from the use of this system at CHU Sainte-Justine Mother and Child University Hospital Center, in Montreal, Canada, demonstrated a dose reduction factor of up to 9.2 times compared to computed radiography, with equal or superior image quality in 97.2%. This uniformly high image quality can reduce the repeat rate for non-diagnostic studies. In patients with disorders requiring multiple follow-up examinations to assess progression, such as the pediatric scoliosis population, these dose savings can be substantial over time.

In addition to the above advantages, post-processing software enables the creation of 3-D images, and may make the assessment of new clinical parameters a reality. Further research in this area is being planned. The EOS machine has been greeted with enthusiasm by the spine, adult reconstructive and pediatric orthopaedic surgeons, and should be well-utilized.

Other dose-reduction initiatives include the installation of two new Siemens Artis zee® multipurpose fluoroscopic units, as well as the purchase of two new Siemens ACUSON S2000™ state-of-the-art ultrasound units.

The Artis zee® rooms are equipped with the CARE (combined applications to reduce exposure) package, which includes: reduced pulse rates in fluoroscopy, radiation-free collimation, radiation-free patient repositioning, automated prefiltration of the X-ray beam, display of dose in the examination room, effective skin dose control, dose information embedded in DICOM structured reports and peak skin dose monitoring.

The ability to program and store multiple positions reduces the fluoroscopy time necessary to obtain requisite procedural views, thereby reducing patient radiation dose.

The addition of the new ultrasound units and expansion of the musculoskeletal interventional ultrasound program at the CMC will allow many of the procedures formerly performed with fluoroscopy to be completed with ultrasound guidance. In some cases, patients previously subjected to CT for diagnosis of disease, particularly in the postoperative state, will be examined with ultrasound instead. Both of these measures will reduce the number of patients being exposed to ionizing radiation.

LEON D. RYBAK, MD
Assistant Professor

Expansion of Radiology Services

"After-Hours" Imaging Available to Inpatients on Nights and Weekends

In lockstep with NYU Langone Medical Center's transition to a 24/7 patient-centric care model, the Department of Radiology provides virtually all imaging services to inpatients 24 hours a day, seven days a week. This significant enhancement of the availability of imaging studies reflects multifactorial influences: the increasingly central role that imaging plays in patient management; the critical requirement that inpatients receive the imaging care they need in a timely fashion; and the department's commitment to the philosophy that access to imaging studies does not delay patient management decisions and discharge planning.

Although our 24/7 services have been in effect for a while, we learned—to our consternation—that many clinicians were unaware of these expanded services. The challenge to the Department of Radiology, therefore, ultimately became informing our clinician colleagues of the availability of imaging services whenever their patients need them, and educating them as to how to access emergent/urgent imaging studies. Faced with this task, the department created a summary sheet, guiding clinicians through the mechanism to arrange imaging studies for their inpatients, at both Tisch Hospital and the Hospital for Joint Diseases, "after-hours," at night and on weekends **(Figure 1)**. This summary, designed as a quick reference, was introduced at a meeting of the service chiefs, and is being distributed as a laminated pocket guide for all house staff and interested attending physicians. Plans are in the works to provide these guides to patient unit clerks, nurse practitioners, and anyone else responsible for ordering imaging studies; these guides will most likely become available in hard copy and as links on various information systems.

GEORGEANN MCGUINNESS, MD, FACR
Professor and Senior Vice Chair of Radiology
Vice Chair of Education and Academic Affairs

Figure 1

NYU Langone MEDICAL CENTER

After-Hours Guide to Imaging for Tisch Hospital Inpatients

Radiology services are available **24/7** for urgent or emergent imaging and studies affecting patient discharge.

Service	After-Hours Operation	To Request A Study: Enter order in ICIS/EPIC then call
CT	Available 24/7	No call necessary following order entry
Radiography Stat Portables		
Ultrasound	M–F 5pm–8am | Sat–Sun 24 Hr	212.263.5230
MRI	M–F 10pm–7am | Sat–Sun 4pm–8am	
Fluoroscopy Emergent or Post–operative	M–F 5pm–8am | Sat–Sun 24 Hr	
Nuclear Medicine	Available daily 8am–midnight	Until midnight call 212.263.7410
Vascular Interventional	M–F 6pm–7am | Sat–Sun 24 Hr	Operator at 212.263.7300 will page VIR coverage
Neuro Interventional	M–F 6pm–7:30am | Sat–Sun 24 Hr	Pager 917.857.3616
Emergency Dept. Radiology	M–F 8pm–8am | Sat–Sun 24 Hr	Resident Beeper 1637 or Phone 212.263.7095
Subspecialty Radiologist Consultation	M–F 6pm–8am | Sat–Sun 24 Hr	The ED Radiologist will contact the subspecialist Resident Beeper 1637 or Phone 212.263.7095

To expedite a study after hours call 212.263.5230. | To reach a radiologist during business hours call Radiology Ombudsman Ms. Michelle Moorehead at 212.263.5222. | To reach a radiologist after hours call 212.263.7095 or beeper 1637.

NYU Langone MEDICAL CENTER

After-Hours Guide to Imaging for Inpatients at Hospital for Joint Diseases

Radiology services are available **24/7** for urgent or emergent imaging and studies affecting patient discharge.

Service	After-Hours Operation	To Request A Study: Enter order in ICIS/EPIC then call
CT	M–F 6pm–8am | Sat–Sun 24 Hr	HJD Operator 212.598.6000
MRI	M–F 5pm–8am | Sat–Sun 24 Hr Transport to Tisch Hospital	
Nuclear Medicine	M–F 5pm–9am | Sat–Sun 24 Hr Transport to Tisch Hospital	
Ultrasound	M–F 6pm–10am | Sat–Sun 24 Hr	
Vascular Interventional	M–F 6pm–9am | Sat–Sun 24 Hr Transport to Tisch Hospital	
Neuro Interventional	M–F 6pm–7:30am | Sat–Sun 24 Hr Transport to Tisch Hospital	
Non Vascular Interventional	M–F 6pm–8am | Sat–Sun 24 Hr	
X–ray	M–F 6pm–8am | Sat–Sun 24 Hr	

Please note that for MRI, nuclear medicine, vascular interventional and neuro interventional studies, HJD patients must be transported to Tisch Hospital.

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7

Research Grants and Publications

Selected Research Grants

(Active as of Fall 2012)

Research in Radiology

Our department stands out in its commitment to connecting clinicians with basic researchers, and to fostering truly translational research that will change the day-to-day practice of biomedical imaging. Our Bernard and Irene Schwartz Center for Biomedical Imaging (CBI) is a worldwide leader in the development and clinical implementation of new imaging techniques and technologies. We have also recently established the Center for Advanced Imaging Innovation and Research, which will advance the capabilities of imaging for cancer, neurological disorders and musculoskeletal disease. The Center for Advanced Imaging Innovation and Research is based upon a new multidisciplinary collaboration model in which basic imaging scientists, clinical radiologists, industry developers, and clinical partners from a wide range of collaborating departments sit down together at the scanners to codevelop new imaging approaches addressed at key unsolved problems and unmet clinical needs. The sampling of our research funding portfolio, in the chart on the opposite page, illustrates both the breadth and the depth of our ongoing research, which addresses multiple body areas, disease processes and imaging modalities. Taken as a whole, our research is aimed at advancing patient care, improving outcomes, and increasing the value of imaging both to patients and to their physicians.

A listing of selected publications follows as well.

DANIEL K. SODICKSON, MD, PhD
Professor of Radiology
Vice Chair of Research
Director, Bernard and Irene Schwartz Center for Biomedical Imaging

Selected Research Grants Active as of Fall 2012		
Principal Investigator	**Sponsor**	**Grant Name**
Leon Axel, MD, PhD	NIH	Quantitative Myocardial Perfusion Assessment with MRI
Leon Axel, MD, PhD	NIH	Noninvasive Assessment of Liver Stiffness with Tagged MRI
Leon Axel, MD, PhD	NIH	Development and Evaluation of MRI Methods to Assess Diastolic Function
Fernando Boada, PhD	NIH	Brain Ion Homeostasis, Lithium and Bipolar Disorder
Hersh Chandarana, MD	RSNA Research & Education Foundation	Evaluation and Prediction of Treatment Response in Liver Metastasis Undergoing Chemotherapy
Gregory Chang, MD	NIH	Osteoarthritis: Identification of Novel Imaging Biomarkers via 23Na/1H MRI at 7T
Christopher M. Collins, PhD	NIH	High-Field MRI: Limitations and Solutions
Yu-Shin Ding, PhD	NIH	The Norepinephrine Transporter: A Novel Target for Imaging Brown Adipose Tissue
Els D.T. Fieremans, PhD	NIH	Quantifying Demyelination and Axonal Loss with Diffusion MRI
Oded Gonen, PhD	NIH	Higher Speed, Field and Spatial Resolution Brain 3-D 1H MRS
Oded Gonen, PhD	NIH	Serial Brain 3-D 1H MR Spectroscopy in Multiple Sclerosis
Glyn Johnson, MD	NIH	Quantification of Tumor Malignancy with MRI
Sungheon Kim, PhD	NIH	DCE MRI Study for Breast Cancer
Mariana Lazar, PhD	NIH	Microstructural Characterization of White Matter in Schizophrenia
Jae Seung Lee, PhD	NIH	Development of Optimal Sodium-MRI Methodology for the Musculoskeletal Field
Yvonne W. Lui, MD	NYUSOM CTSI	Pattern Classification of Quantitative MRI and 1H-MRS for Diagnosis in Mild Traumatic Brain Injury
Yvonne W. Lui, MD	NIH	Quantitative MRI and 1H-MRS in Traumatic Brain Injury
Yvonne W. Lui, MD	NIH via SUNY Downstate Medical Center	Effects of Vascular Health, Aging and HAART on Cognition in HIV: A Pilot Study
David P. Naidich, MD	NIH	Dual-Energy CT Evaluation of Airway Inflammation
Ravinder R. Regatte, PhD	NIH	Quantitative MRI for Early Diagnosis of Arthritis
Ravinder R. Regatte, PhD	US/Israel Binational Science Foundation	MRI Strategies for the Intervertebral Disc
Ravinder R. Regatte, PhD	NIH	Cartilage, Bone and Marrow Interactions in Knee OA
Ravinder R. Regatte, PhD	NIH	Sodium MRI for Assessment of Early OA
Andrew B. Rosenkrantz, MD	Department of Defense	Prostate Cancer Detection Using High Spatial-Resolution MRI at 7.0 Tesla
Henry Rusinek, PhD	NIH via University of Utah Health Sciences	MR Angiography and Renography for Renovascular Disease
Henry Rusinek, PhD	NIH via University of Utah Health Sciences	Accurate Measurement of Renal Function in Cirrhosis
Henry Rusinek, PhD	NYUSOM CTSI	Optimized Management of Prostate Cancer: Pre-Acquired MRI and Image Fusion for Improved Transrectal Biopsies
Eric E. Sigmund, PhD	NIH	Dynamical DTI: A Method for Time-Resolved In Vivo Diffusion Tensor Imaging
Daniel K. Sodickson, MD, PhD	NIH	Parallel Magnetic Resonance Imaging: New Techniques and Technologies
Daniel K. Sodickson, MD, PhD	NIH	High-Performance High-Field Parallel MRI
Daniel K. Sodickson, MD, PhD	Applied Research Support Fund (ARSF)	Novel Magnetic Resonance Radio Frequency Emission Testing (MR-RFET) for Quantifying RF Emission from Wireless Devices
Monvadi B. Srichai-Parsia, MD	American Heart Association	Scientist Development Grant
Yudong Zhu, PhD	NIH	RF Technology Innovation for Advancing High-Field MR

Selected Publications*

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Aquino, T; Aaltonen, E; Charles, HW; Kovacs, S; Gross, J; Richard, L; Hillel, B. Artificial ascites and radiofrequency ablation of subdiaphragmatic hepatocellular carcinoma [Meeting Abstract]. *Journal of Vascular & Interventional Radiology*. 2011;22(3 SUPPL 1):S116.

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**The selected publications are the first author publications of current faculty members as of Summer 2012.*

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Referring Physician Survey

Department of Radiology Referring Physician Survey 2012

In the Department of Radiology's ongoing efforts to improve our level of service and overall quality, we highly value the input of our referring clinicians, who entrust us with their patients. To facilitate communication, we developed a survey for our referring clinicians that focuses on specific, actionable items. We also included an open-ended question to determine what was important to them. The department plans to use these responses to identify areas for improvement. For example, based on the frequency with which it was mentioned, we are already investigating a change to the guidelines for our steroid pretreatment regimen. We also plan to conduct annual surveys to monitor the impact of our improvement strategies.

Here, we highlight the results of our most recent survey, completed a few months ago. We received 115 responses from many different clinical departments, and we appreciate the time spent completing and returning our surveys. Please keep in mind that a survey is just one tool to improve the communication between clinical departments and the radiology department. We are always receptive to any means of communication that is most convenient.

Survey Results

On a scale of 1 (never) to 5 (always)		Response Average
#1	I can rely on the Department of Radiology to specifically answer my clinical question	4.1
#2	I can rely on the Department of Radiology to appropriately prioritize relevant and incidental findings in the report	3.9
#3	I can rely on the Department of Radiology to make relevant comparisons to prior examinations and correlations with other imaging examinations	4.2
#4	The radiologists provide consistent imaging or management recommendations	4.0
#5	The radiologist is accessible for consultations, examinations or procedures	4.0
#6	The radiologist demonstrates professionalism in your interactions	4.5
#7	The radiologist immediately notifies you of emergent findings	4.3
#8	What type of radiology report would you prefer?	Structured report (64) 58% Prose style (14) 12% No preference (33) 30%
#9	Would you like the radiologist to be available to discuss imaging findings with the patient should they have any questions?	Yes (68) 61% No (22) 20% No preference (21) 19%
#10	How willing are you to recommend the NYU Langone Medical Center Department of Radiology to others?	Yes (104) 91%

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Leadership

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