St. Jude Children's Research Hospital | Diagnostic Imaging

Diagnostic Imaging Clinical Operations Management and Research Database

Lean MRI protocol process improvement and software solution

Julie H Harreld MD, Ashish Pagare MBA/PMP, Nancy Foster MHA/CIIP/RDMS, Rozalon Shipp RT, Noah D Sabin MD/JD, Kathleen J Helton MD, Barbara Gingras BSN/MPA/PMP, Zoltan Patay MD/PhD

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Purpose:

Lean is a philosophy that embraces the power of continuous process improvement to add value to customers (patients) and society, while empowering employees and building people and teams as part of "learning organizations" that can adapt and thrive in challenging environments.[1]

Principles of Lean

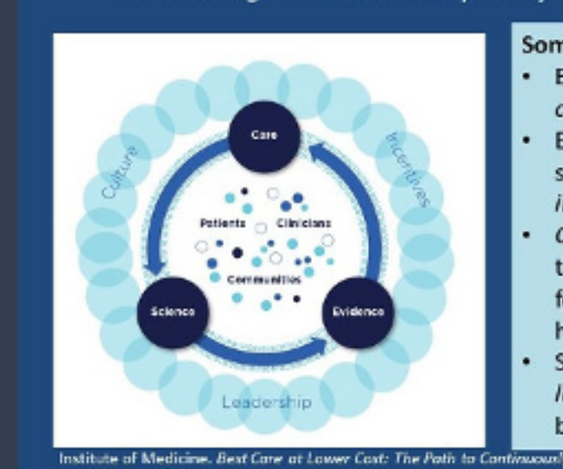
According to "The Toyota Way" by Jeffrey K. Liker[1]

1. Base management decisions on a **long-term philosophy**, even at the expense of short-term gain.
2. Create **continuous process flow** to bring problems to the surface.
3. Use "pull" systems to **avoid overproduction**. (Do not store inventory or work too far ahead)
4. **Level the workload** (*heijunka*). (Don't let one person be very busy while others are sitting idle)
5. Build a culture of stopping to fix problems, to **get quality right the first time**.
6. **Standardized tasks** are the foundation for continuous improvment and employee empowerment.
7. Use **visual control** so no problems are hidden.
8. Use only reliable, thoroughly **tested technology** that **serves your people and processes**.
9. **Grow leaders** who thoroughly understand the work, live the philosophy, and teach it to others.
10. **Develop exceptional people** and teams who follow your company's philosophy.
11. Respect your partners by challenging them and helping them improve.
12. **Go and see for yourself** to thoroughly understand the situation (*genchi genbutsu*).
13. Make decisions slowly by **consensus** (*nemawashi*), considering all options; **implement decisions rapidly**.
14. Become a **learning organization** through relentless reflection (*hansei*) and **continuous improvement** (*kaizen*).

The Institute of Medicine recognizes continuous learning and improvement as the key to addressing the increasing costs and "unmanageable complexity" of the science of health care,[2] and reducing diagnostic error.[3]

Lean in medicine: combatting cost and complexity

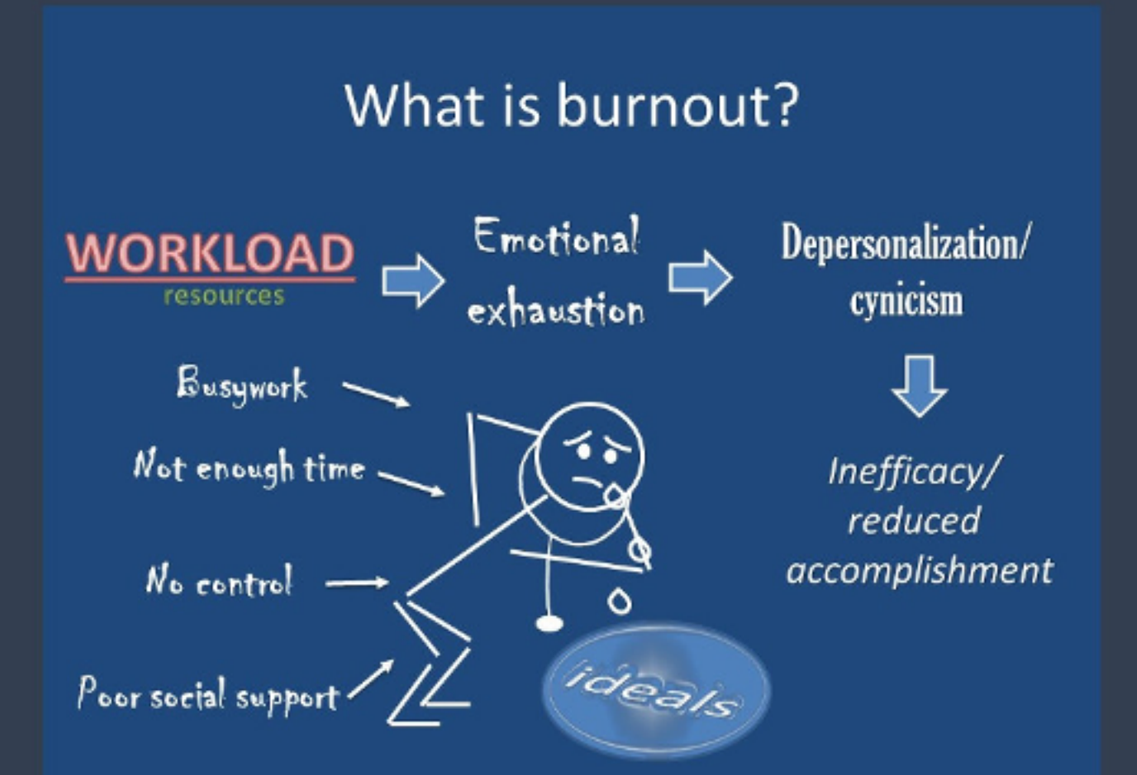
Institute of Medicine, National Academy of Sciences:
Continuous learning and improvement are key to addressing increasing cost and complexity and reducing diagnostic error



Some specific recommendations:
- Expand commitment to the goals of a *continuously learning* health care system
- Establish a work system and *culture* that supports the diagnostic process and *improvements* in diagnostic performance
- *Continuously improve* health care operations to *reduce waste, streamline* care delivery, and focus on activities that improve patient health
- Structure payment to *reward continuous learning and improvement* in the provision of best care at lower cost.

Institute of Medicine. *Best Care at Lower Cost: The Path to Continuously Learning Health Care in America*, (The National Academies Press, Washington, DC, 2013).

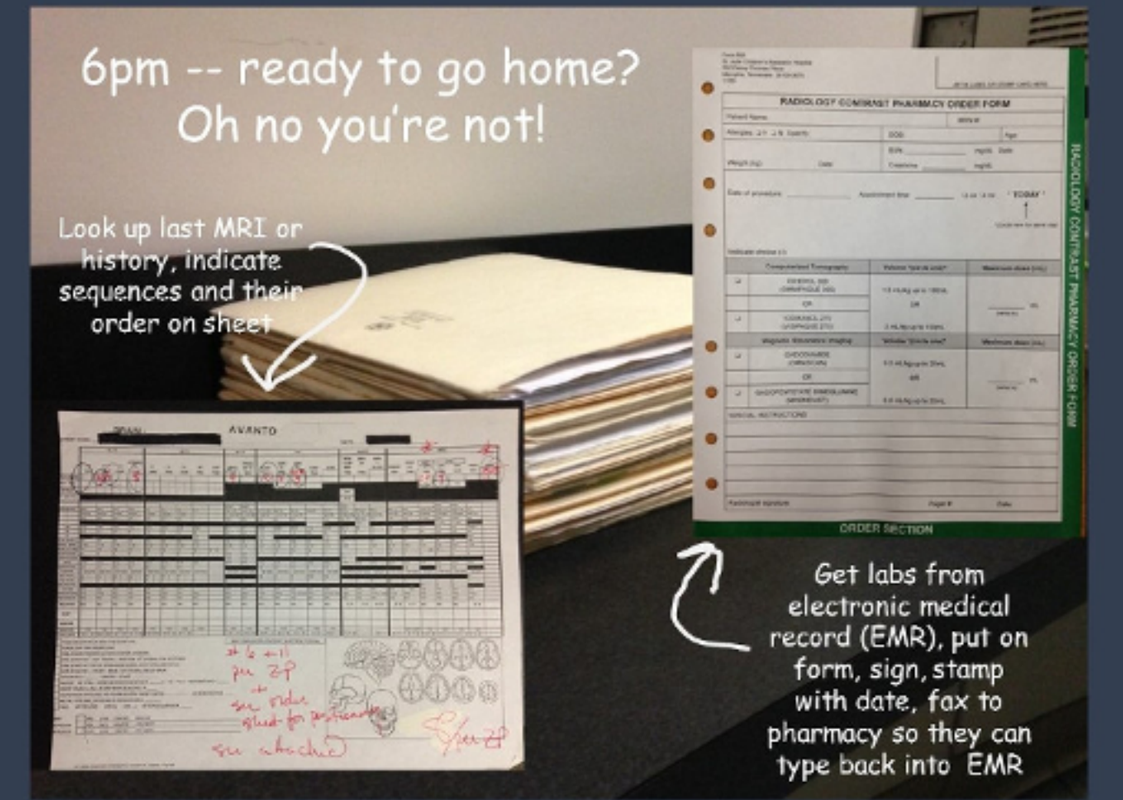
Lean improvement may also reduce burnout through participants' empowerment and engagement, team building and efficiencies allowing more time for personally meaningful work activities.[4-6]



Lean in medicine: combatting burnout

Burnout	Lean Improvement
Depersonalization	Increases engagement
Poor social support	Teamwork, common vision
Inefficient processes and busywork	Process improvement, less non-value added work
Not enough time for family, meaningful work	Efficiency → more time for family and meaningful work
Lack of control	Empowerment
Risk to quality and safety of patient care	Improved quality and safety of patient care
High costs: people, money	Decreased turnover
	Continuous improvement (Learning Organizations)

9 years ago, our neuroradiologists commonly worked 11+ hours per day. The most visible cause of this problem was the late (5:30-6pm) arrival of folders containing imaging protocols and contrast prescriptions to be completed for the next day.



We initiated a lean improvement project targeted toward increasing time available for meaningful activities by eliminating waste from the imaging and contrast prescription process.

Methods:

1. Employed Toyota's Practical Problem Solving Process including the "Five Whys" to define and clarify the problem, identify the root cause and iteratively develop countermeasures

Identifying the root cause of our problem: The Five Whys

The Problem: we are in the reading room way too late every day
Why? The folders come late every day
Why? They take a really long time to prepare
Why? First Tech 1 checks schedule for the next day, pulls all folders from the file room, looks up labs for each patient, writes name/labs/date on each paper, and puts it in the folder. Carried to Tech 2, who looks up the patient's clinical trial and adds the correct imaging protocol sheet, or hand writes all clinical protocols (to be checked by radiologist)
Why? Because **the clinical protocols are not standardized**
Why? The perception was that this was because the vast majority of the patients had clinical trial imaging so **there wasn't much clinical imaging.**

Investigation of root cause:
Almost 70% of neuroimaging was purely clinical.
No reason not to standardize.

2. Standardized MR imaging protocols through consensus (*nemwashi*), beginning with most frequently used protocols, based on a clear set of principles and a checklist for implementation

Principles for Protocol Standardization

- ❑ Start with the most frequently used protocols and work down
- ❑ Use the fewest sequences necessary for diagnosis
- ❑ If it is outdated, update it
- ❑ If someone is very attached to a sequence and can explain why, keep it
- ❑ Document protocol, date it, circulate for approval
- ❑ Install on all MRI scanners
- ❑ Re-assess after two weeks – radiologists, technologists
- ❑ Adjust if necessary
- ❑ Finalize
- ❑ Periodically re-assess (every 2-3 years or with advances in technology)

3. Developed a workflow for continuous imaging protocol improvement

DRIVE
continuous process improvement

Development (radiologists in consensus)
Review (test, consensus re-evaluation)
Implementation (scanners, worksheets)
Vaulting/archiving (back-up workbook)
Evaluation (periodic review, new technology)

4. With a multidisciplinary team, developed software to support radiologist and technologist workflow that integrated a new protocol database with curated clinical information from the EMR (labs, history, allergies, medical device MRI compatibility), capability to prescribe contrast bounded by ACR guidelines, and permitted archiving of radiologist/technologist notes and protocol customization.

4. Developed and implemented a plan/checklist for folder/paper retirement

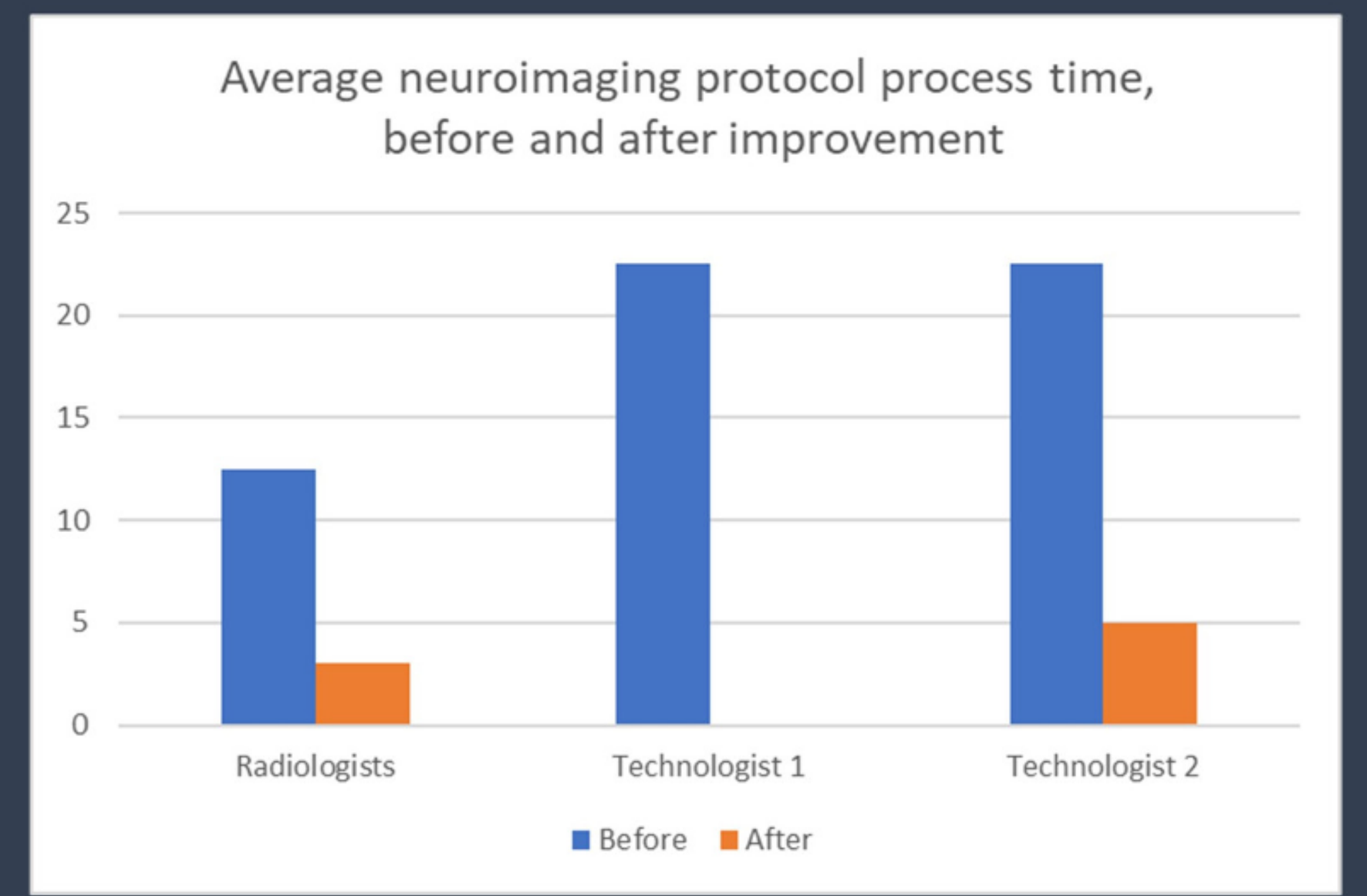
Checklist for Folder Retirement

- ❑ Folders are pulled
- ❑ Radiologist prescribes MRI and contrast based on standardized version of written/previously performed protocol
  - ❑ Clicks "E" box in DICOM-RD to indicate patient's exam may be prescribed electronically moving forward
- ❑ Technologist transfers tech exam notes (patient needs, special exam requirements) to DICOM-RD
- ❑ Folder is returned to file room until 2 exams or 1 year, whichever earlier
- ❑ New patients all prescribed electronically
- ❑ All folders destroyed after 2 years

Technologist and radiologist labor time was assessed before and after implementation through surveys and observation, and descriptive statistics calculated.

Results:

Radiologists' protocol process time was reduced by approximately 60%, or the equivalent of 1 academic day (8 hours). Overall, technologist process time was reduced by approximately 70% (100% for Technologist 1, 50% for Technologist 2), saving 37.5 technologist hours per week (almost 1 FTE). This translated into shorter reading room days for neuroradiologists, and increased technologist availability for advanced image processing and other value-added and meaningful tasks, gains which have been maintained despite steadily increasing imaging volumes.



Radiologists
Before the initiative, radiologists spent an average of 12.5 hours per week on activities related to protocolling and contrast prescription, which decreased to 3 hours per week after implementation.

Technologists
Before the initiative, both technologist 1, who filled out paper protocol sheets for each patient, and Technologist 2, who pulled folders and filled out contrast prescription paperwork, spent 22.5 hours per week (>50% of their work days) on these activities. After implementation, paper-based protocol and prescription preparation was no longer required, with only 5 hours per week required for checking protocols and prescriptions. Technologist 2 was moved to an advanced imaging processing position.

CT protocols and contrast prescriptions were subsequently incorporated into the software.

Other benefits:
- **Consistency** of imaging protocols, facilitating acquisition and improving comparison and diagnosis
- **Standardization** permitted differentiation of clinical versus research imaging, facilitating billing
- **Compliance** with electronic medical record mandate
- Enhanced **safety** of intravenous contrast prescription
- Electronic record of patient-specific imaging needs, improving **patient experience**
- Process for **continued imaging improvement** (DRIVE), which continues today, leveraging advances in technology for improved diagnosis, while promoting **teamwork and mutual respect**

Lessons learned:
- Processes that worked 10 years ago may not be scalable to increasing imaging volumes and complexity.
- Software alone is not a solution for inefficient or poorly defined processes, which should be aggressively reviewed and streamlined before a software solution is considered.
- Software is logical, while people frequently are not. Hiccups in software development/implementation usually indicate ambiguity in processes and should be considered an opportunity for process review and improvement.
- Participation and buy-in of key end users is critical to the success of any process improvement effort.

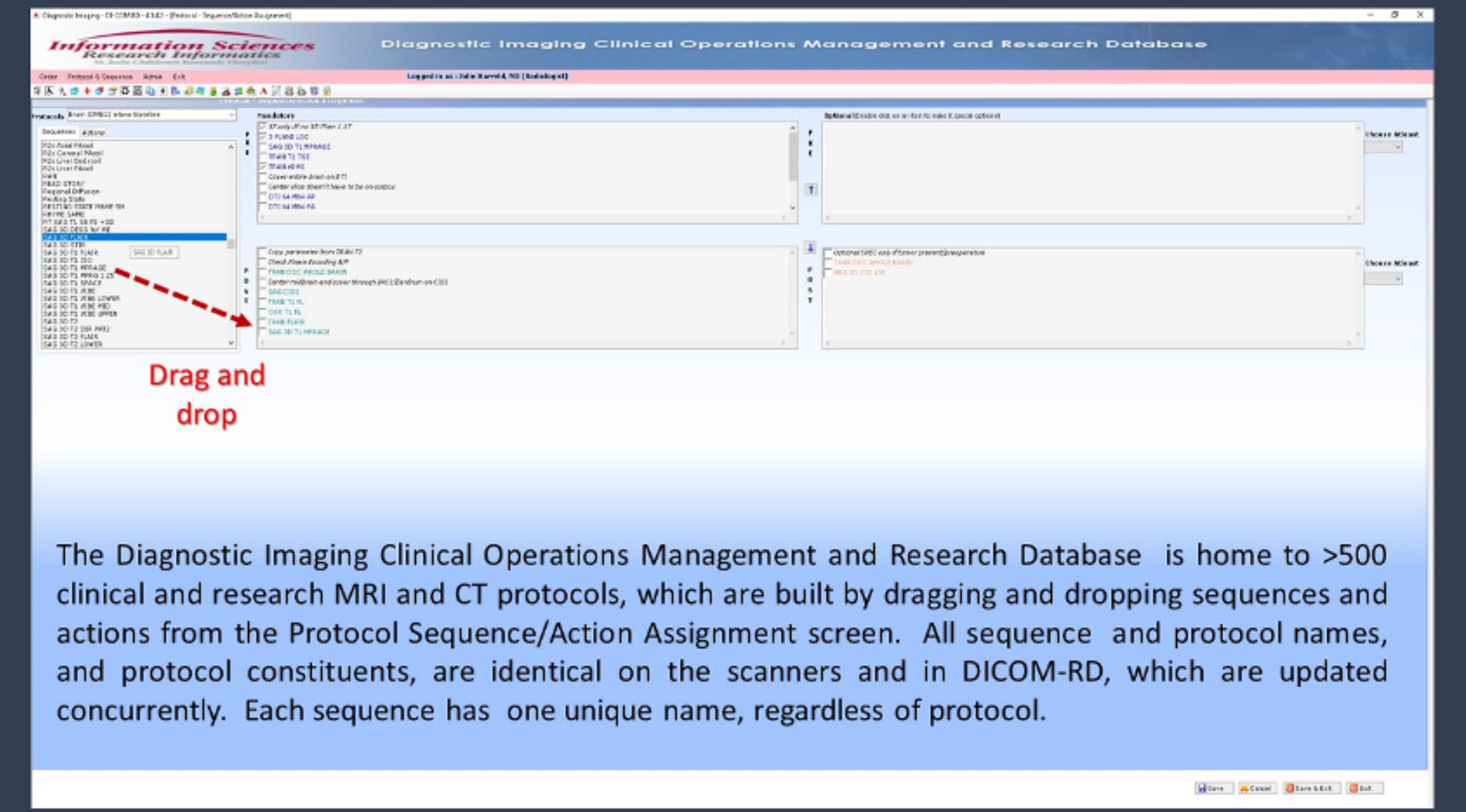
Conclusion:

Lean process improvement can introduce efficiencies accommodating increasing imaging volumes and meaningful value-added activities, while enhancing consistency and safety in patient imaging care and promoting a culture of continuous improvement. With judicious implementation, the inherent logic of software can be leveraged for further process improvement.

References:

1. Liker JK. *The Toyota way : 14 management principles from the world's greatest manufacturer*. New York: McGraw-Hill; 2004
2. Institute of Medicine. *Best Care at Lower Cost: The Path to Continuously Learning Health Care in America*. Washington, DC: The National Academies Press; 2013
3. Institute of Medicine. National Academies of Sciences E, Medicine. *Improving Diagnosis in Health Care*. Washington, DC: The National Academies Press; 2015
4. Hung DY, Harrison MI, Truong Q, et al. Experiences of primary care physicians and staff following lean workflow redesign. *BMC health services research* 2018;18:274
5. Shanafelt TD, West CP, Sloan JA, et al. Career fit and burnout among academic faculty. *Arch Intern Med* 2009;169:990-995
6. West CP, Dyrbye LN, Shanafelt TD. Physician burnout: contributors, consequences and solutions. *Journal of internal medicine* 2018;283:516-529

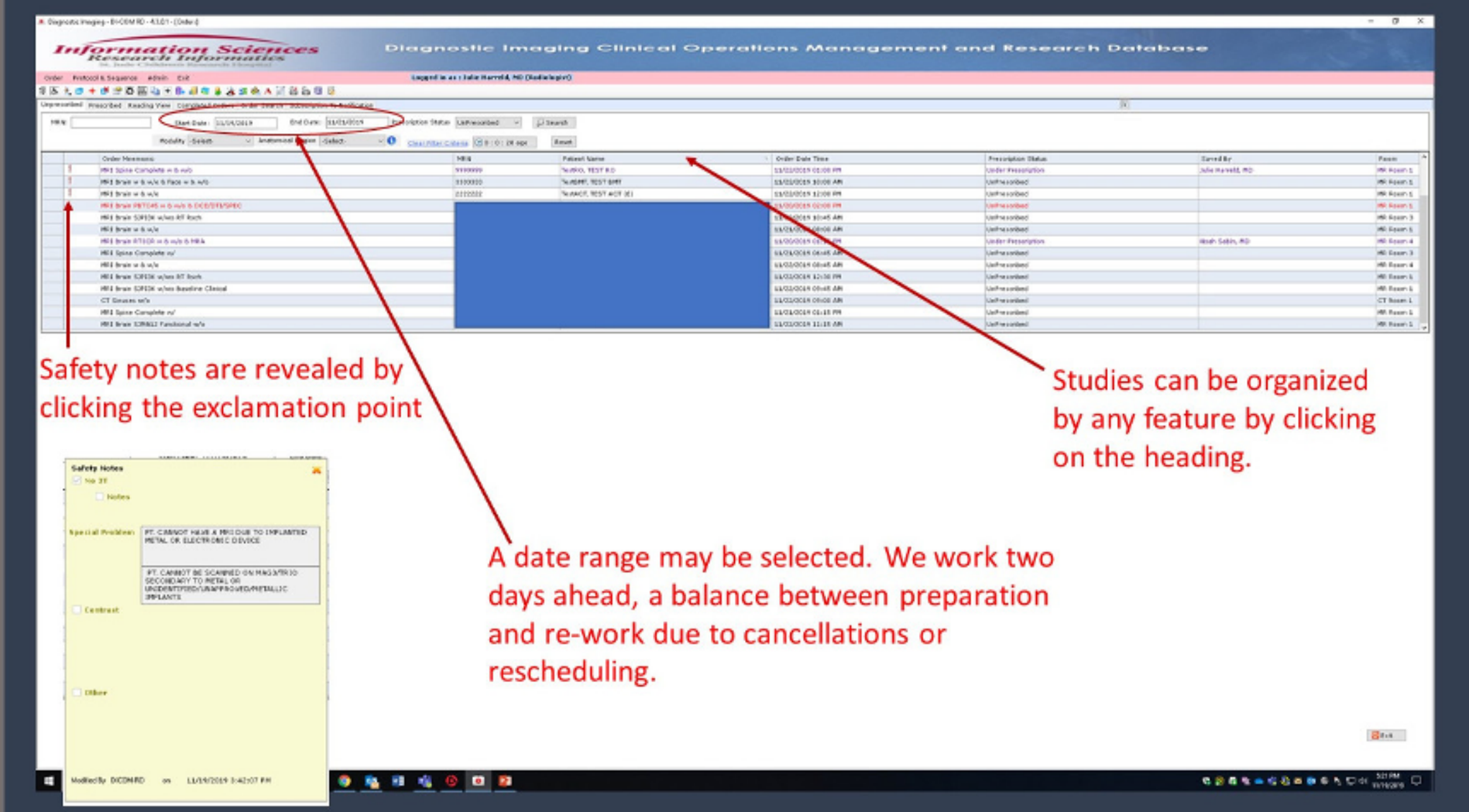
Protocol Database



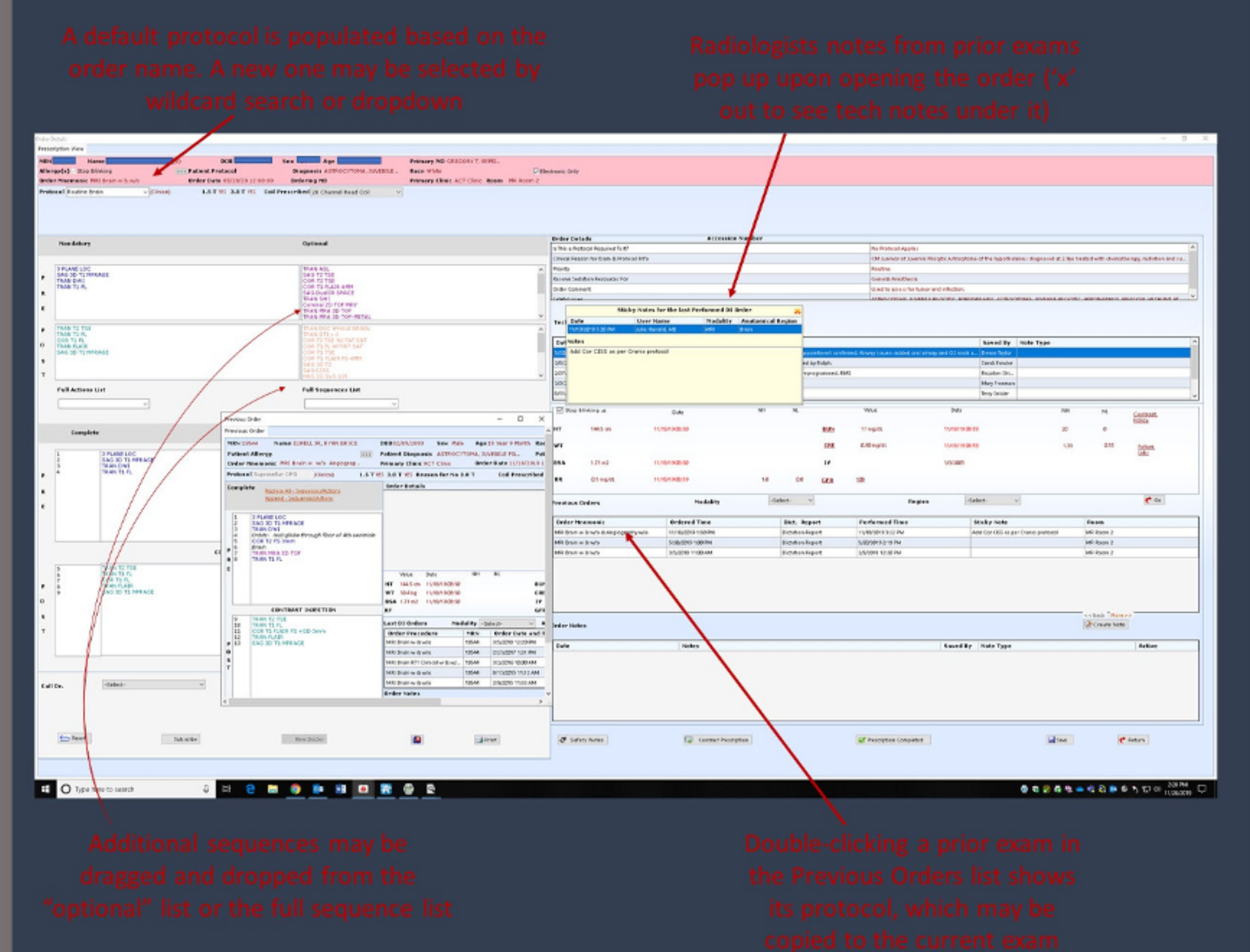
The Diagnostic Imaging Clinical Operations Management and Research Database is home to >500 clinical and research MRI and CT protocols, which are built by dragging and dropping sequences and actions from the Protocol Sequence/Action Assignment screen. All sequence and protocol names, and protocol constituents, are identical on the scanners and in DICOM-RD, which are updated concurrently. Each sequence has one unique name, regardless of protocol.

Radiologist Interface

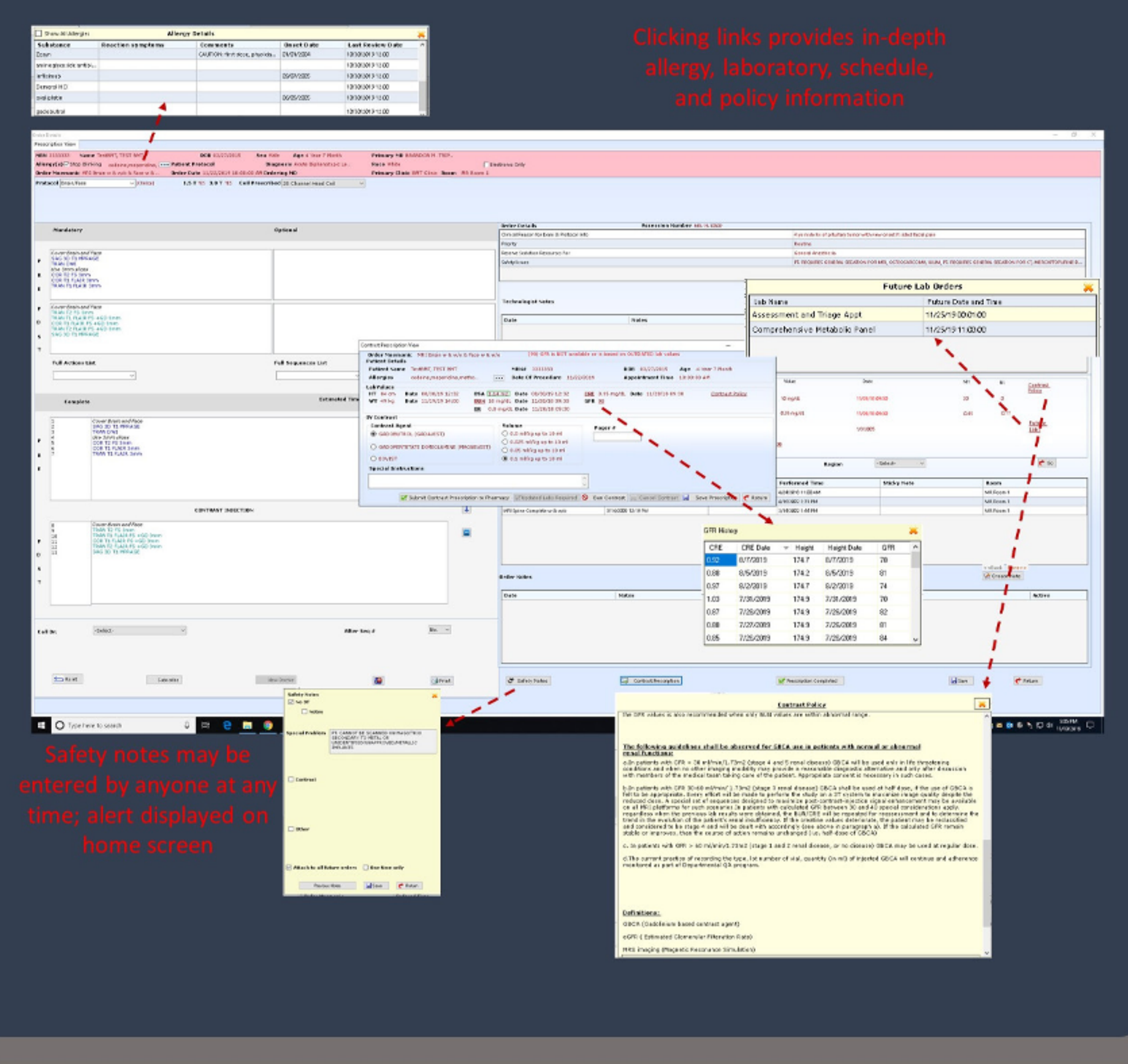
Protocolling/prescription starts on the "Unprescribed" tab of the radiologists' home screen. Studies can be organized by any feature by clicking on the heading.



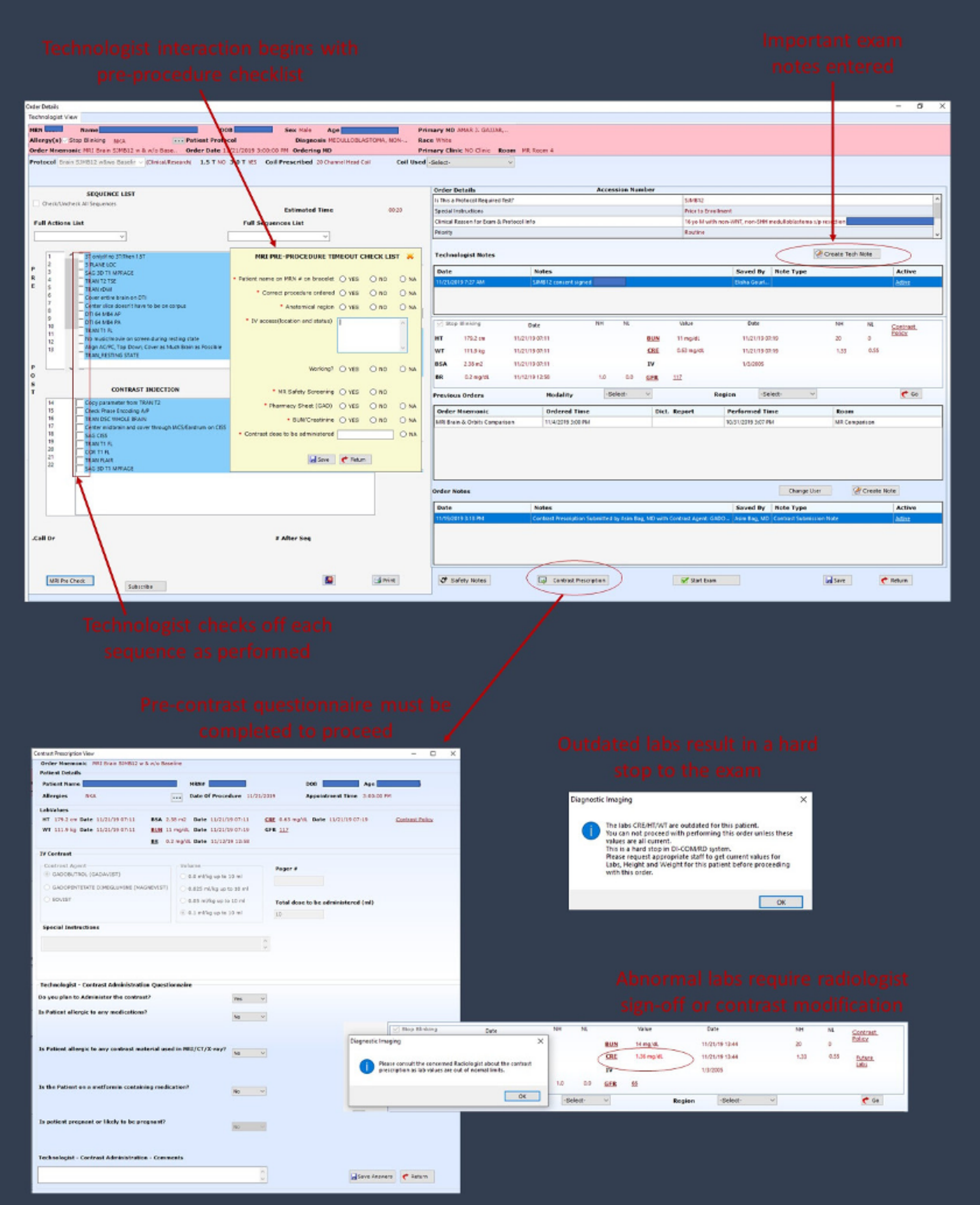
Double-clicking a patient/order brings up the protocolling dashboard, which presents all information needed for MRI protocolling and contrast prescription in a single screen.



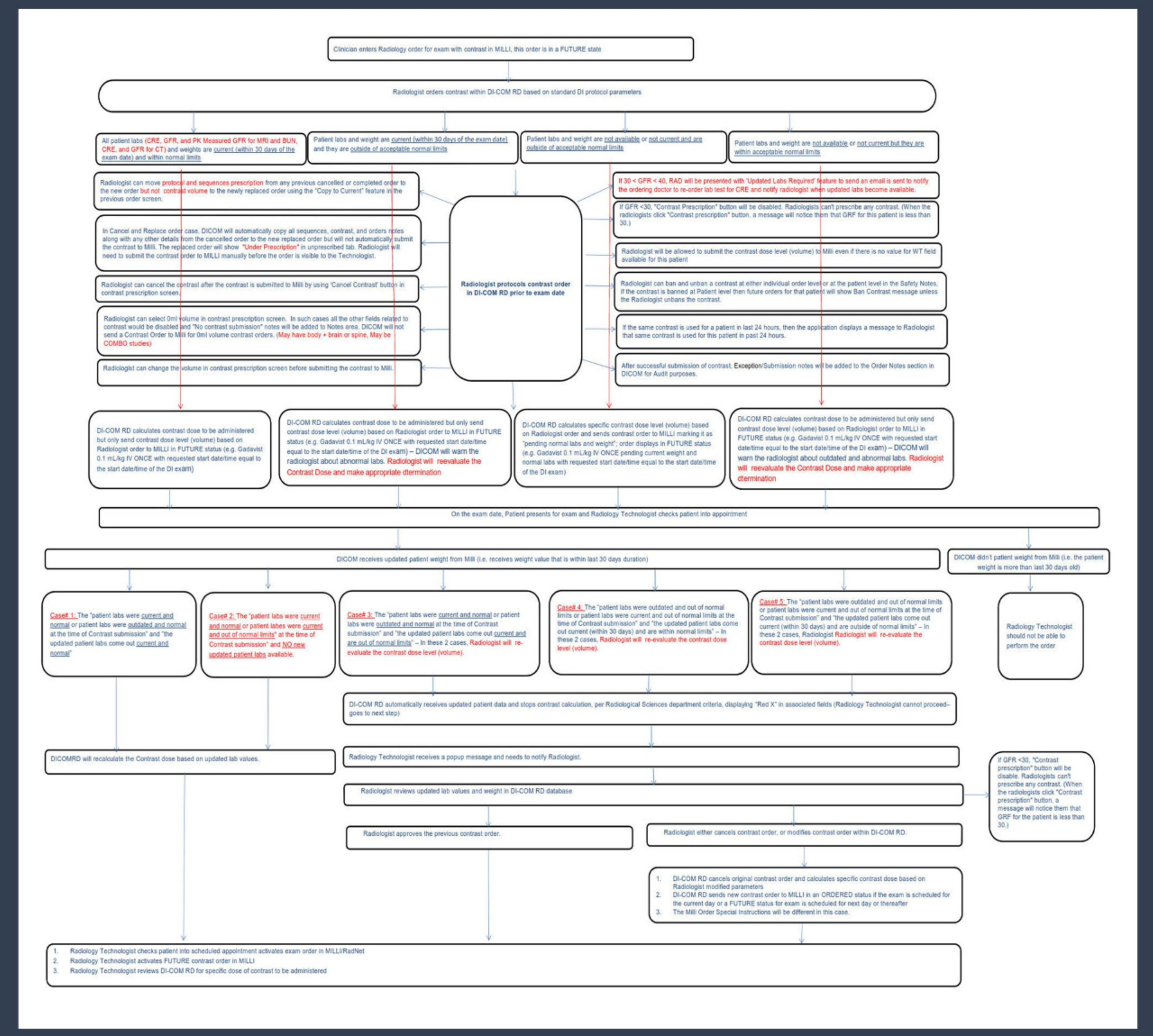
Contrast, Allergies and Safety



Technologist Interface



Gadolinium contrast prescription workflow



DICOM-RD Feature Summary

FEATURE	Paper	DICOM-RD	Power Chart
Single-screen dashboard with all critical information		x	
Search for imaging orders by MRN, name or date		x	
MRI and CT Protocolling (sequence prescription)			
Prescribe MRI and CT sequences	x	x	
Track sequences required for >500 clinical and research Neuro and Body imaging protocols	x	x	
Distinguish between clinical and research MR and CT imaging protocols and sequences	x	x	
Provide an electronic record for sequence additions and rationales		x	
Entry of exam-specific notes by technologist and radiologist	x	x	
Communication of critical information to the radiologist prescribing the next study	?	x	
Display history and special instructions for imaging protocoling at a glance	x	x	
Display reports for relevant prior imaging exams		x	x
Copy sequences and special instructions from prior to current imaging protocol	x	x	
CONTRAST PRESCRIPTION			
Automatically select contrast and dose for protocol exams requiring specific contrast		x	
Prescribe contrast	x	x	x
Calculate GFR		x	
Display 1-year BUN and Creatinine history		x	x
Provide a warning to the Radiologist if contrast is prescribed with GFR<60 per ACR guidelines		x	
Deny radiologist the ability to prescribe contrast if GFR<30 per ACR guidelines		x	
Block technologist from submitting contrast order for administration if GFR<60 without a radiologist consult		x	
Require updated, normal labs prior to contrast submission if most recent labs abnormal		x	
Display detailed allergy history, including type and management recommendations		x	x
Warn radiologist if the same contrast has been prescribed within a 24-hour period		x	
Block technologist from proceeding with study if requested updated labs are not present		x	
Display clinical notes			x
Auditable	x	x	x
Calculate amount of contrast to be administered based on weight & upper limit		x	!
Link contrast prescription to the appropriate imaging examination		x	
Associate the activation of a contrast order with the appropriate exam		x	
Reporting and Notification			
Notify clinician of report status		x	
Automatically notify clinical staff of necessity for updated labs prior to imaging examination		x	
MR Safety			
Entry and viewing of 3T incompatibilities on MRI prescription screen		x	
Display "No 3T" status		x	x

Current DICOM-RD safety feature
! This feature currently fails in PowerChart; criteria for warning are incorrect.