



Quality Improvement of Clinical Cardiac MRI Service Using Analysis of DICOM Image Header Data

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PURPOSE

Cardiac MRI Challenges

- Long image acquisitions due to cardiac gating, respiratory gating, and unique cardiac planes
- High volume and complex caseload
- Limited exam slots

To increase efficiency while maintaining quality service, we analyzed perceived sources of variability in our cardiac MRI division and developed a novel, comprehensive method of analysis to guide departmental policy decisions.

METHODS

We collected cardiac MRI scan data (January 2009 to August 2010; n=1180) and analyzed sources of perceived variability in scan duration including:

- Exam Code
- Scanner Location
- MRI Technologist
- Supervising Radiologist or Cardiologist
- Radiology Fellow

We developed a method of analysis based on Digital Imaging and Communications in Medicine (DICOM) image header fields (Figure 1) and examined DICOM header data for cardiac MRI exams during a targeted three-month period (October to December 2009; n=166) for the following parameters:

- Protocol (cardiomyopathy, arrhythmogenic right ventricular dysplasia [ARVD], myocarditis, aorta, pericardium, mass, valve/shunt, viability, pulmonary vein [PV], and congenital)
- Scan/series duration
- Sources of variability within protocols (localizers, myocardial delayed enhancement inversion time testing, and delayed imaging)

We also reviewed MRI suite wait times to fully measure efficiency of patient flow in cardiac MRI.

AcquisitionDate	0008.0022	20091029
ContentDate	0008.0023	20091029
StudyTime	0008.0030	193816.000000
SeriesTime	0008.0031	142157.000000

Fig. 1. DICOM Image Header Data. Time in hhmmss.

RESULTS

The mean duration of cardiac MRI scans (1/2009-8/2010) was 88 ± 40 minutes, while the official slot length was 90 minutes.

- Exam code, scanner, attending, and technologist were significantly associated with scan duration in univariate analysis
- In our multivariable model, exam code, technologist, and attending were associated with scan duration, accounting for 48% of the variation ($p < 0.0001$)

Parameter	Partial R ²	P value
Exam Code	0.35	<0.0001
Scanner	0.0019	0.07
Attending	0.047	<0.0001
Technologist	0.0021	0.04

Table 1. Partial Correlation of Parameters with Scan Duration in a Multivariable Model.

Given that Exam Code (i.e. indication) was the greatest determinant of scan duration, we analyzed DICOM header data to quantify the effect of this parameter (Figure 2).

- Mean duration of ARVD, pericardium, mass, and congenital protocols was greater than the target 90 minutes at 109 ± 21 , 94 ± 23 , 101 ± 8 , and 102 ± 44 minutes.
- Localizer sequences averaged 12 ± 5 minutes, delayed imaging 16 ± 9 minutes, and MDE tests 4 ± 3 minutes.
- The main protocol accounted for $65 \pm 12\%$ of total scan duration, localizers $19 \pm 18\%$, MDE tests $4 \pm 3\%$; delayed imaging $17 \pm 10\%$
- Protocol type was an important determinant of variation in total scan duration, $R^2 0.55$, $p < 0.0001$

Mean wait time from patient registration at the MRI suite to capture of the first image was 64 ± 45 minutes (Figure 3).

We also analyzed the specific effect of attending cardiologist/radiologist on scan duration (Figure 4).

RESULTS

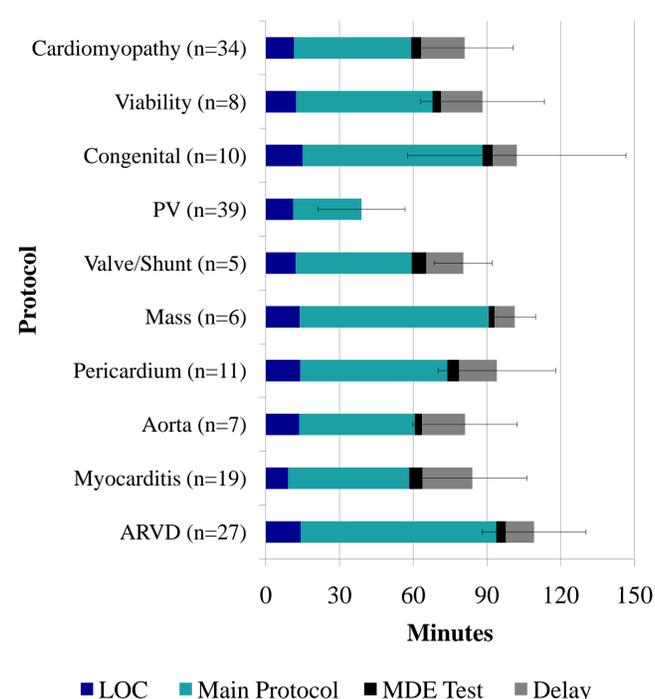


Fig. 2. Protocol Variation. Localizer sequences (LOC), myocardial delayed enhancement inversion time testing (MDE Test), and delayed imaging (Delay).

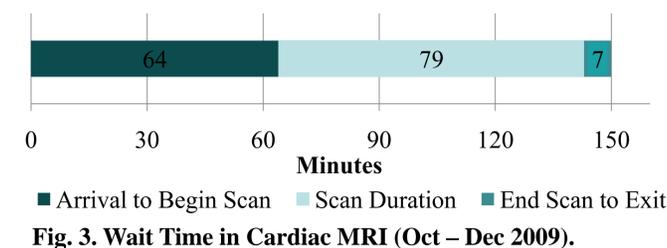


Fig. 3. Wait Time in Cardiac MRI (Oct - Dec 2009).

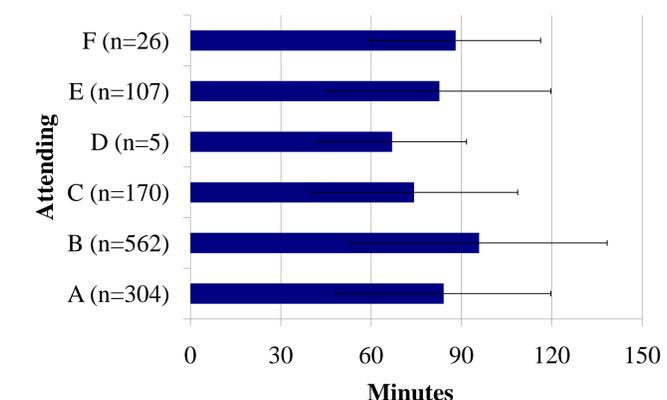


Fig. 4. Attending Scan Duration (Jan 2009 - Aug 2010).

CONCLUSIONS

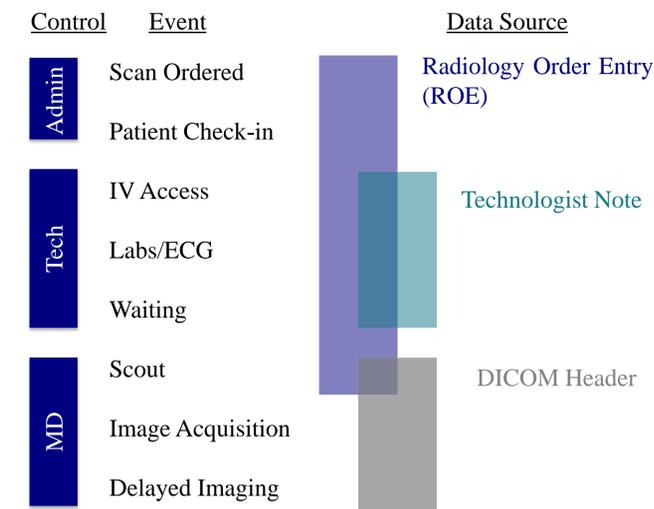


Fig. 5. Cardiac MRI Imaging Chain of Events.

There is a plethora of data available in cardiac MRI from multiple sources (Figure 5). Much of this available data is not collected, leading to the loss of a valuable opportunity for improvement in efficiency.

Review of DICOM header information enabled a systematic, objective, and fair mechanism to seek out and correct underlying causes of variability and excessive scan times.

Future Aims: To thoroughly review and standardize complex protocols prone to variability. Implementation of specific policy changes, with continued DICOM header-based analysis to assess the effects of interventions and to provide prompt feedback to the radiologists and cardiologists on the cardiac MRI service. Additional analysis is needed to assess the specific sequences in each protocol, as well as the diagnostic value of additional time spent on image acquisition.

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