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.

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)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Partial R²</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam Code</td>
<td>0.35</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Scanner</td>
<td>0.0019</td>
<td>0.07</td>
</tr>
<tr>
<td>Attending</td>
<td>0.047</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Technologist</td>
<td>0.0021</td>
<td>0.04</td>
</tr>
</tbody>
</table>

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±12% of total scan duration, localizers 19±18%, MDE tests 4±5%, delayed imaging 17±10%
- Protocol type was an important determinant of variation in total scan duration, R² 0.55, p<0.0001

Mean 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).

CONCLUSIONS

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.

ACKNOWLEDGEMENTS

C. Schlett - Cardiac MR PET CT Program, MGH H. Lumin - Cardiac MR PET CT Program, MGH M.T. Shore - Director of Clinical Operations, Department of Radiology, MGH