

Patient Motion: Small Annoyance or Call To Action?

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Target audience: Radiologists, MR Physicists and Engineers

Purpose: Patient motion frequently degrades MR examinations, often resulting in suboptimal image quality that negatively impacts radiological interpretation. While many motion-correction techniques have been proposed¹⁻⁴, often the most promising methods are available in the research domain only. Additionally, the prevalence of patient motion that results in significantly degraded MR examinations is poorly documented in the literature. We sought to assess the prevalence of significant patient motion in MR examinations of the neuroaxis at an academic level 1 trauma center. Within our population there are a wide range of patients and illnesses and a focus on neurological diseases (especially vascular, traumatic, and infectious), and a large spine population (both traumatic and degenerative).

Materials & Methods: HIPAA and informed consent were waived. The patient population presenting for MR imaging at our institution is comprised of ~50% inpatient and emergency department patients and ~50% outpatients. This study included manual review of one full calendar week of MR examinations of the neuroaxis sent to the picture archiving and communication system (PACS). All exams were performed at a single institution on 3 different MR scanners: a 1.5T outpatient only scanner, and 1.5T and 3T in-hospital scanners capable of accommodating inpatient and outpatient examinations. All patient images were manually reviewed at a PACS station for the detection of significant patient motion; subtle movement within the globes, pulsation artifact, and mild interleaved motion artifacts were generally disregarded.

Results: 70% of the MR examinations performed at our institution are of the neuroaxis (brain, head & neck, and spine). The remaining 30% primarily involve imaging of the musculoskeletal system (~25%), with some general body MR imaging performed (~5%). In this study, 55 of the 175 total MRI examinations of the neuroaxis completed in one calendar week were sent to PACS with at least some motion degradation (31.4%). Within the 55 motion degraded exams, 29 contained additional "repeat" sequences sent to PACS (16.6% prevalence among total cases), for which 27 of these (49.1% of all motion degraded exams) were examinations of the brain, head and/or neck (including MR angiograms), representing 15.4% of total completed examinations. Thus, a total of 84 sequences were motion degraded, and 47 of these were dedicated to imaging the human brain (56%). These numbers likely represent an underestimation of the exact prevalence of motion degradation affecting MR examinations, since partially completed sequences and failed examinations not sent to PACS were not included in our evaluation. Furthermore, examinations requiring sedation for motion control were not differentiated. While an exact dollar amount is difficult to calculate given hospital overhead costs, the variability in sedation requirements, and in hospital referral and practice patterns, we estimate an average cost of at least \$813.44/hour* (\$13.56/min) can be lost due to patient motion (lower than the associated outpatient reimbursement rate for MR examinations). This would represent a cost, using conservative estimates, of \$5,694 per week at our institution, assuming 5-minutes lost per repeat sequence.

Conclusions: Patient motion represents a frequent cause of MR image degradation and potentially affects up to 31% of neuroaxis MR examinations in this patient population, in keeping with a prior report that significant motion may be seen in 10-42% of images (based on computed % of missing data)⁵. Since the indication for patient sedation is multifactorial (and may include the anticipation of motion), this may increase motion-related imaging costs, which we conservatively estimate to approach \$296,092.00/year. The retrospective nature of this study, small sample size, and short duration may appear to weaken the results; however we think that these costs are underestimated given that not all attempted/failed examinations may have been captured by this study design.

Clinical Relevance: Patient motion represents a formidable challenge, potentially affecting much of the global MR community, and may result in significant inefficient use of hospital resources and suboptimal radiological interpretations. Elimination of wasted effort and unnecessary work is increasingly important as payors focus on controlling reimbursement for medical services as part of the general trend toward decreasing the cost of US medical care. The results of this study suggest that more attention should be directed toward providing practical solutions to this dilemma.

*Based on inpatient estimates from the 2010 calendar year data using relative value units (RVU), current procedural terminology (CPT), and volume calculations and does not include any associated professional fees.

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