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Title of session/talk: Session 1: The Problem of Motion, Current Commercial Solutions, Research Overview & Hands-On Introduction

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Highlights

- **Patient motion often results in artifacts that frequently degrade MR examinations, yet the prevalence of artifacts related to patient motion is poorly documented in the literature.**
- **Patient motion artifacts represent a frequent cause of MR image degradation that potentially affects up to 31% of neuroaxis MR examinations.**

Problem summary

Patient motion artifacts frequently degrade MR examinations, often resulting in suboptimal image quality that negatively impacts radiological interpretation. Several motion-correction techniques have been proposed, including[1-4], but often the most promising and new methods are available primarily in the research domain only. Additionally, the prevalence of patient motion artifacts that results in significantly degraded MR examinations is poorly documented in the literature.

Body

We sought to assess the prevalence of significant patient motion artifacts in MR examinations of the neuroaxis at an academic level-1 trauma center, and estimate the financial implications of patient motion artifacts.

Materials & Methods

An IRB approved retrospective HIPPA compliant study was performed in which patient consent was waived. This study included manual review of one full calendar week of MR examinations 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 OP only scanner, and 1.5T and 3T in-hospital scanners capable of accommodating IP and OP examinations. All patient images were manually reviewed at a PACS station for the detection of notable rigid body motion. Subtle movement of the globes, pulsation artifact, breathing and cardiac-related motion, and minimal motion artifacts appearing on a single interleave were disregarded.

Results

The patient population presenting for MR imaging at our institution is comprised of ~50% inpatient (IP) and emergency department (ED) patients and ~50% outpatients (OP). This was performed in a broad patient population with a wide range of illnesses and a focus on neurological diseases (especially vascular, traumatic, and infectious), and a large spine population (both traumatic and degenerative). 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%), which are preferentially imaged at other sites within the University of Washington medical system.

In this study, 175 total MRI examinations were completed in one calendar week (53.1% were OP examinations; 46.9% were IP and/or ED examinations). Of these, 55 (31.4%) were sent to PACS with at least some motion degradation (47.6% of IP/ED exams; 17.2% of OP exams), similar to a prior study (reportedly seen in 10-42% of images[5]). 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). 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 the complex and non-transparent hospital costs (in general), the current reimbursement scale, the variability in sedation requirements, and in hospital referral and practice patterns, we estimate the cost to the hospital in correcting patient motion may be as much as $813/hour* ($13/min), which 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, and that time lost could be used to image alternate patients.

Conclusions

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. We speculate that the prevalence of patient motion artifacts is underestimated, as partially completed sequences and failed exams not sent to PACS were not captured by our study design and not included in our evaluation, and the indication for patient sedation is multifactorial (and may include the anticipation of motion), which may increase motion-related imaging costs. In addition, examinations requiring sedation for motion control were not differentiated. The retrospective nature of this study, small sample size, and short duration may appear to weaken the results; However, we believe that these costs are underestimated and that motion artifacts and repeat sequences represent an additional, unclear cost that is not reimbursed in the current system. 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 this represents an opportunity to improve efficiencies in health costs and that more attention should be directed toward providing practical solutions to this dilemma.

*Based on 2010 calendar year inpatient estimates using relative value units, current procedural terminology, and volume calculations and does not include associated professional fees.

Summary:

- **Patient motion artifacts represent a frequent cause of MR image degradation that potentially affects up to 31% of neuroaxis MR examinations.**
- **Patient motion artifacts potentially impact much of the MR global community, and result in frequently repeated sequences. The true financial impact of patient motion artifacts is unclear.**
- **Reduction in patient motion artifacts represents an opportunity to improve health care efficiency by improving strategies.**

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