

Radiologists make more errors interpreting off-hours body CT studies during overnight assignments compared to daytime assignments

By Dr. M D Patel

Hospital-based radiology, with studies performed on increasingly sicker inpatients and increasing numbers of patients in the emergency room, demands attention 24 hours per day, 7 days per week. The work performed in the evening, overnight, weekends, and holidays is typically collectively considered “off-hours”, and practices have turned to a number of strategies to provide coverage. These strategies include outsourcing using teleradiology, insourcing with an internal group of designated emergency radiologists, or rotating emergency work among radiologists who usually focus on other studies during “on hours” [1, 2]. The night float model can apply to any of these approaches, referring to when an individual interpreting images overnight does so for several consecutive days and does not work during the day. This schedule is especially common in academic institutions using trainees [3, 4]. But do radiologists who typically work during the day and who occasionally engage in the night float shift make more mistakes than they otherwise would during the day? This article summarizes the results of a recent study that examined the collective error rate for radiologists interpreting body CT studies during overnight off-hour assignments compared to their same collective error rate during daytime off-hour assignments

There is increasing research that documents the impact of overnight work [5-8] and fatigue [7,

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9-11] on radiologist performance. Both experimental and empirical studies indicate that diagnostic accuracy suffers when radiologists are fatigued [5-9, 12-14], but many of these studies of imaging interpretive errors committed during overnight shifts have focused on radiology residents (5-). Moreover, they have not compared the performance of radiologists at night as compared

to their same performance during the day, to investigate any possible contribution to error by circadian misalignment.

Our retrospective study was designed to compare the rate of clinically significant interpretation errors for CT examinations of the abdomen and/or pelvis (“body CT studies”) interpreted off-hours by radiologists employed in an academic fellowship not accredited by the Accreditation Council for Graduate Medical Education (ACGME) based on whether the off-hours work assignment was at night or during the day.

DESIGN AND METHODOLOGY

The Department of Radiology at Mayo Clinic Arizona is an academic subspecialty-oriented practice, in which each attending radiologist has completed a fellowship; the attending radiologists are organized into subspecialty Divisions, one of which is Abdominal Imaging. The department has employed radiology fellows—American Board of Radiology (ABR) board-certified or eligible individuals who seek one additional year of subspecialty training after completing a diagnostic radiology residency—since 2000. One unique aspect of Mayo Clinic Arizona is that the department’s subspecialty fellowship program preceded development of a Diagnostic Radiology residency program, which was not fully constituted until July 2018. Therefore, unlike other academic medical centers in the United States, Mayo

Clinic Arizona has more experience with the off-hours work performed by fellows as compared to residents.

Between July 2014 and June 2018, body CT studies that were completed during “standard” working hours, defined as 7 am to 8 pm on Monday-Thursday, or 6 pm on Friday, would have primary interpretation by an Abdominal Division-attending radiologist. During off-hours work assignments (overnight assignments from 8 pm to 7 am Monday through Thursday, overnight assignments from 6 pm to 7 am on Friday through Sunday, or day assignments from 7 am to 6 pm on weekends and holidays), these body CT studies would be independently interpreted by an in-house fellow, who was assigned to a rotating off-hour assignment, always with at least 11 hours off work prior to the assignment, and never taking more than 5 assignments during any 7 day period. An attending radiologist (usually an Abdominal Division radiologist) working remotely would review these studies no more than 10 hours after initial interpretation, revising and marking those with discrepancies that had impact to acute or follow-up care in a web-based database for quality purposes. Cases with discrepancies marked as impacting patient care were reviewed quarterly by the Abdominal Division as part of quality assurance; for this study, these were designated as cases with errors. For the collective group of fellows, statistical tests were used to evaluate the difference in error rate for overnight off-hours assignments compared to daytime off-hour assignments, the error rate in the first half compared to the second half of an assignment, and the proportion of radiologists with higher night error rate.

RESULTS

During the study period, 10,090 body CT studies were independently interpreted by 32 radiology fellows during an off-hours assignment, with 9610 (95.2%) having been reviewed by Abdominal Division attendings. For all studies, 2.0% (44/2195) of day

body CT interpretations had errors while 3.0% (240/7895) of night CT interpretations had errors ($p = 0.02$); of the subset reviewed by Abdominal Division attendings, there was no difference in the error rate, with interpretation errors affecting care identified in 44 of 2164 day studies (2.0%) and 226 of 7220 night studies (3.0, $p = 0.02$). Fewer fellows had a higher error rate during the day (10 of 32, 31.3%) compared to those who had a higher error rate during the night (22 of 32, 68.8%), which was statistically significant ($p = 0.03$). Diagnostic error rates were lower (9/824, 1.1%) in the first half of the day assignment from 7:00 AM to 11:59 AM compared to the second half from 12:00 PM to 5:59 PM, but this comparison was not statistically significant (35/1371, 2.6%; $p = 0.07$). Error rates were significantly lower (115/4537, 2.5%) in the first half of the night assignment from 6:00 PM to 11:59 PM compared to the second half from 12:00 AM to 6:59 AM (125/3358, 3.7%; $p = 0.002$). The work intensity (number of all studies interpreted) was lower during night assignments compared with day assignments.

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DISCUSSION

Our data show that radiologists working off-hours made 50% more body CT interpretation errors at night as compared to during the day (3.0% vs 2.0%, $p = 0.02$), with highest error during the latter part of the night shift (3.7%; $p = 0.002$). Making no claim of direct evidence of the cause of error variation, we suggest a role for circadian misalignment because fellows had higher error rates after midnight despite lower work intensity overnight compared to the day and despite duty hour accommodations promoting rest. Nevertheless, our experience also supports the idea that fatigue contributes to diagnostic

error, since error rates were higher in the latter aspect of any given assignment (day or night). The fact that our observations were made on the work of radiologists who were beyond residency has important quality implications, not only for selecting which studies stand to benefit most from increased quality scrutiny, but also for determining how that scrutiny should be implemented.

Double reading is an established strategy to mitigate radiology errors [15], but providers can be frustrated by report revisions that necessarily ensue when double reading is employed because this increases their work, as patients may need to be contacted with changes in management or follow-up. Consequently, there is pressure to provide a final report for off-hours studies in “real time” which will not be reviewed [4], leading to increased demand for in-house attending coverage for emergency imaging [3], even if that means using a non-expert reviewer in the middle of the night who renders a report that is not subject to subspecialty review.

There are two factors that should give one pause when pursuing this strategy.

First, it is known that radiologist expertise relative to study difficulty contributes to interpretation error [16]. Using resources to employ emergency radiologists for final interpretation or over read in the middle of the night instead of pursuing morning subspecialty review has potential drawbacks for any practice that is otherwise organized along subspecialty lines as a method to pursue increased quality. If so-called emergency radiologist interpretations are just as good as subspecialized radiologist interpretations, why would there be any value in subspecialization?

Second, if there is a fundamental limitation in circadian alignment for radiologists periodically working overnight, as indicated by our study, it would be fallacious to assume that such misalignment does not impact emergency radiologists if these individuals rotate in and out of these

off-hours assignments. When a practice pursues strategies to achieve the highest quality of work, the impact of circadian misalignment and fatigue on diagnostic error will need to be respected in determining which studies might benefit from double reading by a rested circadian-aligned subspecialist [17].

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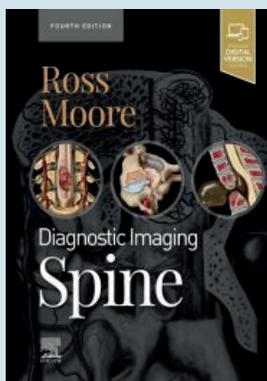
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Book Review Diagnostic Imaging: Spine, 4th Edition

By Jeffrey S. Ross & Kevin R. Moore
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Covering the entire spectrum of this fast-changing field Diagnostic Imaging: Spine fourth edition is an invaluable resource for general radiologists, neuroradiologists and trainees—anyone who requires an easily accessible highly visual reference on today’s spinal imaging. Drs. Jeffrey Ross & Kevin Moore and their team of highly regarded experts provide updated information on disease

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