Academic medical centers have long relied on radiology residents to provide after-hours coverage, which means that they essentially function with autonomy. In this approach, attending radiologist review of resident interpretations occurs the following morning, often by subspecialist faculty. In recent years, however, this traditional coverage model in academic radiology departments has been challenged by an alternative model, the 24-hour attending radiologist coverage. Proponents of this new model seek to improve patient care after hours by increasing report accuracy and the speed with which the report is finalized. In this article, we review the traditional and the 24-hour attending radiologist coverage models. We summarize previous studies that indicate that resident overnight error rates are sufficiently low so that changing to an overnight attending model may not necessarily provide a meaningful increase in report accuracy. Whereas some centers completely replaced overnight residents, we note that most centers use a hybrid model, and overnight residents work alongside supervising attending radiologists, much as they do during the day. Even in this hybrid model, universal double reading and subspecialist final review, typical features of the traditional autonomous resident coverage model, are generally sacrificed. Because of this, changing from resident coverage to coverage by an attending radiologist that is 24 hours/day, 7 days/week may actually have detrimental effects to patient safety and quality of care provided. Changing to an overnight attending radiologist model may also have negative effects on the quality of radiology resident training, and it significantly increases cost.

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After-hours Coverage at Academic Medical Centers

In the traditional academic medical center training model, direct patient care is provided by the so-called house staff: interns, residents, and fellows acting with varying degrees of autonomy with attending physician supervision. This trainee-centered care model for the academic medical center was created by Sir William Osler in the 19th century. In this model, trainee autonomy progressively increases with experience and seniority, with cascading supervision of the house officers, whereby more senior residents and fellows supervise those who are more junior, and all are supervised by an academic faculty physician who meets with them at a minimum on a daily basis. The attending physician reviews the residents’ work and assumes responsibility for the care provided by the house staff under their supervision. In radiology training programs working under the traditional academic house staff model, imaging examinations are initially interpreted by radiology residents, who dictate preliminary reports that are finalized after review by a supervising attending radiologist. After hours, radiology residents function autonomously, with emergency department and other clinicians basing their care decisions on the radiology residents’ preliminary readings. This autonomous resident night coverage duty is limited to residents in year 2–4 of residency. Resident overnight preliminary interpretations are typically reviewed and finalized promptly the following morning by an attending radiologist, 7 days a week. This so-called trainee-centered approach to patient care has been a part of the educational process since the first formal radiology residencies were established in the late 1930s and 1940s. Radiology residents are required to make independent decisions that have immediate effects on patient care, but have a safety net of a delayed second review and teaching input from the attending faculty in each subspecialty. In this model, the residents’ reports are not final because they are occasionally edited or even superseded by the subspecialist radiologist attending. The system of double reading with feedback is expected to lead to prompt detection of errors before they cause patient harm. The training process also leads to progressive reductions in both resident error frequency and severity over time.

Challenges to the Resident Coverage Model

The traditional resident-based care model has been questioned in recent years throughout academic medicine because of concerns for increasing the speed of care and patient safety, with greater expectations for direct patient care that is performed by the attending physician. As a result,
Summary

Available data indicate that overnight coverage by radiology residents with delayed over-reading by subspecialist faculty has a low error rate comparable to that of attending radiologists in the emergency setting. Previous studies suggest that overnight radiology resident coverage in teaching hospitals may improve final report accuracy primarily because of the benefit of routine double reading.

Implications for Patient Care

- Overnight residents functioning autonomously after hours provide a high standard of care. Error rates appear to be low and comparable to those of attending radiologists. Inherent double reading facilitates rapid detection of errors.
- Twenty-four hour attending coverage may reduce report turnaround times and reduce the burden for emergency department callbacks. Twenty-four hour attending coverage does not appear to reduce patient length of stay in the emergency department, rates of hospital admissions, or specialist consultations.
- Twenty-four hour attending coverage reduces resident autonomy, with negative implications for resident training and preparedness for independent practice.

there has been a reduction in resident autonomy across many medical and surgical specialties. The potential for negative effects on the radiology training program has been described (1).

In radiology, the primary area where residents still function with some degree of autonomy is when they provide after-hours coverage. In recent years, a growing number of academic radiology departments have considered or implemented after-hours attending coverage (ie, an attending radiologist onsite 24 hours a day, 7 days a week [hereafter referred to as a 24/7 attending]), with varying degrees of resident involvement. The goal of after-hours attending coverage is to improve report accuracy, expedite finalization of reports, and improve patient care in the emergency department setting (2). Potential benefits would include increased throughput of patients in the emergency department with less need to recall patients for discrepant readings. Radiology attending coverage would also match attending coverage of emergency physicians and trauma surgeons in institutions where those individuals are also in house. The principal rationale for implementing 24-hour attending coverage is three-fold: an after-hours attending radiologist provides a higher level of care than the traditional resident model, it allows a more rapid report turnaround time for the emergency department, and presence of an overnight attending radiologist enhances the status of radiologists in the eyes of the emergency physicians and hospital administrators.

There are two lines of evidence that raise uncertainties regarding the preceding rationale: (a) substantial benefits of double reading for error prevention in all aspects of radiology have been clearly demonstrated (3), and double reading, although inherent to the resident coverage model, is either diminished or lost in the 24-hour attending model; and (b) dedicated attending coverage is typically associated with diminution or loss of subspecialist radiologist final review.

Unless great care is taken to construct the 24-hour attending coverage model, there is the potential for a two-tiered standard of care in the academic medical center: full subspecialist-level care offered for patients during the day and lower level of specialization for patients who are in the emergency department overnight. For example, subspecialty-trained radiologists with neuroradiology or musculoskeletal radiology fellowships would act as generalists in other areas, such as chest or abdominal radiology, when working overnight. A solution might be for these night positions to be filled exclusively by emergency radiology subspecialists (ie, persons who have completed a year of emergency radiology fellowship training), however, these subspecialists are relatively rare because of the limited number of those training positions and potentially lower interest by trainees (4).

Evidence regarding Accuracy of Resident versus Attending Radiologist

In 1949 Leo Henry Garland, MD, (5) showed and subsequently other researchers have shown that experienced, expert attending radiologists are not perfectly accurate, but instead have a fairly predictable error rate. The error rate of attending radiologists for all types of radiologic studies, generally measured as the rate of discrepant readings compared with their peers, has essentially not been credibly measured below 3%–4% (6–8).

In multiple studies, radiology residents’ discrepancy rates for significant missed overnight findings that were detected later by attending subspecialized radiologists is similar to this and sometimes lower, often reported below 2% (Table 1). For this comparison, discrepancy rates between the preliminary resident and final faculty interpretations are used as a proxy for rates of overnight resident interpretive error. For example, a study by Cooper et al (9) of a series of 141,381 examinations found that residents had significant discrepancies with the final attending radiologist’s interpretation in only 1% of the cases, with slightly better performance observed with greater resident experience. In 2016, in a prospective study of resident on-call accuracy, Mellnick et al (10) reported an average resident error rate of 1.4% on the basis of a review of 153,420 examinations. In the same study, the rate of critical discrepancy (ie, findings that are potentially life threatening and that might require immediate or near-immediate medical therapy) was only 0.007%. Similar findings of a low rate of resident-attending discrepancies leading to patient management changes were published by Williams et al earlier this year (16). However, increased error rates have been reported in preliminary reports issued by residents (17) and faculty (18) who work more than 10 consecutive hours overnight, and these error rates have been attributed to fatigue and circadian effects.

Quality and Patient Safety Concerns

The principal quality and patient safety concern in switching to a 24/7 attending for after-hours coverage is the compromise of error detection from loss of double reading in the subset of cases for which there is no resident involvement. Because interpretive errors inevitably occur, a premium must be placed on error detection for the prevention of patient harm. It is generally accepted that perceptual errors, in which abnormal findings are simply not perceived despite being deemed obvious in retrospect, are the primary type of error that radiologists are prone to making (5–7, 19). These errors appear to be random in occurrence, and since Garland’s time, the only remediation
that has been shown to be effective for these types of errors is double reading, as Garland recommended (5), and which has been recently discussed in these pages (3,20). This benefit is at least partially lost with the move to an overnight attending radiologist, whose interpretations are both immediate and final, and will generally not be reinterpreted by a subspecialist the following day.

The double-reading model recognizes that a resident's skill in interpreting a particular image almost certainly falls below that of the specialist who later reinterprets the image. It is understood that residents' overnight interpretations will contain errors but that most are discovered and corrected the following morning. Error detection and correction not only allows for improvements in the trainee's mental model but also enhances overall quality of care and patient safety. Double reading, along with a typically higher degree of subspecialization in the final review, are key elements of the high standard of care inherent to the traditional resident coverage model.

The power of double reading in the trainee-and–attending radiologist dyad model was highlighted in a recent study by Balthazar et al (21), which showed that radiology reports generated without trainee involvement were up to 12 times more likely to include a later addendum than were reports with trainee involvement. The need for an addendum is generally indicative of the presence of one or more errors in the radiology report that were discovered only after the report was finalized by an attending radiologist. Arguably, the main benefit of trainee involvement in this study was from double reading. The results provide an estimate of the value of double reading toward improving report accuracy: double reading may have provided as much as a 12-fold benefit.

Together, these data on the low rate of resident interpretive discrepancies and the power of double reading for error detection support the conclusion that an overnight attending radiologist will not reliably provide a higher level of interpretive accuracy than the traditional resident-and–attending radiologist dyad.

### Training Mission

There is evidence to suggest that the loss of resident autonomy after hours is harmful to the educational mission in radiology, and this has been noted in other specialties (22). Collins et al (1) published the results of a survey of six academic medical centers showing that the majority of faculty and residents surveyed felt that the loss of resident autonomy had negative effects on resident training and their subsequent confidence regarding entering the field as independent practitioners. In this survey, residents in programs with 24/7 attending coverage reported to have initially interpreted only 46% of examinations, and the balance was only interpreted by a faculty member, compared with 81% of examinations initially interpreted by a resident in programs with traditional resident-centered after-hours coverage. In another survey published in 2016 (23), 38% of radiology residents reported that a 24/7 attending coverage model had a negative effect on their ability to independently interpret studies. Most concerning was that more than 50% of 4th-year residents cited this negative effect, whereas 43% of all respondents were neutral regarding this question. Other negative effects to resident education from the switch to 24/7 attending coverage have also been cited in the literature (24). However, one single-institution, survey-based study (25) reported that residents felt positively about the addition of an overnight attending, with less anxiety, apprehension, and stress related to their after-hours work and with no significant decrement in their interpretive confidence after their department instituted an overnight attending physician.

Despite the subjective worsening of the stresses related to after-hours call, in our collective experience we noted that independent night call for residents has recently become an attractor for candidates who choose a radiology residency.

### Cost and Cost Effectiveness

Published data regarding the cost effectiveness of an overnight attending radiologist are limited. In their article, Coleman et al (26) discussed whether their in-house 24/7 attending coverage was cost effective. They noted that their report turnaround time for cases in the emergency department was substantially improved, however, this benefit did not translate into any measurable decrease in patient length of stay in the emergency department, which was their target metric. These authors concluded that the cost-related results of the change were disappointing.

The costs of providing a workable overnight service are high—typically several qualified individuals must be recruited, all of whom must be comfortable interpreting the full range of radiologic studies in the necessary rapid timeframe, and all of whom are willing to work entirely (or primarily) at night.

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### Table 1: Accuracy Rates in the Literature of Resident Overnight Interpretations

<table>
<thead>
<tr>
<th>Author</th>
<th>Year Published</th>
<th>No. of Examinations</th>
<th>Discrepancy Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooper et al</td>
<td>2008</td>
<td>143,381</td>
<td>1.0</td>
</tr>
<tr>
<td>Mellnick et al</td>
<td>2016</td>
<td>153,420</td>
<td>1.35</td>
</tr>
<tr>
<td>Emergency</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inpatient</td>
<td></td>
<td></td>
<td>1.8</td>
</tr>
<tr>
<td>Weinberg et al</td>
<td>2015</td>
<td>416,413</td>
<td>1.7</td>
</tr>
<tr>
<td>Kung et al</td>
<td>2013</td>
<td>2219</td>
<td>1.8</td>
</tr>
<tr>
<td>Tomich et al</td>
<td>2013</td>
<td>193,722</td>
<td>0.33 (0.23–0.42)*</td>
</tr>
<tr>
<td>Branstetter et al</td>
<td>2007</td>
<td>65,780</td>
<td>1.9</td>
</tr>
<tr>
<td>Carney et al</td>
<td>2003</td>
<td>929</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Note: Table summarizing evidence of residents’ high degree of interpretive accuracy as shown in seven published studies over the past 15 years (9,10,14–18).

*Data are average; data in parentheses are range.
A recent radiologist manpower survey (27) by the American College of Radiology suggested that the demand for after-hours radiologists exceeds the available manpower supply. Whereas nighthawk services abound in the private sector, the nighttime work schedule may be viewed as undesirable in the academic setting (perhaps seen as potentially interfering with academic career advancement), therefore making recruitment and retention of night radiologists an even greater challenge for an academic radiology department. Coleman et al (26) reported that at their institution the radiology faculty who work at night in the emergency department received an 18% salary premium. Most academic departments also provide extra paid vacation time to overnight radiologists, often in the form of a work schedule that consists of 1 week working and 2 weeks not working. Despite the higher salary, generous time off and other benefits, concerns for high stress levels and an increased risk of burnout among night radiologists along with relatively high job turnover have been reported (28,29) with associated recruitment-related and other costs.

**Summary**

Although the overnight attending radiologist model is increasing in popularity and accounts for up to 50% of academic centers by some estimates (2), there is reason to question whether this model provides measurable benefit for patients, such as reducing length of stay in the emergency department, reducing the rate of hospital admissions, or clearly improving diagnostic accuracy. The overnight attending radiologist model also eliminates an effective means for error detection and harm prevention, namely routine double reading of all overnight images, and in some scenarios this model may also create a lower standard of care (ie, less subspecialized) for after-hours services. This model also appears to have detrimental effects on residency training, which could compromise the future viability of the subspecialty of diagnostic radiology. If we sacrifice the training of future radiologists for expediency, this is akin to eating the seed corn; there may be short-term gains in customer satisfaction, but we will ultimately produce a long-term decrement in patient care (Table 2). However, radiology departments that use residents for overnight coverage must commit to continuously monitoring rates of interpretive discrepancy, and must be prepared to take swift remedial action if needed.

It is worth noting that in the future, improvements in computer-aided detection made possible by advances in machine learning and artificial intelligence applications in radiology may provide a feasible alternative to radiologist double reading; such systems would provide equal benefits in error reduction to both resident and attending radiologists, and thus are not likely to affect the decision regarding whether an academic department should switch from the traditional resident-coverage model to the overnight attending model.

Despite our concerns and the evidence that supports them, we acknowledge that the observed trend away from the traditional resident coverage to an overnight 24/7 attending model will likely continue. The transition to overnight attending radiologist coverage is also likely to be an irreversible one for most academic departments because the perception that it represents a higher standard of care will impede returning to the traditional model.

The trend toward switching to overnight attending radiologist coverage in academic radiology presents our specialty with numerous complex challenges and unintended consequences. It is our hope that academic radiology departments will consider these ramifications carefully in weighing their options and future directions, particularly regarding potential negative effects on quality and patient safety, and the effect that the presence of an overnight attending radiologist has on resident training, autonomy, and preparedness.

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