AJR FOCUS ON:

Effects of Performance Feedback Reports on Adherence to Evidence-Based Guidelines in Use of CT for Evaluation of Pulmonary Embolism in the Emergency Department: A Randomized Trial

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OBJECTIVE. The purpose of this study was to assess whether implementing emergency department (ED) physician performance feedback reports improves adherence to evidence-based guidelines for use of CT for evaluation of pulmonary embolism (PE) beyond that achieved with clinical decision support (CDS) alone.

SUBJECTS AND METHODS. This prospective randomized controlled trial was conducted from January 1, 2012, to December 31, 2013, at an urban level 1 adult trauma center ED. Attending physicians were stratified into quartiles by use of CT for evaluation of PE in 2012 and were randomized to receive quarterly feedback reporting or not, beginning January 2013. Reports consisted of individual and anonymized group data on guideline adherence (using the Wells criteria), use of CT for PE (number of CT examinations for PE per 1000 patients), and yield (percentage of CT examinations for PE with positive findings). We compared guideline adherence (primary outcome) and use and yield (secondary outcomes) of CT for PE between the control and intervention groups in 2013 and with historical imaging data from 2012.

RESULTS. Of 109,793 ED patients during the control and intervention periods, 2167 (2.0%) underwent CT for evaluation of PE. In the control group, guideline adherence remained unchanged between 2012 (78.8% [476/604]) and 2013 (77.2% [421/545]) ($p = 0.5$); in the intervention group, guideline adherence increased 8.8% after feedback report implementation, from 78.3% (426/544) to 85.2% (404/474) ($p < 0.05$). Use and yield were unchanged in both groups.

CONCLUSION. Implementation of quarterly feedback reporting resulted in a modest but significant increase in adherence to evidence-based guidelines for use of CT for evaluation of PE in ED patients, enhancing the impact of CDS alone. These results suggest potentially synergistic effects of traditional performance improvement tools with CDS to improve guideline adherence.

Keywords: imaging overuse, performance improvement, physician feedback, pulmonary embolism, randomized controlled trial

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With rising health care costs, a number of recent initiatives have focused on increasing the appropriateness of tests ordered by physicians, to reduce waste and improve quality of care. In parallel, national campaigns such as Choosing Wisely and local efforts have focused on improving utilization of high-cost imaging [1, 2]. Approximately 5% of U.S. health care costs are for emergency department (ED) visits [3]; thus, many of these efforts have been led by emergency medicine physicians and radiologists and focused on patients cared for in the ED [4]. Two federal regulations promote use of health information technology, in the form of clinical decision support (CDS), to improve appropriate use of imaging. CDS, including for imaging, is a fundamental component of stage II of meaningful use regulations [5, 6] and provides relatively small incentives for providers to adopt CDS. The more recent Protecting Access to Medicare Act of 2014 [7], however, requires use of imaging CDS for targeted high-cost ambulatory and ED imaging procedures, beginning in January 2017, to receive payment for imaging services. However, best practices for the design, implementation, and even the content of evidence presented in imaging CDS are still being debated [8, 9].

One such group of patients, those presenting with symptoms suggestive of acute pulmonary embolism (PE), has been the focus of considerable attention. Use of CT for diagnosis of PE has increased significantly without a significant change in mortality, suggesting evidence of overdiagnosis [10]. The diagnosis of PE requires risk stratification and, potentially, use of CT—which may carry risks of both radiation and renal injury owing to administration of IV contrast material [11]. Whereas CDS has been shown to improve adherence to evidence-based guidelines for evaluation of suspected PE [12], there is still opportunity for additional improvement because a significant portion of CT examinations for PE remain nonadherent to evidence-based guidelines even after CDS implementation [13].

Physician-specific performance feedback reports are a well-established tool for quality improvement initiatives [14, 15]. Our objective was to assess the effect of performance feedback reports on adherence to evidence-based guidelines for use of CT for evaluation PE in the ED. Our secondary objective was to determine the combined impact of these reports on use and yield of CT for PE. We hypothesized that the addition of performance feedback reports to CDS implementation would improve adherence to evidence-based guidelines for use of CT for evaluation of PE beyond that achieved with CDS alone, as well as decrease use and increase yield of CT for PE.

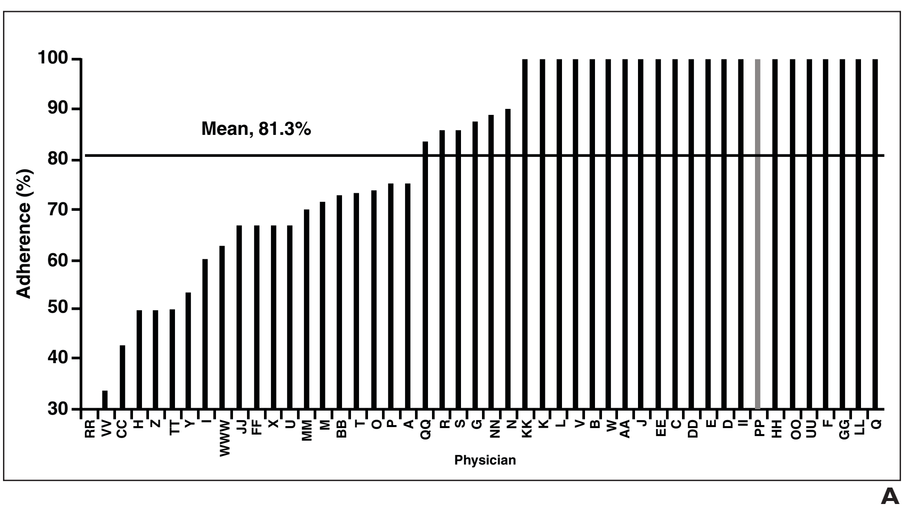
Subjects and Methods

Setting and Subjects

This institutional review board–approved and HIPAA-compliant prospective randomized controlled trial was conducted from January 1, 2012, to December 31, 2013, in the ED of an urban level 1 adult trauma center. Imaging CDS was deployed for all requests for CT for evaluation of PE throughout the study period, as previously reported [12, 13]. Ordering providers could ignore the evidence presented in CDS and proceed with requests for CT for evaluation of PE that deviated from evidence-based guidelines without interference. We included all attending emergency physicians and, before randomization, stratified them into quartiles by use of CT for PE in 2012. Attending physician assignment in the ED was random, with all attending physicians being equally likely to work in all areas of the ED. Attending physicians were then randomized by quartile into two groups using a random number generator; the intervention group received individualized feedback reports on adherence to evidence-based guidelines on use of CT for evaluation of PE, use (defined as number of CT examinations for PE per 1000 patients), and yield (defined as percentage of CT examinations for PE with positive findings), whereas the control group did not.

Intervention

The intervention consisted of quarterly performance feedback reports, sent via e-mail, that displayed both individual physicians' statistics and their performance compared with anonymized results for the entire group of emergency physicians (Fig. 1). The frequency of feedback report distribution was selected to mirror other physician performance feedback reporting initiatives at our institution. In addition, physicians were given the medical record numbers of any patients for whom the CT examinations ordered for evaluation of PE were deemed nonadherent to evidence-based guidelines by CDS to facilitate individual chart review. These quarterly reports began in January 2013; both new physicians who joined the group



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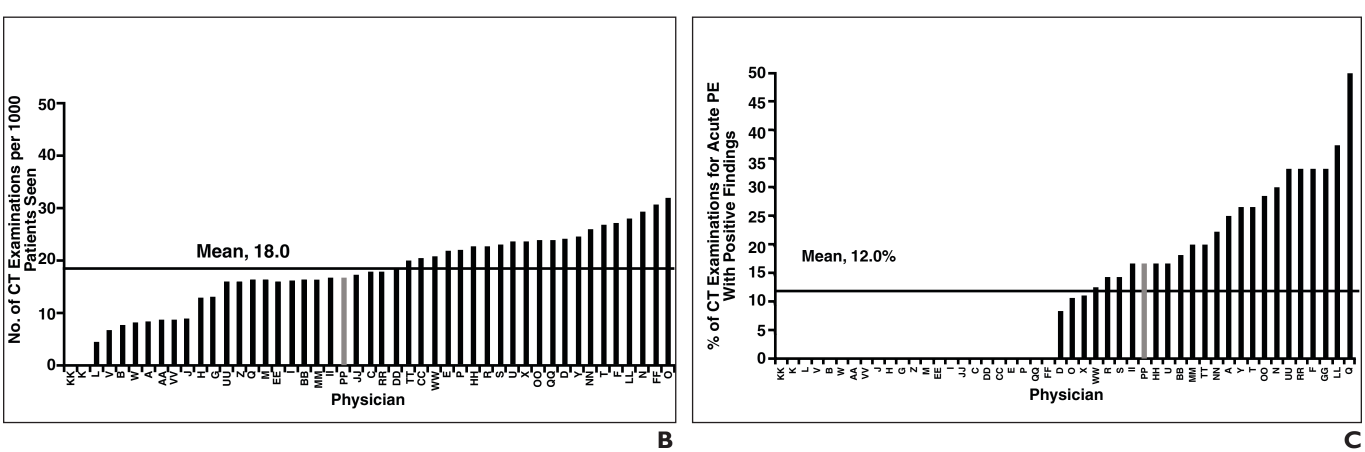

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Fig. 1—Sample feedback report with physicians anonymized and individual data highlighted in gray column.
A, Adherence to evidence-based guidelines, with mean of all attending physicians noted.
B, Use of CT evaluation for pulmonary embolism (PE), with mean of all attending physicians noted.
C, Yield of CT evaluation for PE, with mean of all attending physicians noted.

after this date and physicians who left before study completion were excluded from the analysis.

Data Collection

Use of CT for evaluation of PE for each physician was calculated using the number of completed CT examinations for PE and the total number of patients seen during the quarter. Yield of CT for acute PE was determined using a previously validated natural language processing tool and reported as a percentage of total CT examinations for PE that were completed [12]. Adherence to evidence-based guidelines was determined by applying the Wells criteria and reviewing the serum D-dimer levels (if obtained) [16]. The discrete criteria making up the Wells criteria were prospectively documented in our computerized physician order entry (CPOE) system at the time of order entry, as previously reported [12].

To determine whether any differences observed in guideline adherence were the result of "gaming the system" (i.e., erroneous data entry to either avoid potentially onerous CDS interactions or enhance the physician's apparent performance on feedback reports), we performed manual chart reviews of 100 randomly chosen charts from each of the two groups. These chart reviews were performed by an attending physician to assess concordance between adherence to evidence-based guidelines calculated from the CDS data and adherence to evidence-based guidelines calculated from data documented in the ED visit clinical notes. The sample size was determined using a baseline concordance of 90%, as previously reported [17], and chosen to detect a difference in concordance of 15% between groups with a power of 80% and an alpha error rate of 5% [17]. Demographic data (including sex, age, and years since residency training as measured at the beginning of the study period) were also captured for all the attending physicians in the study.

Outcome Measures and Statistical Analyses

We compared adherence to evidence-based guidelines (the primary outcome measure) and use and yield (secondary outcome measures) of CT examinations for PE between the control and intervention groups in 2012 to determine the historical baseline characteristics of the groups. We then implemented the quarterly feedback reports and compared outcomes, both between the two groups and between each group and its historical control. An a priori sample size calculation for the primary outcome measure indicated that we would need 335 CT examinations for PE in each group to detect a 10% increase from a baseline of 75% adherence, as previously reported [13], with 90% power and alpha error rate of 5%, and we calculated that this could be achieved within 12 months. All statistical analyses were conducted using JMP (version 11.0, SAS Institute).

Results

A total of 43 attending physicians, 13 of whom (30%) were women, were randomized. Mean (± SD) age of all physicians was 40.3 ± 8.1 years, with mean experience of 8.8 ± 8.4 years of experience after residency training (Table 1). During the study period, a total of 109,793 patients were evaluated in the ED, of whom 2167 (2.0%) underwent CT for evaluation of PE—1148 of 56,526 patients (2.0%) in 2012 and 1019 of 53,267 patients (1.9%) in 2013. The baseline characteristics of both the control and intervention groups were similar in 2012; there were no differences in adherence to evidence-based guidelines (78.8% vs 78.3%; $p = 0.837$), use (20.4 vs 20.2 CT examinations for PE per 1000 patients; $p = 0.9052$), or yield (11.6% vs 11.2%; $p = 0.8413$) between the groups.

After the intervention, adherence to evidence-based guidelines, use, and yield all remained unchanged in the control group (Table 2). However, the intervention group showed an improvement in adherence to evidence-based guidelines, increasing from 78.3% in 2012 to 85.2% in 2013 ($p = 0.0043$); this represented an absolute increase of 6.9% and a relative increase of 8.8%. Alternatively, these data represent a 31.8% reduction in deviation from evidence-based guidelines (i.e., $[(100\% - 78.3\%) - (100\% - 85.2\%)] / (100\% - 78.3\%) = 31.8\%$; $p = 0.0043$). Although we observed a trend toward decreased use (20.2 CT examinations for PE per 1000 ED visits before intervention vs 18.1 per 1000 ED visits after intervention; i.e., relative reduction of $(20.2 - 18.1) / 20.2 = 10.4\%$; $p = 0.08$) and increased yield (11.2% before and 13.1% after intervention; i.e., relative increase of $(13.1\% - 11.2\%) / 11.2\% = 17.0\%$; $p = 0.36$), neither use nor yield showed significant change. There was no significant difference between the concordance of adherence to evidence-based guidelines on the basis of data captured in the CDS system and the ED visit clinical note for either the control (87% concordant) or the intervention (92% concordant) groups ($p = 0.3565$) (Table 3).

Discussion

We found that implementation of quarterly physician-specific performance feedback reports modestly but significantly (8.8% rel-

TABLE 1: Attending Physician Characteristics

Parameter	Control Group	Intervention Group	Total
No.	21	22	43
Mean (SD) age (y)	41.2 (8.6)	39.4 (7.6)	40.3 (8.1)
Female sex (%)	6 (29)	7 (32)	13 (30)
Mean (SD) experience (y)	9.2 (9.0)	8.3 (7.9)	8.8 (8.4)

TABLE 2: Outcomes in Control and Intervention Groups

Outcome	Group	Period[a]	Value[b]	p
Adherence to evidence-based guidelines (%)	Control	Before	78.8 (476/604)	0.5235
		After	77.2 (421/545)	
	Intervention	**Before**	**78.3 (426/544)**	**0.0043**
		After	**85.2 (404/474)**	
Use (no. of CT examinations for PE per 1000 ED patients)	Control	Before	20.4 (604/29,642)	0.8033
		After	20.1 (545/27,139)	
	Intervention	Before	20.2 (544/26,884)	0.0789
		After	18.1 (474/26,128)	
Yield (% of CT examinations for PE with positive findings)	Control	Before	11.6 (70/604)	0.8326
		After	11.2 (61/545)	
	Intervention	Before	11.2 (61/544)	0.3625
		After	13.1 (62/474)	

Note—PE = pulmonary embolism, ED = emergency department. **Boldface** denotes statistical significance.
[a]Relative to intervention.
[b]Raw data are given in parentheses.

TABLE 3: Concordance of Adherence to Evidence-Based Guidelines in Clinical Decision Support Versus Clinical Notes

Group	Result	No.	*p*
Control	Concordant	87	0.3565
	Discordant	13	
Intervention	Concordant	92	
	Discordant	8	

ative increase) increased adherence to evidence-based guidelines for CT evaluation for PE beyond the improvements gained through use of CDS alone. The use of imaging CDS is mandated to comply with relatively modest meaningful use stage II requirements—as well as with the much broader regulations forthcoming as a result of the Protecting Access to Medicare Act of 2014 [7, 18]. Prior studies have shown that implementation of imaging CDS alone is unlikely to optimize adherence to evidence-based guidelines [12, 13]. However, our findings suggest that the use of traditional performance improvement methods and strategies (e.g., physician-specific performance feedback reports) in conjunction with CDS may enhance the return on the substantial health information technology investment being made in the U.S. to help transform the health care system.

The observed improved adherence to evidence-based guidelines for CT evaluation for PE in the ED is similar to care improvements achieved in other specialties with the use of feedback reports. Prior research has shown that feedback reports can result in proportional improvements in colorectal cancer screening in primary care [14] and administration of prophylactic antibiotics by anesthesiologists [19] similar to that seen in our intervention group. Our control group, by contrast, maintained adherence similar to that previously documented to evidence-based guidelines on CT examinations for PE after the use of CDS [13].

Given the improvement in adherence to evidence-based guidelines observed in the intervention group, it might have been expected that our study would show a concurrent decrease in the use and increase in the yield of CT examinations for PE. However, although we observed a 10.3% reduction in use of CT examinations for PE per 1000 ED visits and 17% increase in yield of CT for PE in the intervention group, these results were not statistically significant, likely because our study did not have sufficient power to detect significant changes in the secondary outcomes of use and yield of CT evaluation for PE in the ED.

One potential explanation for the increase in adherence to evidence-based guidelines as documented in the CPOE system might be erroneous data entry by providers who knew that they were being measured (i.e., gaming the system). However, comparison of the adherence based on CPOE data to the adherence based on data documented in ED visit clinical notes showed a trend toward increased concordance in the intervention group, rather than the decreased concordance, as would have been expected if providers were entering erroneous data.

Notably, both our CDS and our feedback reports target and monitor adherence to guidelines based on validated high-quality evidence, a concept that has fundamental face validity to providers. Such evidence, defined by disease-specific guidelines, can be unambiguously represented in CDS. This focus on promoting and monitoring adherence to validated high-quality evidence may have improved provider buy-in of our intervention.

A number of limitations of this randomized trial should be noted. First, given that this study was performed at a large academic medical center with a well-integrated CDS system, the results may not be generalizable to other sites, particularly those currently without a CDS system on which to build these performance feedback reports. However, given the increasing use of CPOE systems [20], we believe that integrated CDS will become increasingly common in EDs and that adding this traditional performance improvement method based on CDS reports will soon be more practical for many sites. Second, most of our orders for CT examinations for PE are placed by resident physicians or physician assistants, but the feedback reports were given to attending physicians. However, our ED culture is one of attending physician involvement, and imaging decisions are typically made at the level of the attending physician, rather than solely by a resident or physician assistant. This, as well as the short rotation length of some of the off-service residents (often only 2–4 weeks), made randomization at the level of attending physicians a necessary—but appropriate—method at our site. Other sites with less attending physician–level decision making may find that other provider groups require feedback reports as well. Also, our study had sufficient power only for adherence to evidence-based guidelines and not for use or yield of CT examinations for PE. A larger sample size may have captured significant change in these last two outcomes. Notably, our reports were distributed via e-mail, so it is possible that some providers simply ignored the reports altogether. However, the effect on the intervention group seems to imply that at least a certain percentage of the intervention group reviewed the reports. It is also possible that our results underestimated the impact of feedback reports, because attending physicians in the control group may have become aware of the distribution of feedback reports and potentially modified their ordering behavior. Finally, we were unable to measure the impact of physician performance feedback reporting alone, because all orders for CT evaluation for PE were exposed to CDS throughout the study period. However, our CDS implementation enabled prospective documentation of the discrete data needed to unambiguously measure physician adherence to evidence-based guidelines for every request for CT evaluation for PE, likely the most clinically relevant component of the feedback report. Without CDS, because provider documentation of the needed discrete data to determine adherence is not easily enforced in the free text format of existing electronic health records, even extensive manual chart reviews would have been unlikely to provide a detailed measure of adherence to evidence-based guidelines for our feedback reports.

In conclusion, earlier studies using imaging CDS have shown improved use of CT for evaluation of patients suspected of having pulmonary embolism in the ED; however, nearly one in four CT examinations for PE still deviated from evidence-based guidelines after CDS implementation. Our findings show that the use of quarterly physician-specific performance feedback reports in conjunction with CDS augmented adherence to evidence-based guideline gains observed through CDS use alone. These data suggest that supplementing CDS with traditional quality-improvement strategies and tools such as individualized performance feedback reports may improve the return on the substantial national health information technology investment in the United States to help transform health care, improve quality of care, and reduce waste.

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