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Common Resident Errors When Interpreting Computed Tomography of the Abdomen and Pelvis: A Review of Types, Pitfalls, and Strategies for Improvement

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A B S T R A C T

Objective: The purpose of this study was to identify common errors that radiology residents make when interpreting abdominopelvic (AP) computed tomography (CT) while on call, to review the typical imaging findings of these cases, and to discuss strategies for improvement.

Materials and Methods: AP (or chest, abdomen, pelvis) CTs from 518 weekend senior call shifts (R3 or R4) were retrospectively reviewed. Discrepancies between preliminary and final reports were identified and then rated by whether the miss could impact short-term management. The imaging findings from the cases were reviewed.

Results: A total of 4695 CTs were reviewed, revealing a total of 145 discrepancies that could affect short-term clinical management (miss rate 3.1%). The most common misses were related to blood clots (13.8%), colitis (8.3%), misplaced lines or tubes (6.9%), or pyelonephritis (5.5%). Common pitfalls and strategies from improved detection are discussed using image examples.

Conclusions: Through increased attention to the vasculature, colon, devices, and kidneys, trainees may improve their discrepancy rates and improve on-call reporting.

Introduction

When radiology examinations are performed after hours at academic medical centers, radiology residents often provide preliminary interpretations. These initial reads can influence overnight management and guide treatment until the following morning, when an attending radiologist renders a final report. The literature suggests that on-call residents perform well, with low rates of discrepancies between preliminary and final reports.[1-6] However, no radiologist is infallible, and discrepancies (also called “errors” or “misses”) do occur.

Multiple studies have shown discrepancy rates for computed tomography (CT) of the abdomen and pelvis (AP) are higher than for other body regions.[3,6,7] In these complex studies that feature a wide variety of pathology, preliminary interpretation errors can cause delayed diagnosis and treatment, potentially leading to poor outcomes.

The goal of this study was to identify the most common interpretation errors that residents make when independently reading AP CT scans, and to discuss factors that may contribute to these errors.

Methods

Our institutional review board (IRB) approved this study, which was compliant with the Health Insurance Portability and Accountability Act (HIPAA).

We retrospectively analyzed 518 consecutive weekend call shifts in 6 month increments between January and June of 2011 through 2015. The shifts (259 day shifts, 259 night shifts) were taken by a senior radiology resident in either the R3 (PGY-4) or R4 (PGY-5) year. No attending radiologist was on site, though an on-call attending was available for consultation via telephone. Final interpretations were rendered the next morning by an attending radiologist with specialty training in abdominal imaging.

For each shift, every AP CT was screened for possible discrepancy between the preliminary and final reports. Our institution does not have an automated discrepancy tracking system, so we identified potential discrepancies by searching for either standardized language in the final impressions of reports with discrepancies or any reference in the final report to a next-day phone call reporting a possible discrepancy. When either criterion was met, the preliminary and final reports were evaluated by a fourth-year radiology resident and a faculty member with 22 years postfellowship experience, in consensus.

Each discrepancy was evaluated for its possible impact on short-term management. Specifically, if a discrepancy could influence decision making in the interval between the rendition of the preliminary and final report, it was considered a significant miss.

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TABLE 1
Prevalence of time-sensitive misses on abdomen and pelvis CT, by body part/region

Region	*N*	Percentage of misses (%)
Small/large bowel	47	32.4
Solid organs/viscera	41	28.3
Vascular	28	19.3
Miscellaneous	16	11.0
Musculoskeletal	7	4.8
Thoracic	6	4.1
Total	145	

TABLE 2
Commonly missed pathologies on abdomen and pelvis CTs read by on-call residents

Pathology	*N*	Percentage of misses (%)
Blood clot	20	13.8
Colitis	12	8.3
Misplaced line/device	10	6.9
Pyelonephritis	8	5.5
Total	50	34.5

Thus, errors that could change management or treatment decisions within a few hours (ie, pulmonary embolism [PE]) were counted, while discrepancies that might be life-threatening but nonacute (ie, colon cancer) were not. Any disagreement was resolved by a second faculty member with 5 years postfellowship experience.

With all the discrepancies counted and categorized, the most common misses were identified and examined.

Results

Discrepancy Results

During the 518 call shifts that comprised the study period, 4695 AP CTs were performed that had preliminary resident interpretations. The total number of misses (that would impact short-term management) was 145, for a discrepancy rate of 3.1%. The prevalence of discrepancies by general body region is found in Table 1. The most common misses were related to blood clots (PE, deep vein thrombosis [DVT], or other venous clots), colitis, device or line misplacement, and pyelonephritis (Table 2). These 50 cases across 4 pathology groups comprised 34.5% of the discrepancies.

CT Findings

Blood Clots

Five cases of PE (3.4% of total misses) (Fig 1) were missed on AP CT (PE was also missed on 3 CAP studies), representing the most common type of the 20 missed blood clots. Inferior vena cava (IVC) thrombus (Fig 2A) was the next most common blood clot missed (4 cases, 2.8% of total misses). Portal vein thrombus (Fig 3) was also missed 4 times (2.8% of total misses). Other less common blood clots

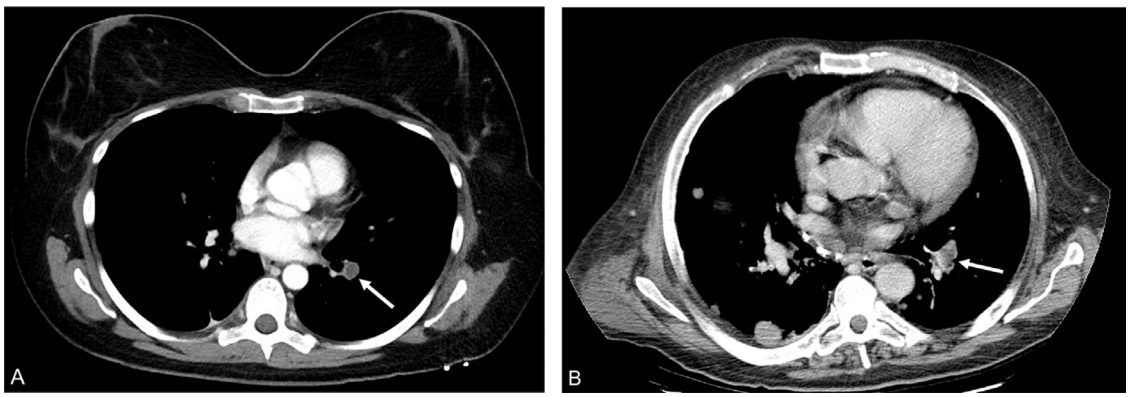

FIG 1. Missed pulmonary embolism (PE) on abdomen-pelvis (AP) contrast-enhanced CT (CECT). (A) A 37-year-old woman with acute abdominal pain. The missed left lower lobe PE (white arrow) was evident on the first slice of this AP CECT. This finding was incidental. (B) A 70-year-old man with colon cancer and abdominal pain. This left lower lobe PE (white arrow) was missed by the on-call resident. Detection is difficult because of the portal venous phase of imaging.

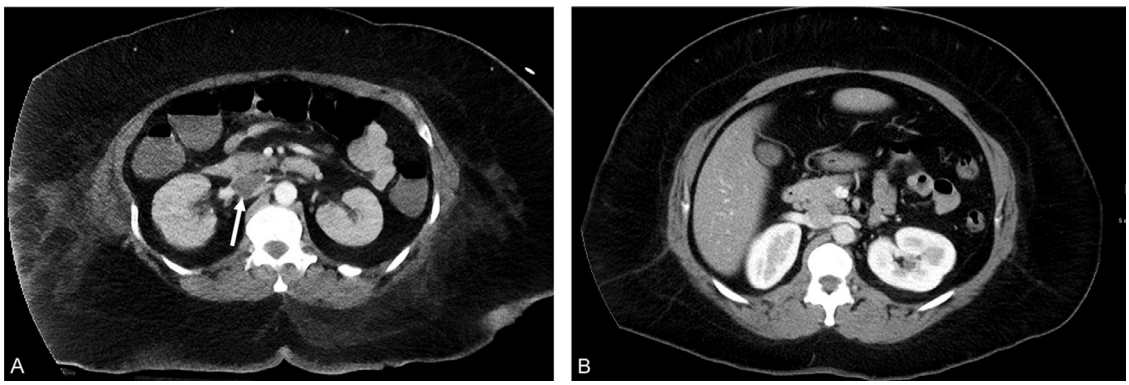

FIG 2. Missed inferior vena cava (IVC) thrombus on contrast-enhanced CT (CECT). (A) A 56-year-old woman with acute abdominal pain. Low density clot in the IVC (white arrow) was part of extensive iliofemoral thrombus. Note the sharp margins of the clot. (B) A 43-year-old man with abdominal pain. On AP CECT there is mixing artifact in the IVC as opacified blood returns to the IVC from the renal veins. Note the similarity to clot in Figure 2A.

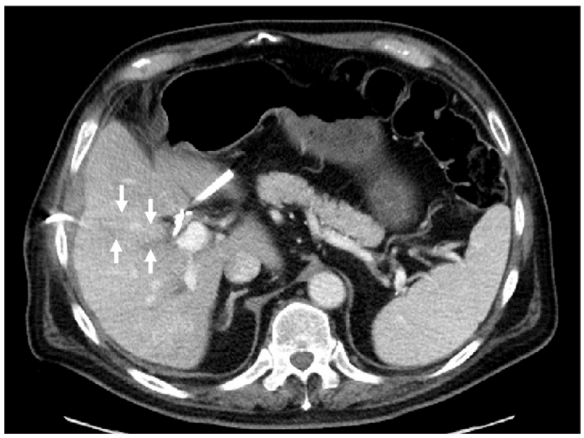

FIG 3. A 56-year-old man with a percutaneous biliary drain. Missed occlusion of a right portal vein branch on contrast-enhanced CT. Small white arrows denote the expected location of the vein. This diagnosis is made difficult by the absence of a structure (the vein) rather than the presence of an expansile clot.

that were missed included catheter-associated thrombus, femoral DVT, splenic artery occlusion, and splenic vein occlusion.

Colitis

We found 12 cases of missed colitis affecting all parts of the colon (8.3% of total misses) (Fig. 4A, B). Missed cases often featured mild wall thickening (Fig 4C) or occurred in cases without iodinated contrast (Fig 4D).

Misplaced Devices or Lines

There were a total of 10 misplaced devices among the misses (6.9% of total misses). Among the spectrum of devices were a misplaced central venous catheter in the azygous vein (Fig 5A), a migrated pancreatic stent (Fig 5B), and a low-lying intrauterine device (IUD) (Fig 5C).

Pyelonephritis

The final category of common misses was pyelonephritis, with 8 cases (5.5% of total misses). Pyelonephritis was missed in both the corticomedullary phase of imaging (Fig 6A) as well as the nephrographic phase (Fig 6B).

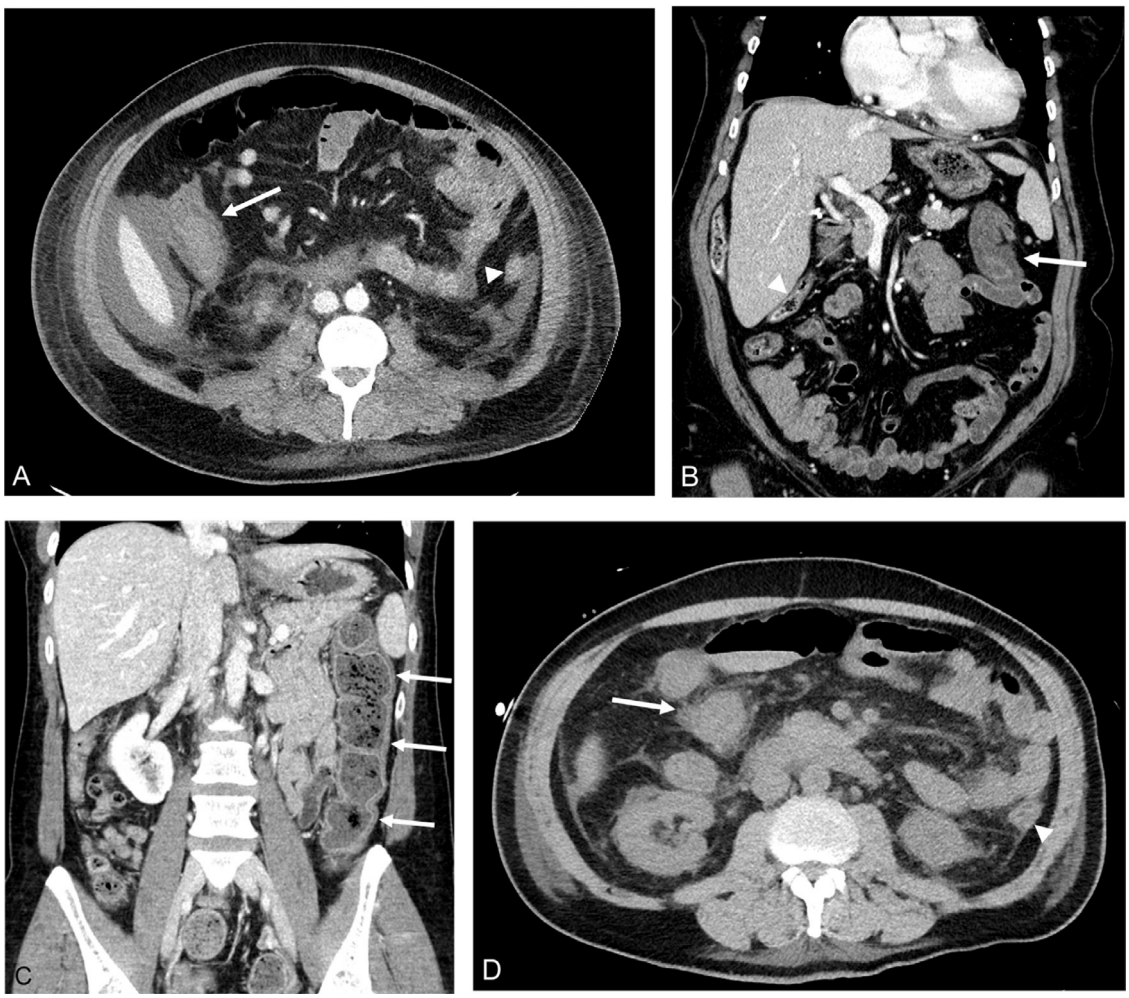

FIG 4. Multiple cases of missed colitis on CT. (A) A 45-year-old man with fever and abdominal pain. Missed wall thickening and inflammatory change of the colon at the splenic flexure (white arrow), compatible with ascending colitis. Comparison with the decompressed and normal appearing descending colon (white arrowhead) can be helpful. (B) A 50-year-old man with left-sided abdominal pain. Missed colitis at the splenic flexure (white arrow). As in (A), comparison with the opposite, normal appearing colon (white arrowhead) can be helpful. (C) A 39-year-old man with an abnormal white blood cell count and crampy abdominal pain. Mild colitis in the descending colon (white arrows). Trainees often find coronal imaging helpful in order to visualize longer segments of colon in 1 image. (D) A 65-year-old man with fever and nonspecific abdominal pain. Wall thickening and inflammation surrounding the proximal transverse colon (white arrow), suggestive of colitis. This diagnosis was missed by the on-call resident—the lack of intravenous contrast can make diagnosis more difficult. Note the normal, decompressed descending colon in the left paracolic gutter (white arrowhead).

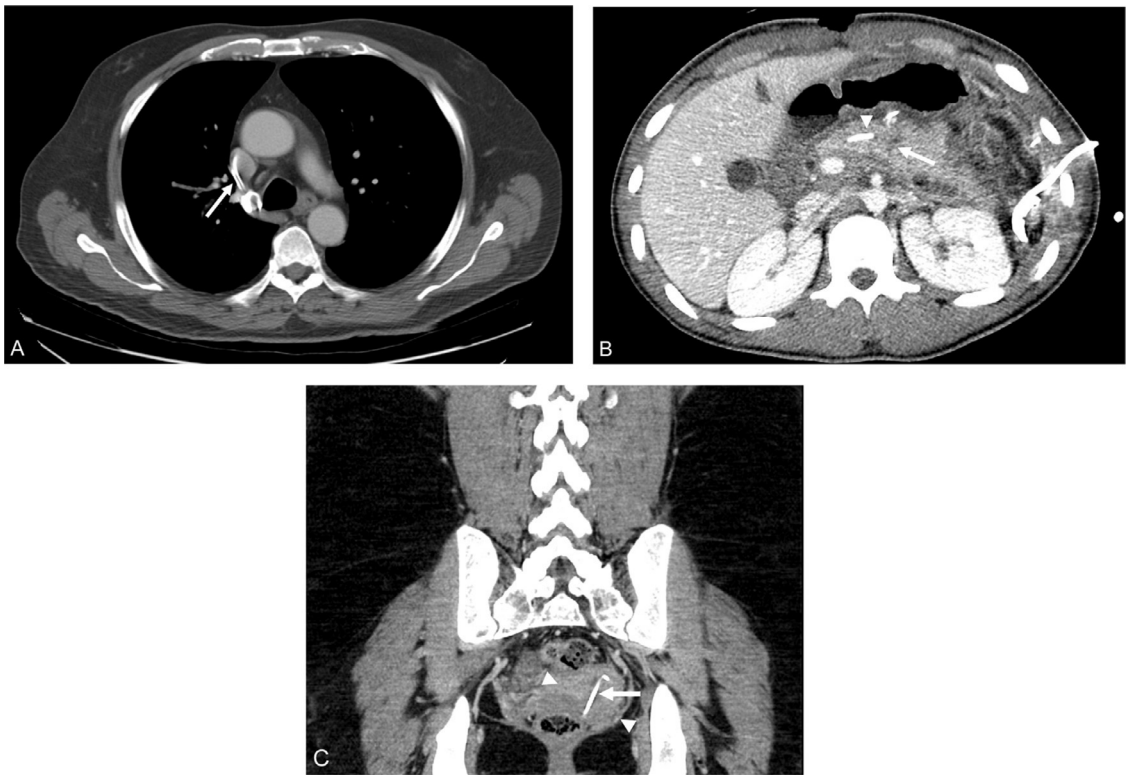

FIG 5. Multiple cases of missed malpositioned devices. (A) A 69-year-old man with right lower quadrant abdominal pain. The tip of a peripherally inserted central venous catheter is seen in the azygous vein (white arrow). This image was from the first slice of the dataset. (B) A 18-year-old man with recent trauma and an increasing white blood cell count. The proximal aspect of a pancreatic stent (white arrowhead) is downstream from a pancreatic laceration (white arrow) that it had previously bridged. This stent migration was not detected by the on-call resident. (C) A 19-year-old woman with generalized abdominal pain. Missed low-lying intrauterine device (white arrow), seen within the cervix (white arrowheads). The endometrial canal is seen on other slices.

Discussion

Upon examination of 4695 AP CTs interpreted by on-call radiology residents, we found time-sensitive discrepancies that could affect immediate (or nearly immediate) management in 3.1% of cases. The most common type of miss was related to blood clots, with PE representing the most commonly missed clot. The other most common misses were colitis, misplaced devices, and pyelonephritis.

This discrepancy rate for AP CT is in line with prior studies, which have ranged from 1.4%-10%.[6-9] AP CTs cover a large anatomical area and can include a large spectrum of pathologies affecting a variety of organs.

Blood clots represented the most common resident oversight, and PE was the most commonly missed blood clot. Detection of PE on AP CT can be particularly challenging for multiple reasons. First, the pulmonary arteries are incompletely visualized on an AP CT, and often only the lower lobe segmental (or in some cases lobar) arteries are imaged. Because of this, clots are often visible only in the first few slices of the dataset (Fig 1A), which can make their detection more challenging.[10] Second, contrast timing for standard AP CTs is not typically

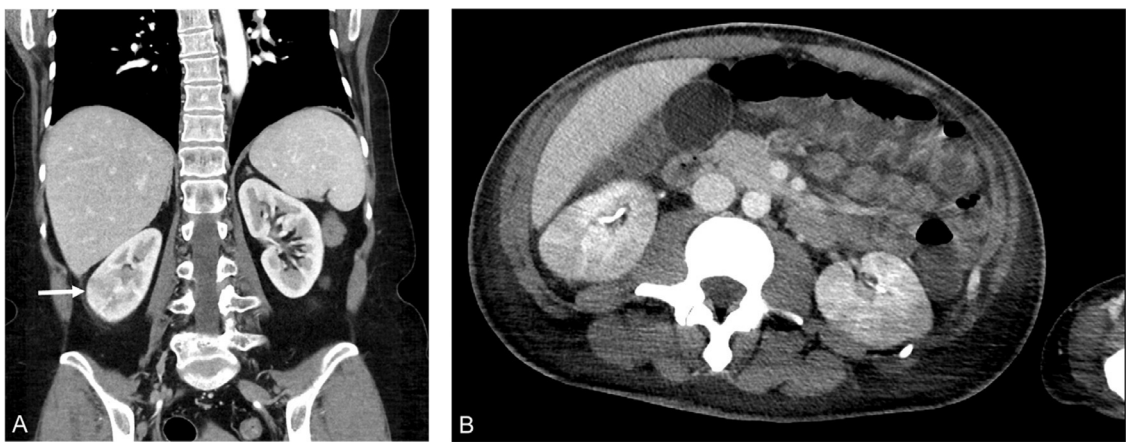

FIG 6. Pyelonephritis on contrast-enhanced CT. (A) A 48-year-old woman with right-sided abdominal pain and an abnormal urinalysis. Focal pyelonephritis in the right kidney (white arrow) was missed; diagnosis is more difficult because of the corticomedullary phase of imaging and the focal nature of the finding. (B) A 57-year-old man with fever and T-cell lymphoma. Bilateral striated nephrograms in the nephrographic phase were missed; this case of pyelonephritis is difficult to appreciate due to streak artifact from a lowered left arm.

optimized for visualization of the pulmonary arteries. Images in the portal venous phase are not optimal to detect pulmonary clot (Fig 1B), again making diagnosis more difficult. Third, motion artifact affecting the lung bases can also reduce sensitivity for detecting clot. Lastly, the indication for an AP CT is never to evaluate the pulmonary arteries; consequently, this finding is typically incidental and may fall outside of a trainee's search pattern.

Other commonly missed blood clots included IVC and portal vein thrombi. Diagnosis of IVC thrombus (Fig 2A) can be challenging depending on the phase of contrast. In earlier phases the IVC will be poorly opacified, but as time passes it will opacify with contrast returning from the renal arteries as well as eventually from the lower extremities. The returning contrast can create a mixing artifact that can resemble clot (Fig 2B).[11] Obtaining delayed images can rectify any confusion created by this artifact. Portal venous clot can be also be subtle, particularly because portal vein occlusion is sometimes identified as the absence of the vein in its expected location rather than by the presence of expansile clot (Fig 3), and identifying absent findings is a known challenge for radiologists.[12] Though its prevalence was low in our data, femoral DVT merits mention because just as PE can be seen in the first few images of an AP CT, femoral DVT can be seen on the last few images.

Following blood clots, colitis was the next most common resident miss. While admittedly subtle and often subjective, the detection of bowel wall thickening can be enhanced by a practiced approach. First, one must habitually examine the entire colon, a practice that should be part of every basic search pattern. Next, when deciding whether bowel is abnormal, using the patient as an internal control can be helpful. While this tip would not help in pancolitis, comparing different parts of the colon can help determine if a segment of bowel is abnormal (Fig 4A and B). Additionally, using a gas filled portion of bowel can help to evaluate the bowel's true wall thickness, as decompressed loops can appear thickened.[13] Colitis with mild wall thickening (Fig 4C) and colitis on noncontrast images (Fig 4D) represent more challenging examples in which an experienced eye can help. Though we do not routinely use luminal contrast agents for AP CT, some institutions recommend oral or rectal contrast agents to assist in bowel wall assessment,[14] which may help in cases without intravenous contrast. In general, our trainees find coronal images particularly helpful when evaluating the colon, as longer segments can be viewed in a single image to allow for better visualization.

Misplaced devices (ie, lines and tubes) were another commonly missed finding. This diverse group of cases has a correspondingly varied set of pitfalls. For example, in the case of a malpositioned peripherally inserted central catheter (PICC) with its tip in the azygous vein (Fig 5A), the miss was probably attributable to 2 factors. First, the finding was evident within the first few images of a dataset, and second, this is not a typical finding on abdominal CT. Had this finding been present on a chest radiograph, the trainee would likely have a better chance of finding it. Evaluation of lines and tubes is often an emphasized component of chest radiography interpretation, but may not be as central to the AP CT search pattern for a trainee. Other devices may be recognized but not fully evaluated. In the example of a migrated pancreatic stent (Fig 5B), a trainee may recognize the device but not fully appreciate its function or intended location. In this case, the stent had bridged a pancreatic laceration but had migrated. In another example, this time a low-lying IUD (Fig 5C), a trainee may see the IUD but not formally evaluate its position because that is typically done using ultrasound. Moreover, it can be difficult to evaluate IUD positioning on axial images. Multiplanar reformats, particularly sagittal images, can be helpful.

The final commonly missed pathology on AP CT was pyelonephritis. While missing subtle blood clots or malpositioned devices may at times be attributable to an incomplete search pattern (ie, the trainee did not look at the requisite blood vessel or examine the device), trainees do not typically omit the kidneys from their search pattern. Thus, missed pyelonephritis often occurs in more difficult cases or in instances where there is insufficient clinical history. For example, detecting pyelonephritis can be challenging when the kidneys are imaged in the corticomedullary phase or when the finding is focal (Fig 6A). Diagnosis can be problematic even in the nephrographic phase, whether due to streak artifact from patient positioning (Fig 6B) or generally subtle findings. As with examination of the colon, our trainees find the use of coronal imaging helpful when evaluating the kidneys. A thorough evaluation of the renal cortices to ensure uniform enhancement is paramount, often in both axial and coronal planes. The 4 most common discrepancies accounted for 34.5% of resident misses for AP CT while on call at our institution. Even if the heterogeneous category of blood clots is narrowed to include only PE, the results still comprise 26.2% of misses. These errors are common both because these pathologies are common but also because they can be difficult to detect. Knowledge of these commons errors can help trainees while on call.

There are limitations to our study. First, our error rates were calculated based on AP (or CAP) CTs, not every study with resident preliminary interpretations. While our rates may be slightly different from an overall true error rate, our intention was to focus on the abdomen and pelvis. Next, detecting colitis on CT is often subjective, and not all of our cases had colonoscopy or laboratory correlation. Consequently, some discrepancies regarding colitis are essentially errors in detecting wall thickening or hyperenhancement. That some of these cases are not proven colitis is a limitation of radiologic diagnosis. In addition, we relied on the final attending interpretation as the gold standard; the possibility that residents were correct does exist, and this could have a small effect on our error count. Lastly, what constituted a time-sensitive error was determined by radiologists, not referring clinicians. We could only estimate how each discrepancy might influence a given medical team's choices overnight. When in doubt, we included misses in a more conservative fashion so as not to underestimate discrepancy rates.

In conclusion, residents should be cognizant of the vasculature (in particular the pulmonary arteries), colon, devices, and kidneys when interpreting AP CT. Increased scrutiny of these sites of common misses could help reduce discrepancy rates.

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