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Diagnostic Errors in Radiology:

Lessons from the Field

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Diagnostic Errors in Radiology:
Lessons from the Field

INTRODUCTION

A radiologist logs into her workstation and checks the work list. She sees two emergency department (ED) cases, one neurological case marked STAT, and two lengthy body cases among the 20 studies on her list. The race is on.

Radiologist workloads have increased over past decades, including the number and complexity of imaging studies.[1,2] Working quickly and under pressure can increase diagnostic errors, including delayed diagnosis or misdiagnosis.[2]

Diagnostic errors occur in all medical practice areas, but radiology is one of the top specialties involved in malpractice claims.[3] In the United States, about 31 percent of radiologists experience a malpractice lawsuit once during their career. Diagnostic errors account for 75 percent of these claims.[4]

Diagnostic error in radiology can lead to treatment delays and contribute to patient harm. Average radiology diagnostic error rates range from three to five percent daily (approximately 40 million diagnostic errors annually worldwide). The way radiologists think and various aspects of the work environment have been identified as contributing causes of diagnostic error.[5]

According to Degnan, et al., "Interpretation of increasingly complex imaging studies involves multiple intricate tasks requiring visual evaluation, cognitive processing, and decision-making." Within the interpretation process, opportunities for error, including cognitive and perceptual errors, may relate to biases and other underlying root causes. Perceptual errors occur more frequently than cognitive errors[6], and they are the focus of this article.

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Using a combination of diagnostic error risk reduction strategies, radiologists can reduce the challenges interfering with interpretation and, therefore, mitigate patient injury and malpractice liability. Administrators can improve systemic factors by evaluating and monitoring the reporting environment and promulgating patient safety policies, procedures, and processes, which can further reduce radiology errors.[4]

COGNITIVE ERRORS

Cognitive or interpretive errors occur when a radiologist identifies an abnormality and incorrectly interprets the meaning or importance of the finding, or does not act upon the finding, leading to missed and delayed diagnoses. Cognitive errors account for 15 to 28 percent of total errors.[6]

One example of cognitive error is when a radiologist interprets an alignment abnormality on lumbar spine radiographs as being secondary to degenerative changes rather than spondylolysis. Another example: a radiologist interprets a foreign body overlying the patient on a frontal view chest x-ray as a VP shunt catheter instead of a retained guidewire. In these instances, the radiologist interpreted a radiographic finding incorrectly.[7]

A radiologist interpreting a study uses diagnostic reasoning processes, including mental shortcuts and pattern recognition, otherwise referred to as heuristics. This approach to problem solving, known as Type 1 thinking, allows a person to make judgments intuitively, quickly, and efficiently. Often decisions made by rapid Type 1 thinking are prone to cognitive biases, leading to predisposed or less rational outcomes. Type 2 thinking is analytical, slow, deliberate, and uses a purposeful approach to problem solving and decision making.[2,5] Complex decision making requires a combination of Type 1 and Type 2 thinking.[8]

PERCEPTUAL ERRORS

Errors in perception (failure to identify an abnormality that is clearly present)[2,9] occur in 60 to 80 percent of radiology errors.[7] Errors in perception are discovered in retrospect and are often referred to as “misses” or “missed diagnoses.”[8]

As with cognitive errors, perceptual errors may occur because of a radiologist’s diagnostic reasoning process or a host of systemic factors.[5] Although little is known about risk factors predisposing a radiologist to a perceptual error versus a cognitive error, research suggests the imaging technique, specific imaging finding, and underlying diagnosis, as well as the radiologist’s experience and environmental conditions, influence the type of error made.[8] Perception errors are also associated with faster reading rates, higher case volumes, and readings that occur later in the work shift.[9] Conditions affecting the reporting environment and potentially adding to perceptual errors include problems with lighting and ergonomics, inadequate rest periods, excessive workload, and interruptions.[4]

The two case studies in this article highlight the role and impact of biases and other system factors on a radiologist’s interpretation. The cases are based on closed malpractice claims and introduce strategies for recognizing errors with the objective of maintaining patient safety and reducing medical liability risk. Although the cases involve perceptual errors, many of the risk reduction strategies presented can be used to mitigate the risk of cognitive errors as well.

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Failure to Diagnose Aneurysm in a Migraine Sufferer:

Anchoring Bias and Availability Bias

In the following case, the radiologist's diagnostic process stopped at migraine, despite the patient reporting the worst headache he had ever experienced. The patient's history of migraine and the prevalence of migraine headaches in the general population likely contributed to the radiologist's failure to identify the aneurysm.

CASE ONE

Allegation: Failure to diagnose right posterior communicating artery (PCOM) aneurysm resulted in severe neurological damages.

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A 32-year-old male patient presented to the ED on May 11 with complaints of a headache for approximately 20 minutes, photophobia, and nausea. He described the initial onset of the headache as feeling like someone had snapped a rubber band in his temple, causing a sharp shooting pain. He described the headache as the worst he had ever had, and different from past migraines he had suffered over many years.

MAY 11 The ED physician ordered a neurology consult, and the neurologist found the exam to be normal. The neurologist ordered a brain CT for headache, and Radiologist 1 read it as "no acute intracranial hemorrhage, mass effect, or midline shift." The ED physician prescribed a headache-medication cocktail and did an occipital nerve block. This relieved the patient's pain, and he was discharged.

MAY 14 The patient returned to the ED with complaints of severe right frontal migraine with nausea, phonophobia, and photophobia. The ED physician ordered a CT angiography (CTA). Radiologist 1 interpreted the CTA as "no intracranial hemorrhage, mass effect, or midline shift; no significant atherosclerotic change or narrowing in the intra- or extracranial carotid or vertebrobasilar arteries; and no aneurysm or dissection." The ED physician ordered pain medication, which relieved the patient's pain. The ED physician discharged the patient and instructed him to follow up with his primary care physician (PCP).

MAY 29 The patient returned to the ED with a right temporal headache intermittently for the past three weeks. He described the headache as a sudden, sharp jolt of pain to his right temple, occurring when he bent over. The patient also reported photophobia, nausea, right eye diplopia, right forehead, and right ear and eye pressure. The ED physician admitted the patient for observation.

MAY 29 The admitting hospitalist ordered a neurology consult. The neurologist ordered an MRI/MRA of the brain with and without contrast. Radiologist 2 interpreted the MRI as "negative for ischemic infarct or intracranial hemorrhage," and the MRA as "satisfactory patency to the major arterial vessels of the Circle of Willis and satisfactory patency to the major dural venous sinuses."

MAY 29 Later that day the patient complained of double vision and headache. The neurology nurse practitioner (NP) evaluated the patient and noted that his right pupil was larger and less reactive than the left. The NP ordered a lumbar puncture (LP). The opening pressure was 6 cm H2O (normal range = 10-20 cm H2O) without blood in the fluid.

MAY 30 The registered nurse observed seizure activity and was unable to palpate a pulse. The code team initiated CPR. The patient was intubated and placed on a ventilator. The hospitalist ordered a head CT. Radiologist 3 interpreted the head CT as "diffuse subarachnoid hemorrhage (SAH) with extension of blood products into the fourth ventricle and posterior horn left lateral ventricle." He compared the current studies to prior studies and recommended emergent endovascular consultation based on the prior findings of right PCOM aneurysm 4x2 mm. A neurosurgeon consulted and retrospectively reviewed the May 14 CTA, noting a right PCOM aneurysm. An interventional radiologist performed a diagnostic cerebral angiogram followed by coil embolization of the aneurysm.

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MAY 31 The intensive care unit (ICU) resident noted that the patient remained intubated and sedated; however, he followed verbal commands and moved all four limbs.

JUNE 1 The ICU resident ordered a brain CT. Radiologist 2 interpreted it as "new area of right basal ganglia hypoattenuation."

JUNE 2 Further imaging, including a head CT, CTA of head and neck, and a CT perfusion study suggested "ischemic penumbra in the right middle cerebral artery (MCA) distribution involving the parietal, occipital and temporal lobe, small focal areas of infarct, and multifocal narrowing in the right anterior, middle, and posterior cerebral artery suggestive of vasospasm from SAH."

JUNE 4 The patient developed a large MCA infarct and elevated intracranial pressure requiring a right side frontal temporoparietal decompressive hemicraniectomy.

Over the next five days the patient's condition worsened, and he experienced continued cerebral swelling and infection. He had a tracheostomy tube and a PEG tube, and he remained paralyzed on his left side. The physician transferred the patient to a continuing care facility a month later. The patient remained fully paralyzed from the waist down and completely paralyzed on the left side. He was able to use his right upper extremity, but he would require a personal attendant for the remainder of his life.

The patient filed a lawsuit against various members of his healthcare team that focused on Radiologist 1 and his failure to diagnose the aneurysm on the initial brain CT, CTA, and MRI. The patient alleged the miss resulted in his permanent injuries.

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DISCUSSION

Radiology and neuroradiology consultants on both sides agreed that the undiagnosed aneurysm on the head CTA was an obvious miss. They also identified the patient's report of feeling like someone had snapped a rubber band in his temple, causing a sharp shooting pain that was his worst headache ever, as a classic presentation of a ruptured aneurysm. In his defense, Radiologist 1 believed the ordering ED physician should have provided more information to him, including the patient's description of his headache pain. He also believed distractions in the reading room contributed to his missing the finding.

Studies indicate that radiologists tend to consider more common conditions rather than looking for "zebras," thereby eliminating the obvious before probing for a rare or unlikely finding.[8]

Cognitive biases can affect a radiologist's thinking and interpretation, causing errors.[8] In this case, the radiologist fixated on the early diagnosis of migraine and discounted the factors that did not support his assumption that the patient's symptoms were caused by migraine. This is known as "anchoring bias." Anchoring bias can be mitigated by obtaining further clinical information to circumvent the tendency to anchor on initial findings.[2]

"Availability bias" also may have contributed to the radiologist's error in this case. Availability bias refers to the tendency to consider diagnoses more likely if they readily come to mind.[2,8] This radiologist may have had an increased sensitivity to more common causes of headaches or had recently observed CT findings for headaches, and had decreased sensitivity to those rarely seen.[5,8] Studies indicate that radiologists tend to consider more common conditions rather than looking for "zebras," thereby eliminating the obvious before probing for a rare or unlikely finding.[8]

This case was settled due to a lack of standard of care support, potential damages in the $20 million range, and the defendants' requests to settle.

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RISK REDUCTION STRATEGIES

Consider the following strategies to decrease the potential for diagnostic error:[4,5,7,8]

- Be aware of cognitive processing biases that can affect the diagnostic process. Doing so can guard against the human tendency to stop too early in the search or to look for signs confirming a preconceived idea about diagnosis.
- Consider various alternative diagnoses when initial impressions seem obvious.
- In establishing a differential diagnosis list, do not settle on a particular diagnosis too early in a patient's workup.
- Develop a routine of wondering: "What else might this be?" Consider the worst possible diagnoses for a patient with the same symptoms.
- Consider patient comorbidities or multiple disease processes occurring simultaneously.
- Review all clinical data or discuss the patient with the referring physician for additional information to resolve limitations in interpretation.
- Obtain second opinions in ambiguous cases.
- Limit unnecessary interruptions during image interpretation.
- Recommend further diagnostic studies when current findings are not definitive.
- Comment on the quality of the image or other limitations if they affect your interpretation.
- To increase skills, create a quality improvement and peer review program, and encourage all radiologists to participate.
- Analyze errors to identify conditions that may impact the risk of future errors.

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Failure to Diagnose Stroke in a Young Patient:

Cognitive Biases Affecting the Diagnostic Process

In the following case the complaint alleged a neuroradiologist failed to diagnose a blockage on a CTA for a 29-year-old patient experiencing stroke-like symptoms. A variety of different cognitive biases may have affected the neuroradiologist, including inattentional or perceptual blindness, satisfaction of search, framing bias, and attribution bias.

CASE TWO

Allegation: Failure to properly interpret a CTA study resulted in stroke and locked-in syndrome.

A 29-year-old male patient presented to his PCP with complaints of a two-hour history of frontal headache with nausea and vomiting on December 18. He received ketorolac, and the PCP instructed him to go to the ED; however, he initially declined.

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DECEMBER 20 The patient presented to the ED with complaints of left facial droop, fatigue, and slurred speech. He reported neck manipulation two weeks prior for neck pain. The physician conducted an assessment and observed facial asymmetry; however, he observed no other neurological deficits. He ordered a CTA, which Neuroradiologist 1 interpreted as normal. The ED physician diagnosed the patient with Bell's palsy and discharged him. The discharge instructions included follow-up with his PCP and a neurology referral.

DECEMBER 21 The patient presented to the neurologist for right facial droop and difficulty speaking. The neurologist prescribed an eye patch and ophthalmologic ointment and instructed the patient to return in one week.

DECEMBER 23 The patient presented to his PCP, who observed right upper and lower extremity weakness and lack of coordination. The PCP ordered a brain MRI, including the brain stem, with and without contrast.

DECEMBER 26 Neuroradiologist 2 interpreted the MRI as: "moderate size region of abnormal signal, restricted diffusion within the central pons, extending asymmetrically towards the left. Findings nonspecific but could represent an acute/subacute infarct or central pontine myelinolysis; other etiologies such as MS, low grade astrocytoma or lymphoma felt to be less likely." Neuroradiologist 2 referred the patient to the ED immediately.

DECEMBER 26 The ED physician noted that the patient had speech difficulty, headaches, dysarthria, left facial paralysis, right-side weakness, and slurred speech. He ordered a repeat head CTA and head CT. Neuroradiologist 2 reported the CTA as: "subacute infarcts, left vertebral artery dissection, and basilar thrombosis proximal to mid-basilar artery." He reported the head CT as: "subacute infarcts consistent with left vertebral artery dissection." He noted the presence of a mid-basilar high-grade stenosis on the December 20 CTA when he compared the current head CTA to the prior study.

DECEMBER 26 The ED physician admitted the patient and paged the stroke team, but they determined time exceeded the window for IV thrombolysis. The ED physician diagnosed the patient with "acute/subacute left pontine ischemic stroke" and ordered a neurology consult.

DECEMBER 29 The hospitalist ordered a STAT head and neck CTA and head CT due to new complaints of left-side weakness. Neuroradiologist 2's finding on the head CT was "stable" and on the CTA was "less blood flow noted in the vertebral arteries." A cerebral angiogram during a mechanical stent thrombectomy was ordered. The procedure report indicated: "Basilar thrombosis from vertebral basilar junction to basilar bifurcation with brainstem strokes; left V4 vertebral artery dissection; recanalization of the mid-basilar occlusion; occlusion left vertebral artery left PICA, attenuated left AICA, distal left PCA branch attenuation; and good Circle of Willis collateral to basilar bifurcation and bilateral SCA territories from right posterior communicating artery."

After a month in the hospital the patient was transferred to a rehabilitation institute with a diagnosis of left vertebral artery dissection and pontine stroke with locked-in syndrome. The patient filed a lawsuit against various members of his care team alleging failure to diagnose and timely treat a basilar artery stroke.

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DISCUSSION

There was a strong defense for each defendant named in the case; however, the hospital settled the case, and the plaintiff continued to pursue a claim against Neuroradiologist 1. It was clear that he was the key target in the lawsuit.

Defense standard of care consultants who reviewed the defendant neuroradiologist's interpretation of the initial CT were not supportive. They opined that there was a clear miss of the dissected left vertebral artery and an occluded basilar artery on the CTA images from December 20. The neuroradiologist admitted that he visualized the clot in retrospect and, had he seen it earlier, he would have recommended an MRA at that time.

Although biases are inherent in human thinking, recognizing, understanding, and mitigating them can reduce the potential shortcomings of intuitive decision making.[9]

The plaintiff's neuroradiology expert alleged that Neuroradiologist 1 breached the standard of care in failing to observe and document the CTA findings of high-grade stenosis/occlusion of the basilar and left vertebral arteries, dissection of the left vertebral artery, and thromboembolism of the basilar and left vertebral arteries.

The plaintiff's expert alleged that if Neuroradiologist 1 had properly interpreted the CTA, the plaintiff would have received timely treatment intervention to restore cerebral blood flow via recanalization by way of stent placement, thrombolysis, thrombectomy and/or anticoagulation. He opined that this would have prevented the plaintiff's devastating pontine stroke, resultant quadriparesis, damage to the vision and cranial nerves, facial paralysis, dysphagia, and other disabilities.

It is possible that perceptual errors and cognitive biases impacted the defendant neuroradiologist's interpretations of the imaging at issue. Although biases are inherent in human thinking, recognizing, understanding, and mitigating them can reduce the potential shortcomings of intuitive decision making.[9]

Cognitive biases may have influenced the neuroradiologist's diagnostic process. For example, "inattentional/perceptual blindness" (also known as "scrolling error" or "tunnel vision") describes missing findings that are hidden in plain sight.[8] In one study the researcher inserted a gorilla into the image of a chest CT. A total of 83 percent of highly skilled radiologists did not see the gorilla, even though it was 48 times larger than an average nodule. The researchers reviewed radiologist eye tracking and found that most looked directly at the location of the gorilla.[11]

Another bias associated with radiology misses is "satisfaction of search"—the tendency to stop a search for an abnormality once the radiologist finds a diagnosis.[2] In the foregoing case it is possible that Neuroradiologist 1 quickly reviewed the images and concluded everything else was normal.

"Framing bias" (or "framing effect"), which describes drawing different conclusions from the same information depending on presentation of the information,[4] also may have affected the diagnostic process. In this case the neuroradiologist was informed the patient presented with left facial droop, fatigue, and slurred speech. Perhaps if he had known the patient had a neck manipulation two weeks prior he would have reviewed the vertebral arteries for injury more closely.[9] Finally an "attribution bias" (attributing findings to patient characteristics or stereotypes) may have influenced the neuroradiologist, prompting him to discount the likelihood of stroke in a 29-year-old patient.

The case was settled due to lack of standard of care support, the plaintiff's potential damages in the multi-million-dollar range, and the neuroradiologist's desire to settle.

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RISK REDUCTION STRATEGIES

Consider the following strategies to decrease the potential for perceptual diagnostic error:[2,4,5,9,8,9,10]

- Use a systematic search or structured image evaluation to ensure identification of all relevant findings.
- Be aware of the difficulties of radiological interpretation and that conducting complicated cognitive processes is always subject to human error.
- Use heightened diligence when analyzing areas in the periphery, first and last images, scout and localizer sequences, and anatomic "blind spots"—regions with densely compact anatomy with confluent vascular, nervous, bony, and soft tissue structures that make it difficult to assess pathology.
- Recognize the signs of visual fatigue (e.g., looking at an image without registering it, blurred or double vision, headache).
- Take breaks and follow the 20-20-20 rule: Every 20 minutes, look 20 feet away for 20 seconds.
- Ensure your computer monitor/tablet display resolution is adequate.
- Limit workload volume and the length of work shifts.
- Review an image first while masking the clinical history and before reading the prior report.
- Look over patients' clinical data to help with assessments; however, be aware that sometimes clinical data can cause bias (e.g., knowing the youthful age of a patient may diminish suspicion for stroke).
- Conduct a secondary search with the understanding that bias may have contributed to initial impressions.

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CONCLUSION

Radiology is one of the most frequent specialties involved in delayed and missed diagnosis medical liability claims, and these diagnosis-related failures can lead to treatment delays and contribute to patient harm.[5] Reducing interpretation errors is complicated because it requires radiologists to acknowledge susceptibility to biases and to change thought processes to incorporate both Type 1 and Type 2 thinking.[4,8] Increasing radiologist awareness of diagnostic errors and what causes them can improve diagnostic performance and reduce individual harm.[4] Individual factors, including fatigue, physical and emotional health, and cognitive load, can increase the likelihood that cognitive and perceptual errors will interfere with the diagnostic process.[8] System factors, such as lighting and monitor conditions, ergonomics, shift length, volume, workflow, and interruptions, can also increase the occurrence of cognitive and perceptual errors.[2,5] Recognizing and addressing individual and system factors that contribute to these errors can reduce both the potential for patient injury and the risk of medical liability.[2]

ENDNOTES

The documents referenced in this article, along with many other risk management resource documents and past editions of ***Claims Rx***, are available by calling Risk Management at 844-223-9648 or by email at RiskAdvisor@ProAssurance.com.

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