Errors in Neuroimaging

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Purpose & Disclosures

- Review scenarios for common mistakes on emergent head CT & MRI
- What type of mistakes? Why do they happen?
- Review some literature regarding this topic
- Show examples of missed lesions
- What can we do to avoid these mistakes?
- Disclosures: none

Errors

- Errors in medicine: 10% of deaths, $29 billion/year, 20% of autopsies show a diagnosis different than the pre-mortem diagnosis
- Types in imaging:
  - Perceptual
  - Interpretative (knowledge)
  - System-related
- Neuroradiology: 2-8% rate of errors

Emergency Head Imaging

- Most common emergency scenarios: stroke, headache, altered mental status & trauma
- In USA, 1 of 14 ED patients gets a head CT
- General radiologists vs. neuroradiologists:
  - 2% significant disagreements
  - Most missed: pituitary masses

J Emerg Med 2014; 47: 684
AJR 2003; 180 1727

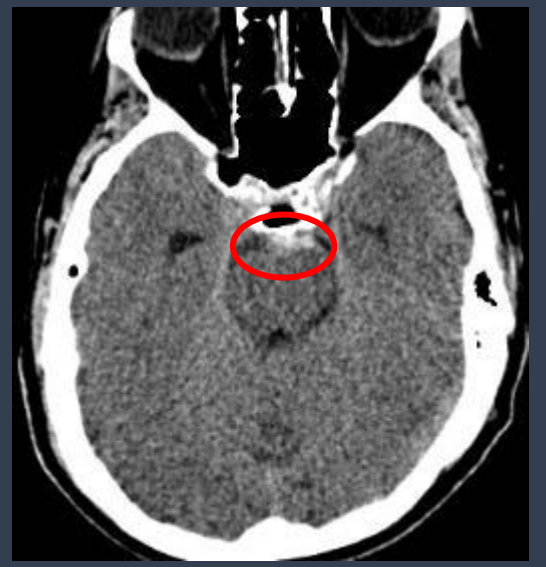
Emergency Cranial Imaging

- Clinical consequences of misinterpretations among radiologists in all neuroradiologic studies:
  - Change in management in 3 of 2388 patients (0.12%)
- Disagreements in trauma head CT studies:
  - 0.8% required changes in management

AJNR 2000; 21: 124
J Am Coll Radiol 2009; 6: 864

Emergency Cranial Imaging

- Radiology residents vs neuroradiologists
  - 2% significant disagreements
  - Most missed: hemorrhages & fractures
- Radiologists vs emergency physicians
  - 24% significant disagreements
  - Most missed: new infarctions



AJNR 2002; 23: 103
Ann Emerg Med 1995; 25: 169

Emergency Cranial Imaging

- Common issues of misinterpretations of trauma head CT (n= 955) by residents:
  - Highest #: 2:30PM to 8PM (more work)
  - Lowest #: midnight to 8AM (less work)
  - 1st year residents: more false-positive interpretations
  - Overall less errors: 3rd year residents

Isr Med Assoc J 2013; 15: 221

Factors That Increase Errors in All Imaging Studies

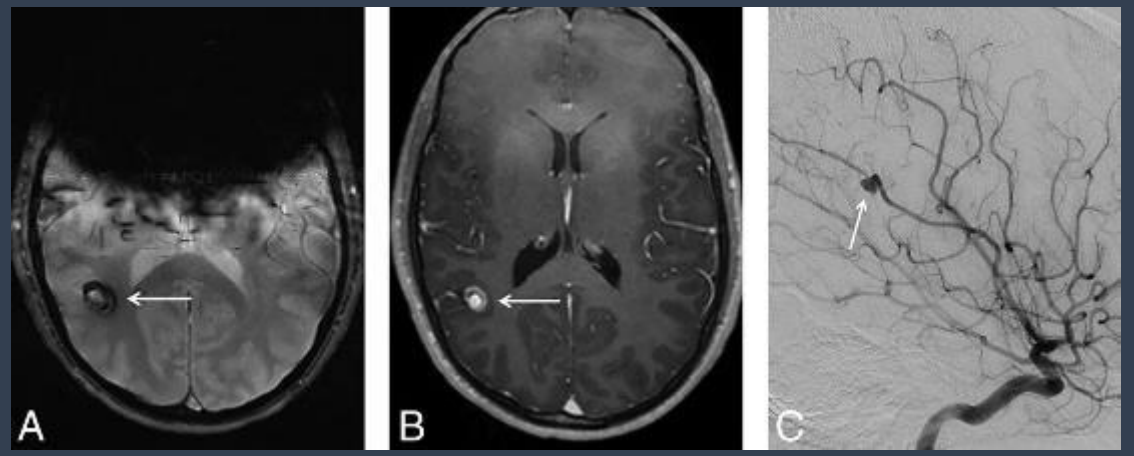
- Shorter viewing times
  - Doubling speed of interpretation increases errors by 100%
- Higher case loads (60?)
  - Influences well-being
- Night shift (even following ACGME guidelines)

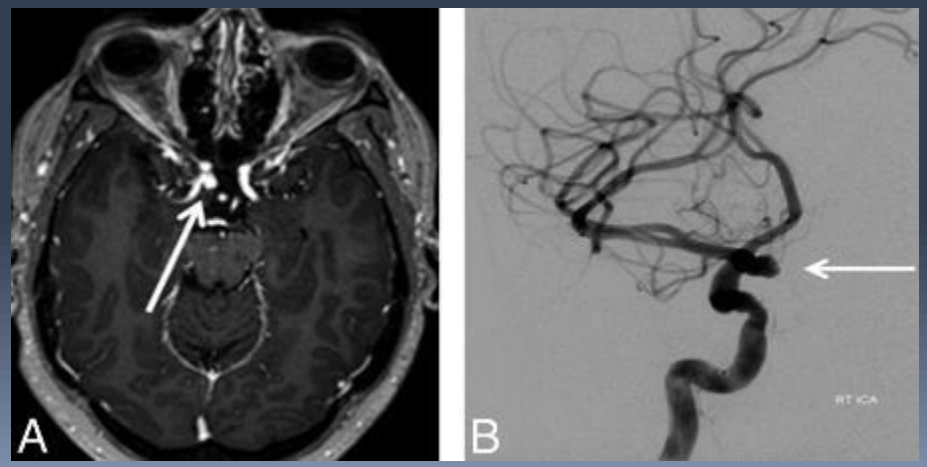
RadioGraphics 2015; 35:1668–1676

Types of Diagnostic Errors

- Errors of Interpretation:
  - Lesions detected but misinterpreted

- Errors of Perception:
  - Lesions not seen





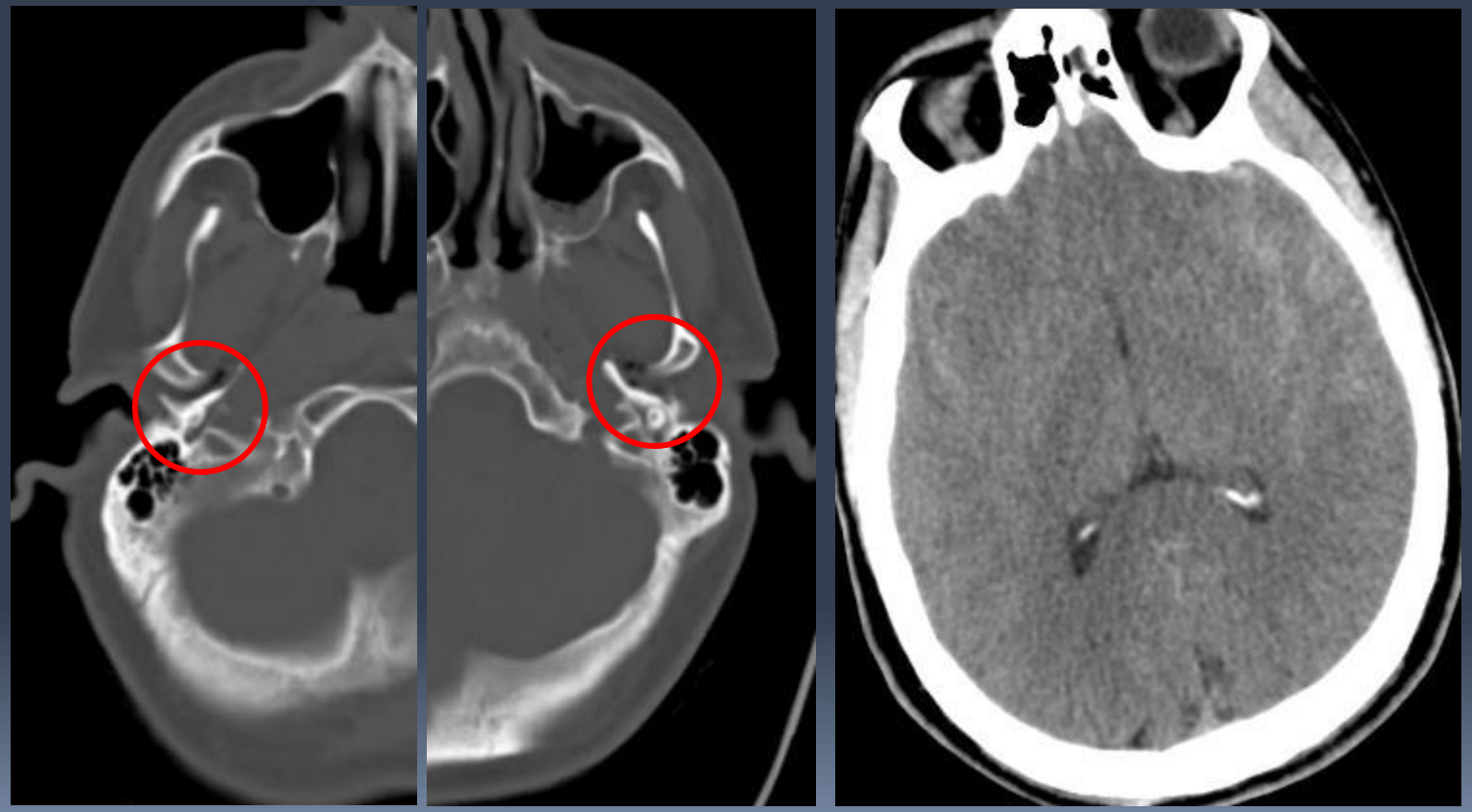
AJNR 2019; 40: 1252

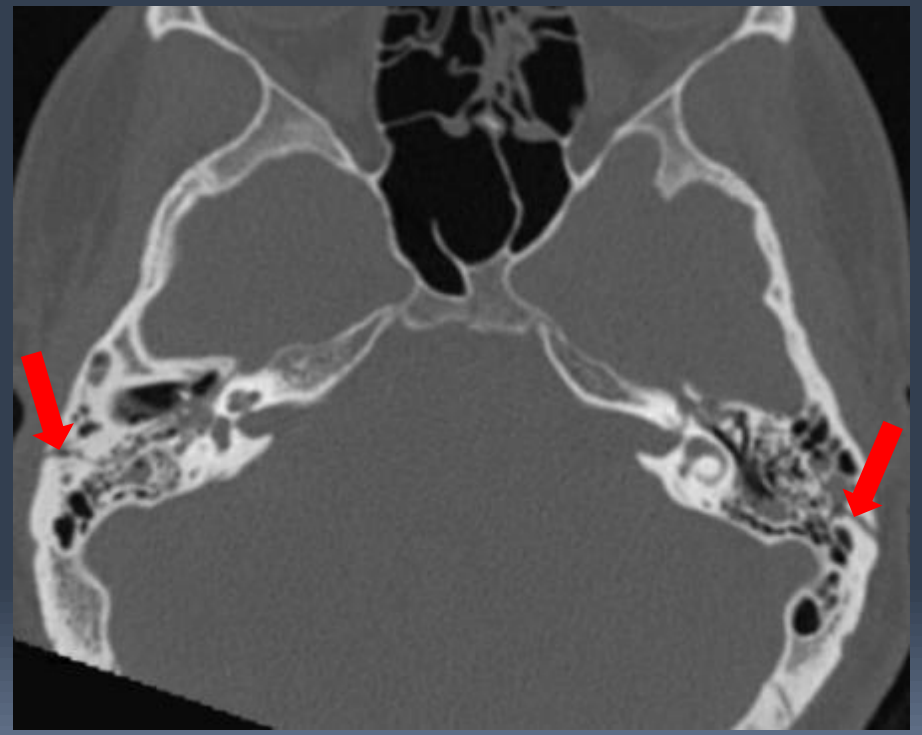
Emergency Cranial Imaging, Errors

- Perception vs interpretation errors (n=254):
  - Perception: 75%
    - Twice as common with <5 years experience
    - More likely with MRI than CT
  - Interpretation: 25%

AJNR 2019; 40: 1252

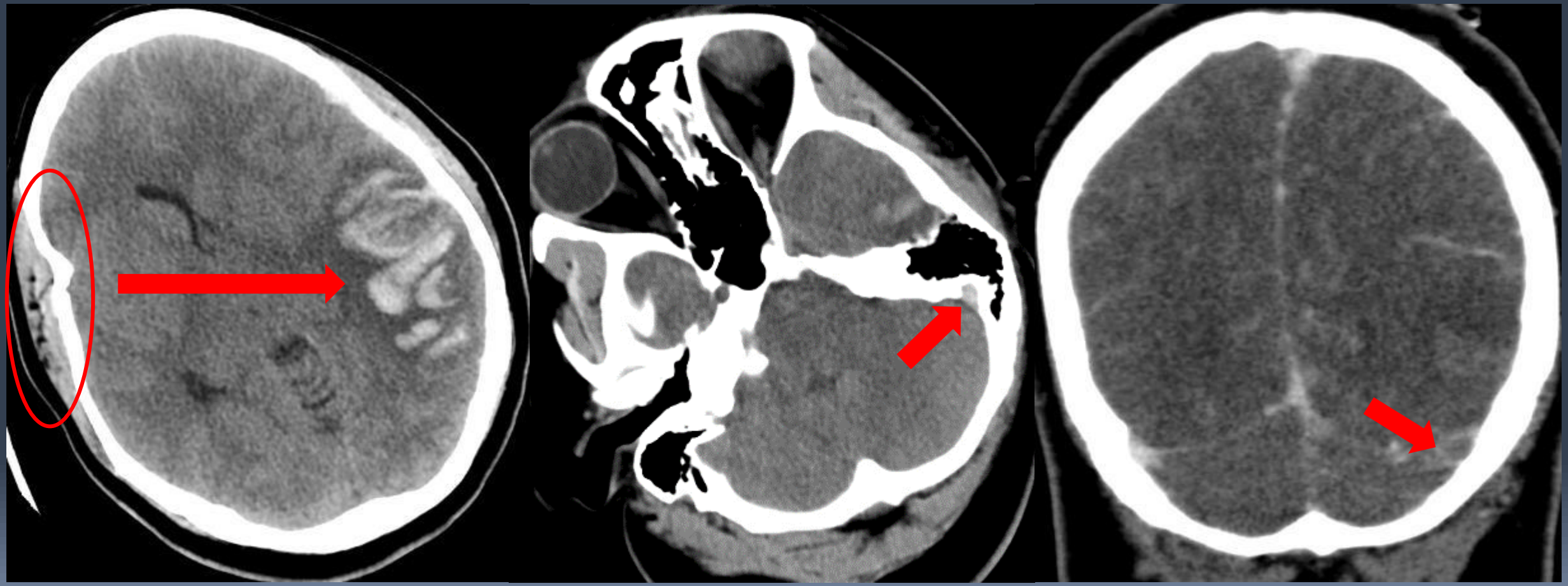
Young Adult w/head Trauma: Perception Error





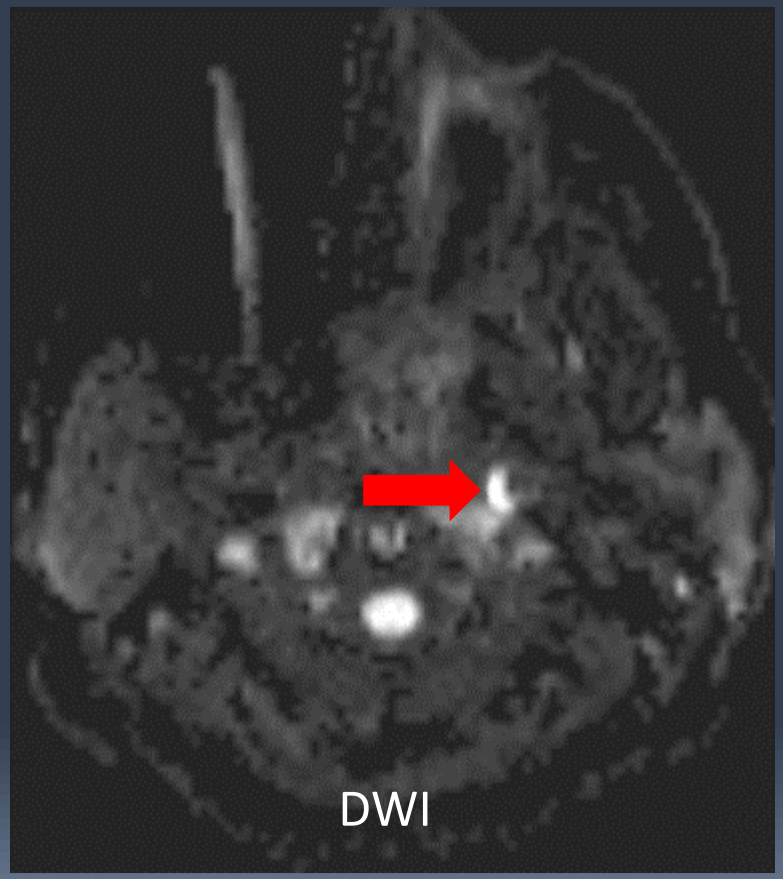
Bilateral temporal bone fractures

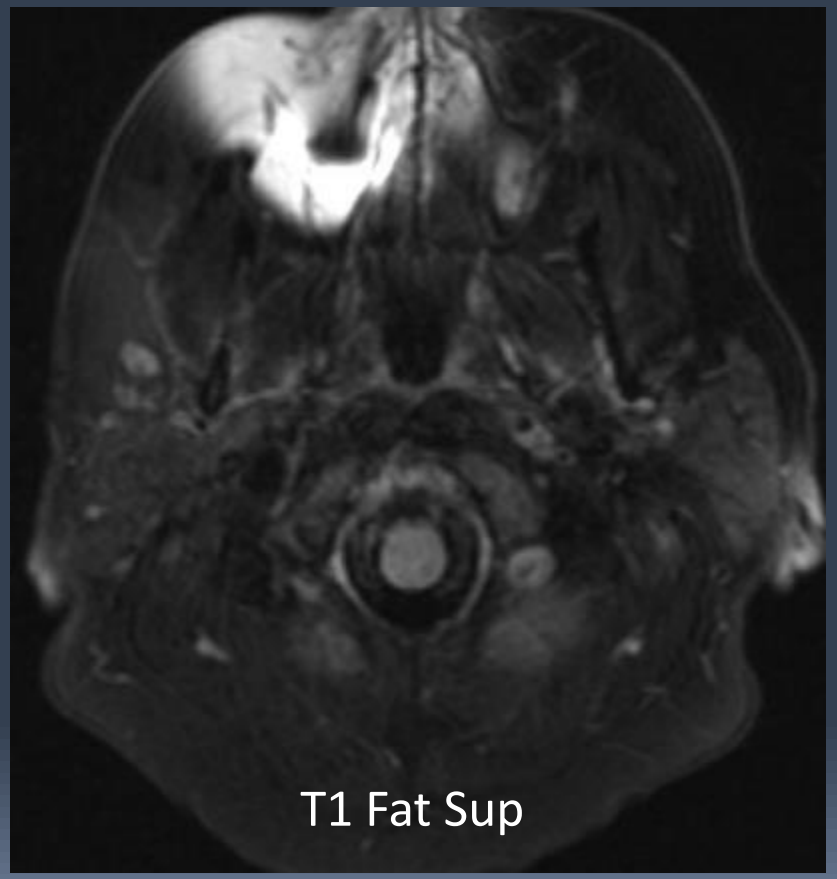
Young Female w/seizures: Perception Error

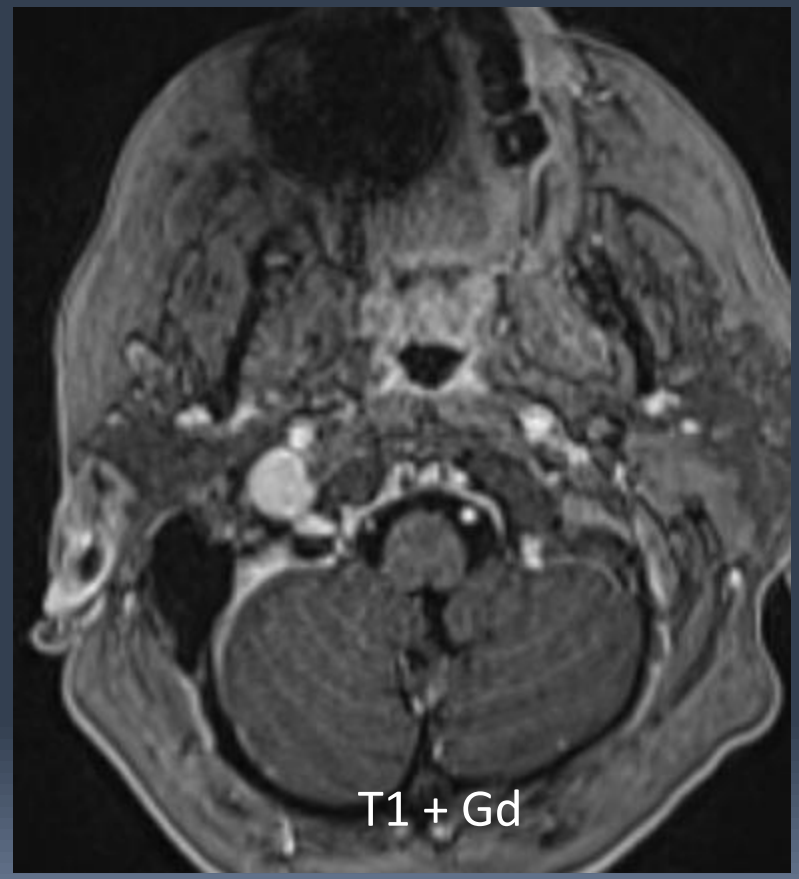


Hemorrhagic infarction due to venous thrombosis

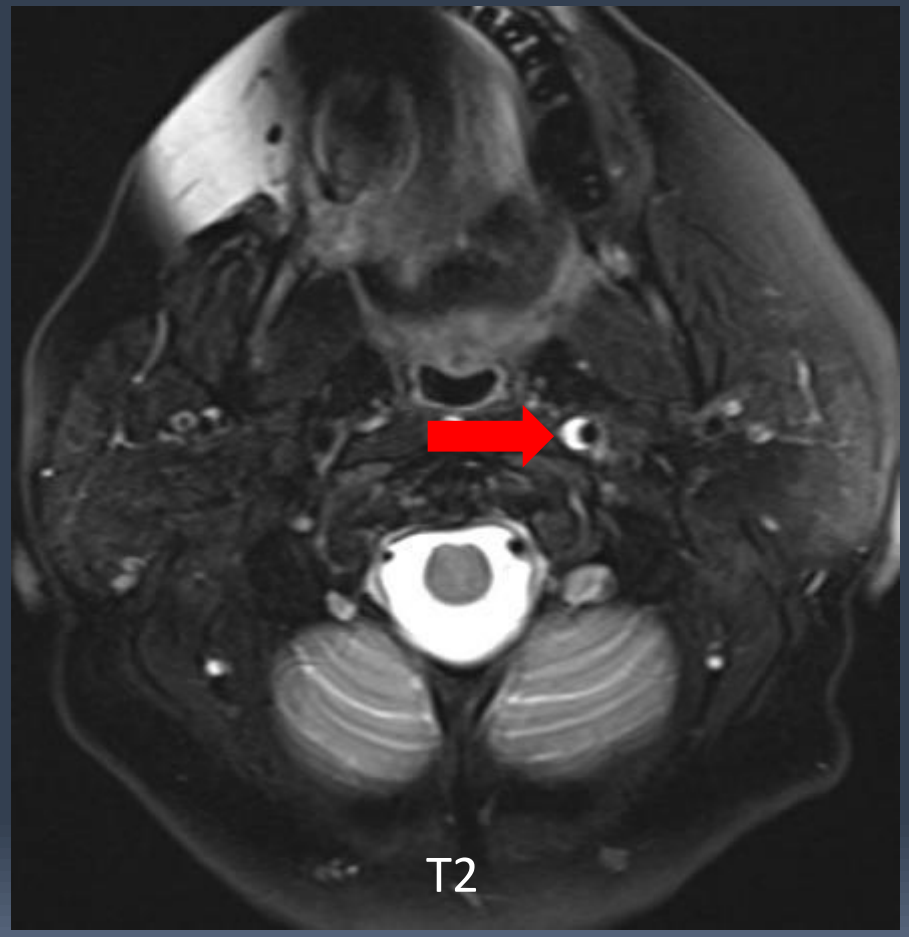
Minor Trauma & Neck Pain: Perception Error

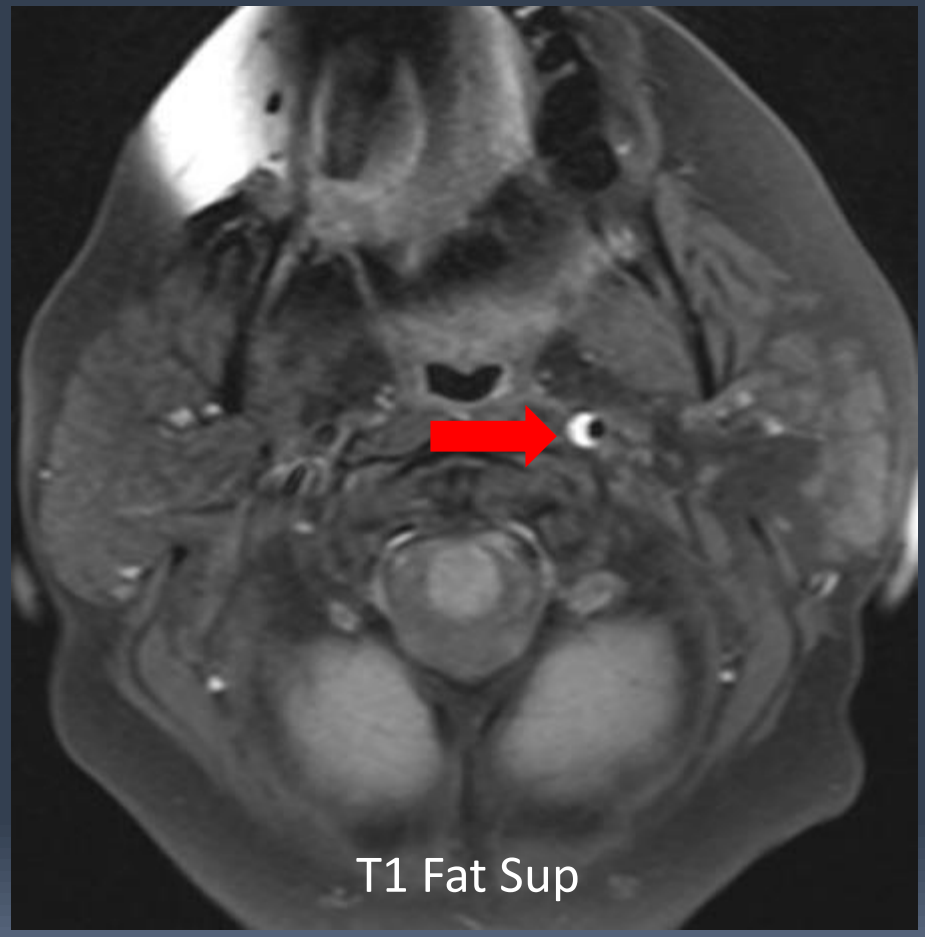






Right ICA dissection





Images from MRI dissection protocol

Published January 16, 2020 as 10.3174/ajnr.A6383

ORIGINAL RESEARCH
EXTRACRANIAL VASCULAR

Standard Diffusion-Weighted Imaging in the Brain Can Detect Cervical Internal Carotid Artery Dissections

G. Adam, J. Darcourt, M. Roques, M. Ferrier, R. Gramada, Z. Meluchova, S. Patsoura, A. Viguier, C. Cognard, V. Larrue, and F. Bonneville

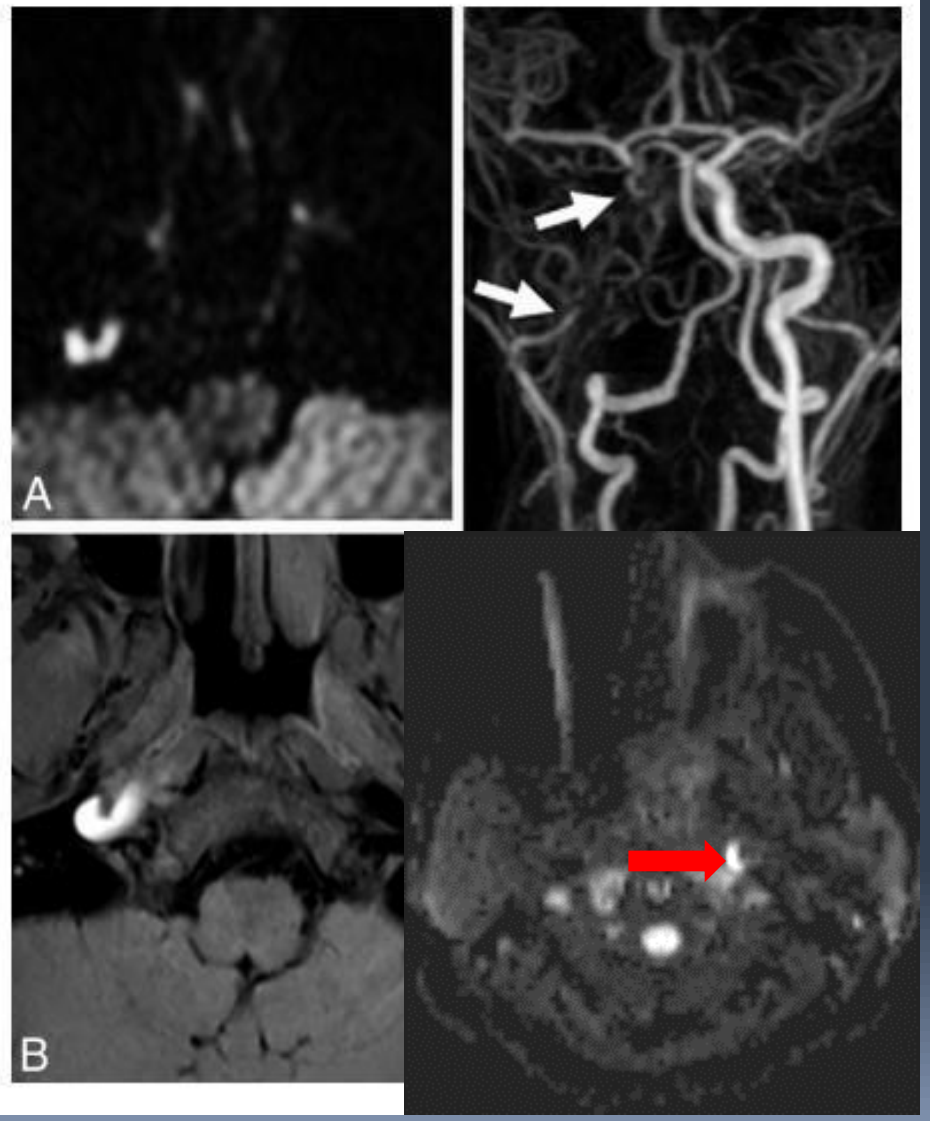
ABSTRACT

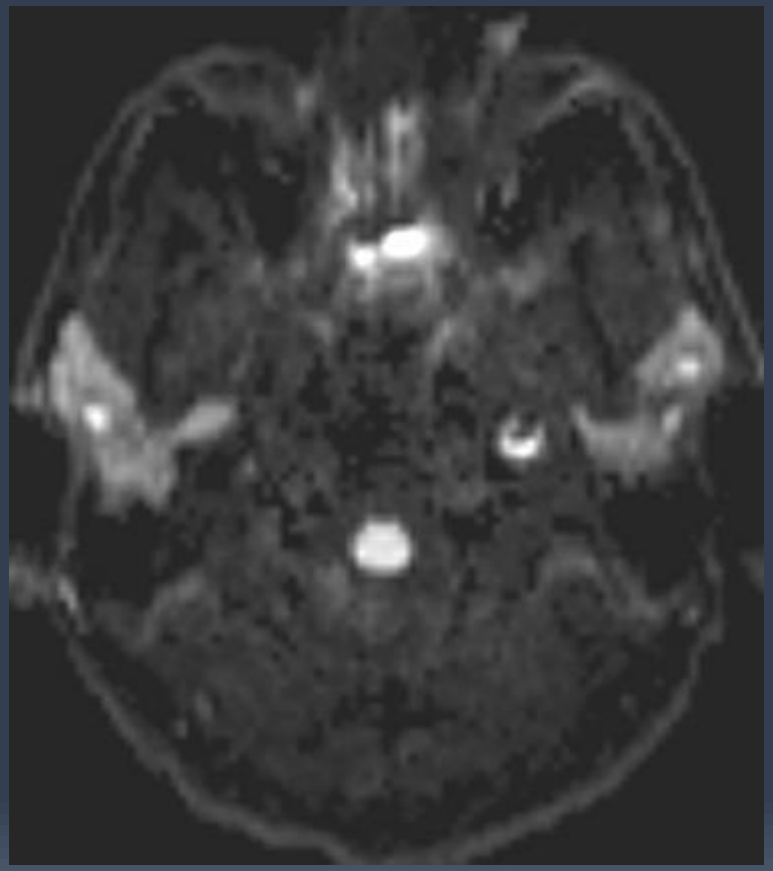
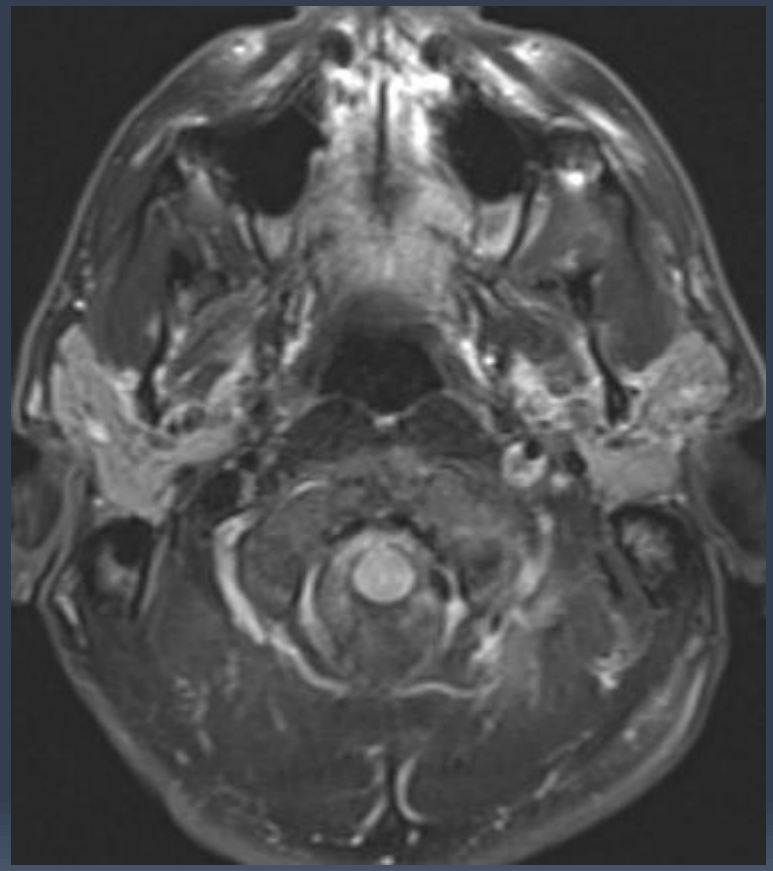
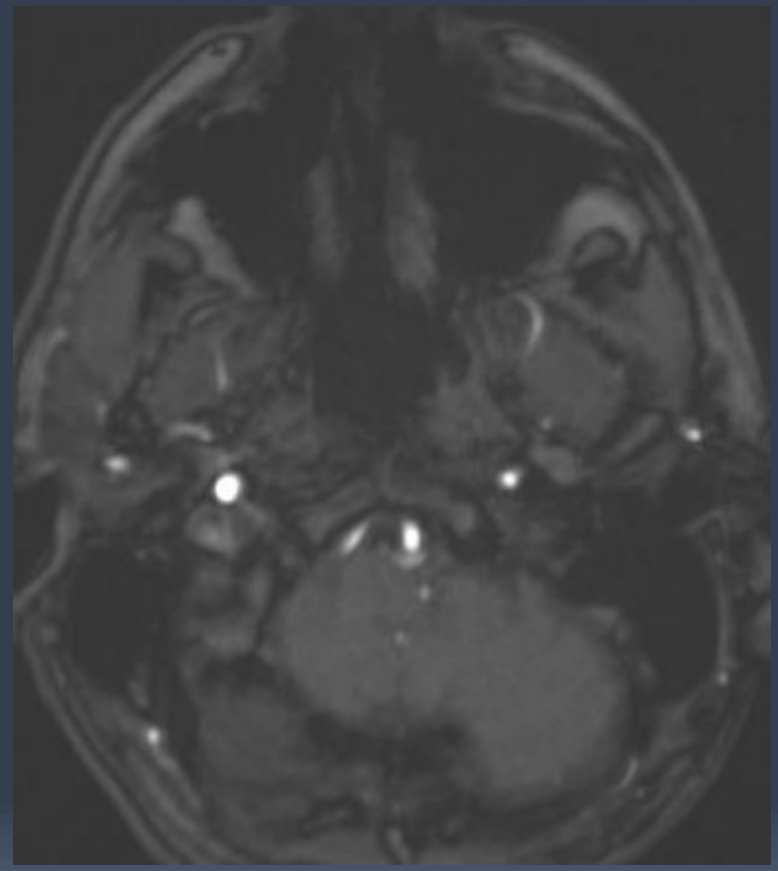
BACKGROUND AND PURPOSE: The ICA is the most common site of cervical artery dissection. Prompt and reliable identification of the mural hematoma is warranted when a dissection is clinically suspected. The purpose of this study was to assess to capacity of a standard DWI sequence acquired routinely on the brain to detect dissecting hematoma related to cervical ICA dissections.

MATERIALS AND METHODS: This was a retrospective study of a cohort of 110 patients younger than 55 years of age (40 women; mean age, 46.79 years) admitted at the acute phase of a neurologic deficit, headache, or neck pain and investigated by at least a standard 3T diffusion-weighted sequence of the brain. Among them were 50 patients (14 women; mean age, 46.72 years) with subsequently confirmed ICA dissection. In the whole anonymized cohort, both a senior and junior radiologist separately assessed, on the DWI sequences only, the presence of a crescent-shaped or circular hypersignal projecting on the subpetrosal segment of the ICA arteries, assuming that it would correspond to a mural hematoma related to an ICA dissection.

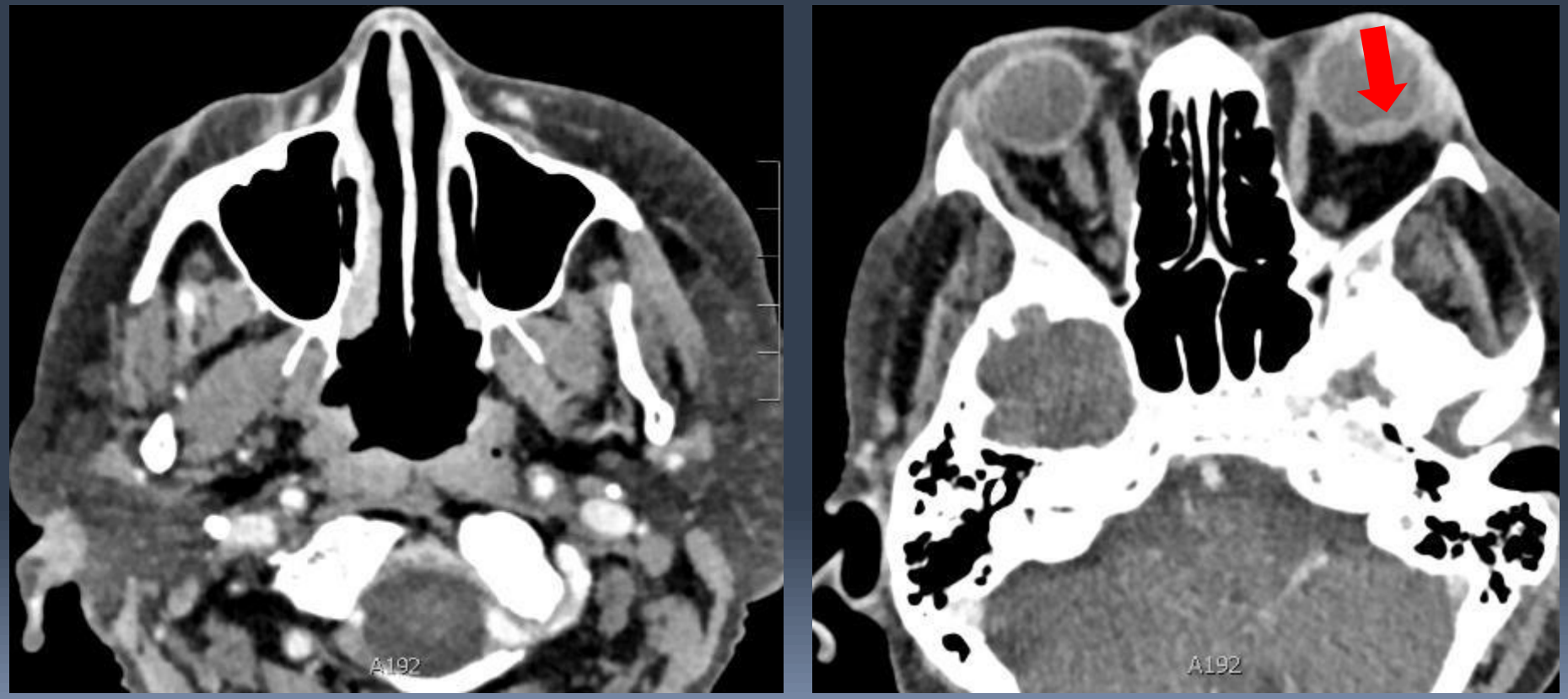
RESULTS: The senior radiologist found 46 subpetrosal hyperintensities in 43/50 patients with ICA dissection and none in patients without dissection (sensitivity, 86%; specificity, 100%). The junior radiologist found 48 subpetrosal hyperintensities in 45/50 patients with dissection and none in patients without dissection (sensitivity, 90%; specificity, 100%).

CONCLUSIONS: In our cohort, a standard DWI sequence performed on the brain at the acute phase of a stroke or for a clinical suspicion of dissection detected nearly 90% of cervical ICA dissections.



Immune suppressed patient, r/o fungal sinusitis: Perception Error



Ocular melanoma

Radiologic Errors and Malpractice: A Blurry Distinction

Leonard Berlin[1]

Medical error: Failure of a planned action to be completed as intended [1].

Medical malpractice: Unreasonable lack of skill. Failure of a physician...to exercise that degree of skill and learning commonly applied under all the circumstances in the community by the average prudent reputable physician with the result of injury...to the [patient] [2].

Approximately 4% of radiologic interpretations rendered by radiologists in their daily practice contain errors [3]. Fortunately, most of these errors are of such minor degree, or if serious are found and corrected with sufficient promptness, that they do not cause injury to patients. Nevertheless, many radiologic errors do harm patients and, as a result, medical malpractice lawsuits are generated. If it is determined by a judge or jury that the diagnostic error committed by a defendant–radiologist was the result of negligence, in other words, a breach of the standard of medical care, the radiologist will be held liable and compensation will be awarded to the plaintiff–patient. On the other hand, if the defendant's radiologic error is found not to be due to negligence, litigation is terminated without compensation. It follows then that certain radiologic errors result from radiologists' negligent conduct, and others do not. One may then logically ask whether these two kinds of radiologic errors, those that constitute negligence and those that do not, can be distinguished and if so, how? This article will attempt to seek an answer to these questions.

Malpractice Defined

In order for a radiologist or any other physician to be found liable for—that is, "guilty" of—medical malpractice, four elements must be established. There must be a physician–patient relationship [4, 5], the radiologist must have committed a negligent act (a breach of the standard of care), the negligent act must have caused injury to the plaintiff–patient (proximate cause) [6], and the patient must have sustained an injury. Except in unusual circumstances, three of these four elements—the physician–patient relationship, proximate cause, and patient injury—are not contentious issues in a lawsuit. The remaining allegation that must be proven for a plaintiff to succeed in a malpractice lawsuit, the one claiming that the defendant's conduct has breached the standard of care, is the most frequently contested. Inasmuch as nearly 75% of all medical malpractice lawsuits lodged against diagnostic radiologists allege negligence related to errors in diagnosis [7], our discussion here will be limited to the relationship between radiologic errors and malpractice.

American law derives from three sources: constitutional law, generated by federal and state constitutions and their subsequent interpretations by the courts; statutory law, rules and regulations enacted by state and federal legislatures; and the "common law," based on judicial decisions that serve as precedents on which courts base future decisions. The common law is a legacy of America's early English colonists [8]. It is the product of a continuum of state appellate and supreme court decisions and thus is constantly evolving.

At the conclusion of a medical malpractice trial, the "trier of fact" (usually the jury, occasionally the judge) determines whether the conduct of the defendant–physician constituted negligence. Before deliberation, jurors are instructed on the law by the presiding judge. The judge explains that medical negligence is a breach by the defendant–physician of the standard of medical care to which the physician is held. It is true, of course, that more than 90% of medical malpractice law-

Keywords: malpractice, medical–legal, radiologic errors

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AJR 2007; 189:517–522

0361–803X/07/1893–517

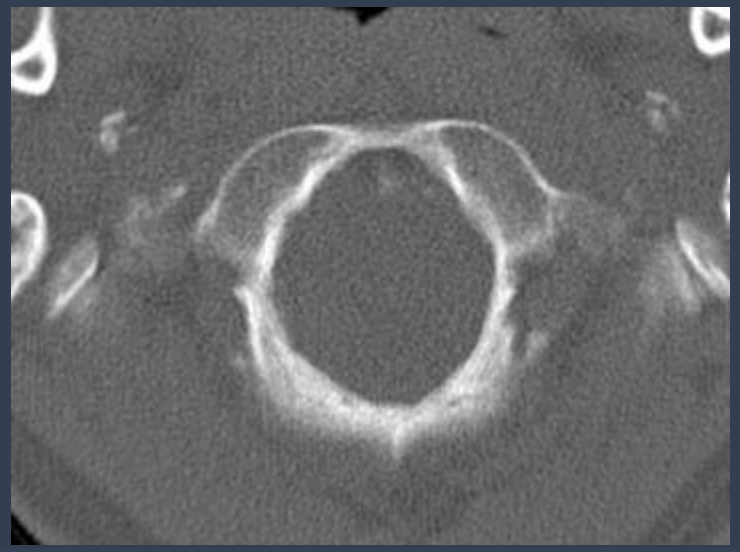
- Rate of perceptual errors has not changed in 50 years
- Errors in 4% of all imaging studies

3rd Type of Errors

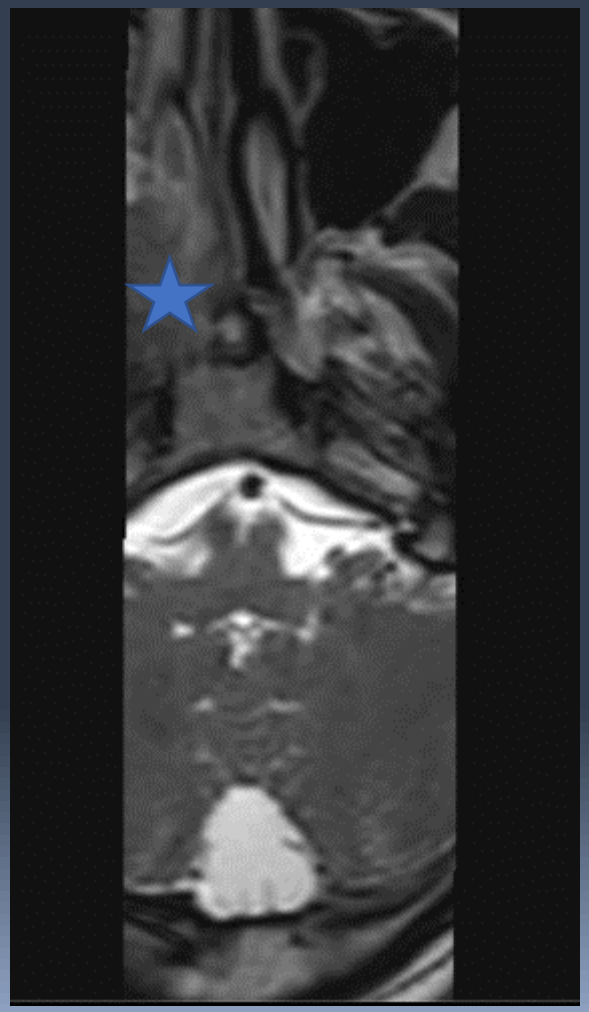
- System-related errors
  - Inadequate technique
  - Breakdown in communication: failure to report critical findings

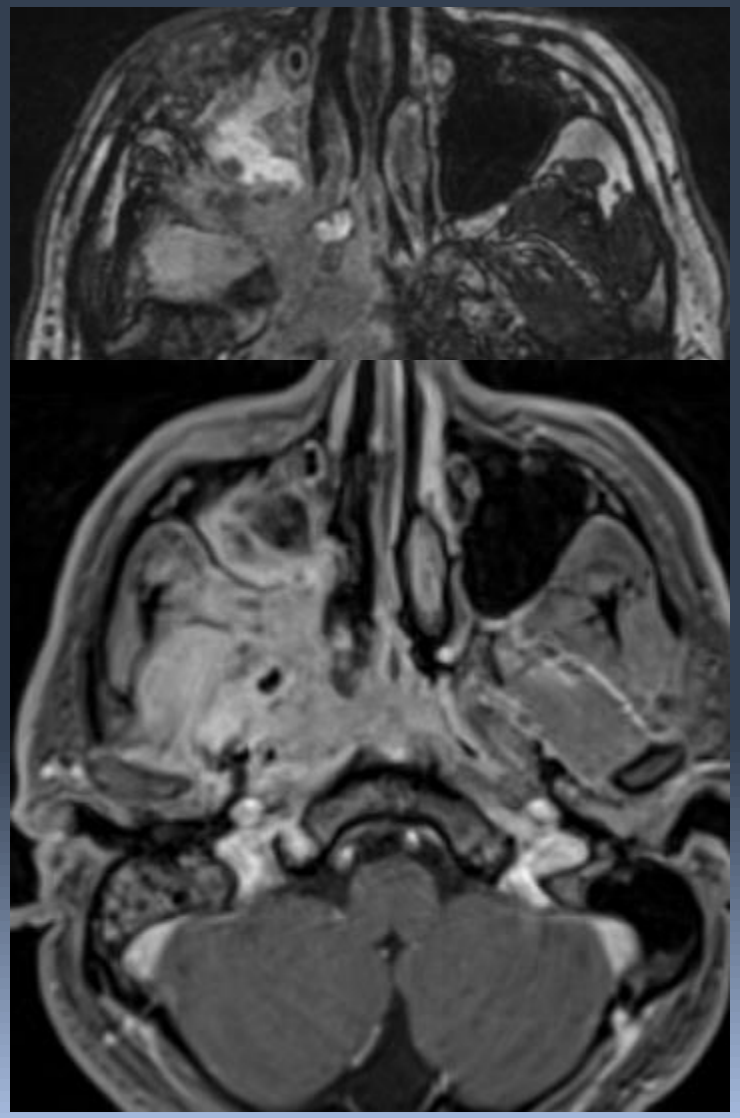
AJR 2013; 201: 611

Post trauma & neck pain: Poor Technique



Nasopharynx SCCA



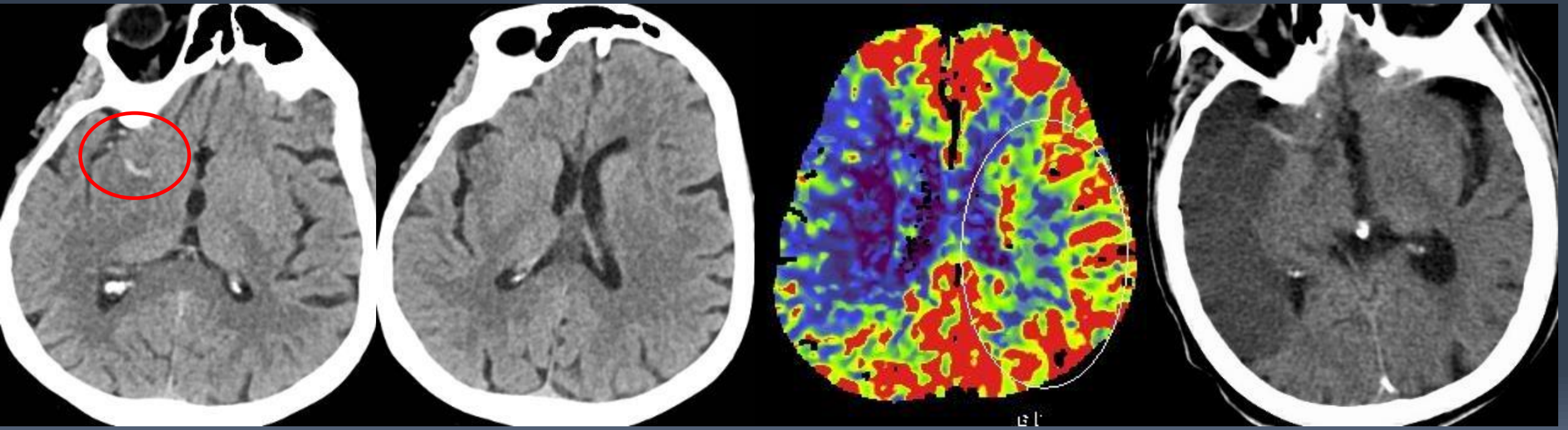


Reporting Critical Findings

- In USA only 41% of radiology programs had a critical findings list
- Most common findings in these lists:
  - Cerebral hemorrhage
  - Acute stroke
  - Brain herniation
  - Hydrocephalus
  - AVM/aneurysm
  - Masses
  - Meningitis/abscess
  - Edema

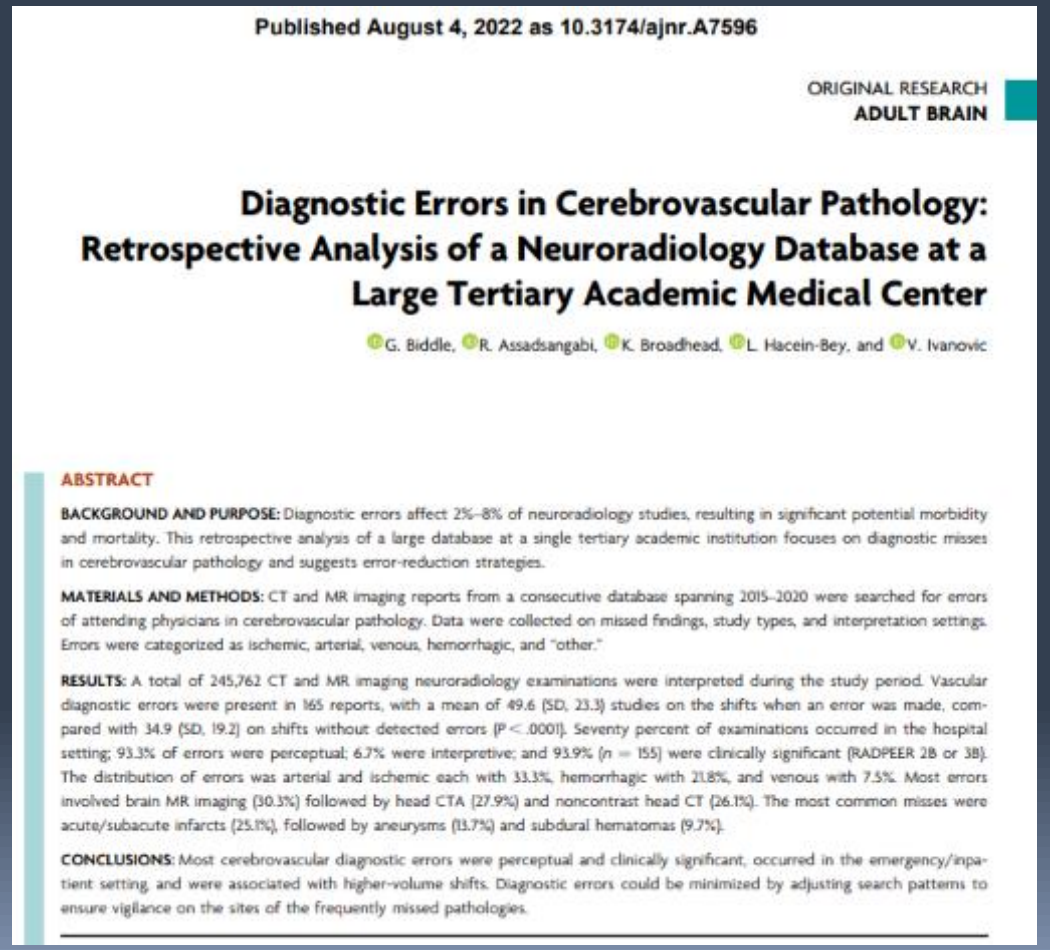
AJNR 2013; 34: 735
AJNR 2014; 35:1485

Failure to Communicate Critical Findings



Errors in Vascular Pathology

- 63 months, 16 neuroradiologists
- RadPeer
  - 1- concur w/interpretation
  - 2- discrepancy in interpretation not ordinarily expected to be made
    - A. Clinically insignificant
    - B. Clinically significant
  - 3- discrepancy that should be made most of the time
    - A. Clinically insignificant
    - B. Clinically significant
- For 2B & 3B: study type & error type



Published August 4, 2022 as 10.3174/ajnr.A7596

ORIGINAL RESEARCH
ADULT BRAIN

Diagnostic Errors in Cerebrovascular Pathology: Retrospective Analysis of a Neuroradiology Database at a Large Tertiary Academic Medical Center

G. Biddle, R. Assadsangabi, K. Broadhead, L. Hacein-Bey, and V. Ivanovic

ABSTRACT

BACKGROUND AND PURPOSE: Diagnostic errors affect 2%–8% of neuroradiology studies, resulting in significant potential morbidity and mortality. This retrospective analysis of a large database at a single tertiary academic institution focuses on diagnostic misses in cerebrovascular pathology and suggests error-reduction strategies.

MATERIALS AND METHODS: CT and MR imaging reports from a consecutive database spanning 2015–2020 were searched for errors of attending physicians in cerebrovascular pathology. Data were collected on missed findings, study types, and interpretation settings. Errors were categorized as ischemic, arterial, venous, hemorrhagic, and "other."

RESULTS: A total of 245,762 CT and MR imaging neuroradiology examinations were interpreted during the study period. Vascular diagnostic errors were present in 165 reports, with a mean of 49.6 (SD, 23.3) studies on the shifts when an error was made, compared with 34.9 (SD, 19.2) on shifts without detected errors ($P < .0001$). Seventy percent of examinations occurred in the hospital setting; 93.3% of errors were perceptual; 6.7% were interpretive; and 93.9% ($n = 155$) were clinically significant (RADPEER 2B or 3B). The distribution of errors was arterial and ischemic each with 33.3%, hemorrhagic with 21.8%, and venous with 7.5%. Most errors involved brain MR imaging (30.3%) followed by head CTA (27.9%) and noncontrast head CT (26.1%). The most common misses were acute/subacute infarcts (25.1%), followed by aneurysms (13.7%) and subdural hematomas (9.7%).

CONCLUSIONS: Most cerebrovascular diagnostic errors were perceptual and clinically significant, occurred in the emergency/inpatient setting, and were associated with higher-volume shifts. Diagnostic errors could be minimized by adjusting search patterns to ensure vigilance on the sites of the frequently missed pathologies.

Results

- 245,762 total studies
- 165 studies contained 175 errors
- 70% errors were in patients in hospital settings
- Types of studies:
  - MR: 30%
  - CTA head: 28%
  - Non contrast head CT: 26%

Results

- Types of errors:
  - Perceptual: 93%
  - Interpretative: 7%

Table 2: Error type based on pathology

Pathology	Total Errors (n = 175)	Percentage (%)
Acute/subacute infarct	44	25.1%
Aneurysm	24	13.7%
Subdural hematoma	17	9.7%
Significant arterial stenosis	11	6.3%
Dural sinus occlusion	11	6.3%
Epidural hematoma	8	4.6%
Large-vessel occlusion	8	4.6%
Overcall	7	4.0%
Arterial dissection	7	4.0%
Hypoxic-ischemic encephalopathy	7	4.0%
Chronic infarct	5	2.9%
AVM-AVF	5	2.9%
Subarachnoid hemorrhage	5	2.9%
Hemorrhagic contusion	3	1.7%
Embolic infarct	2	1.1%
Intraventricular hemorrhage	2	1.1%
Retroclival bleed	2	1.1%
Vasospasm	2	1.1%
Subclavian steal	1	0.6%
Sinus pericranii	1	0.6%
Deep neck vein occlusion	1	0.6%
Growing hemorrhage	1	0.6%
PRES	1	0.6%

Potential Solutions to Avoiding Errors

- Education (feedback system: path-rad correlations, peer review)
- Good technique
- Minimize distractions (RR assistants?)
- Supervise trainees
- Structured reports & checklists
- Workload to align with realistic benchmarks, rest
- Artificial intelligence, double readings?

- Increases report quality
- High rate of discrepancies
- Better for targeted, high-risk examinations

Insights into Imaging (2018) 9:287–301
https://doi.org/10.1007/s13244-018-0599-0

REVIEW

Added value of double reading in diagnostic radiology, a systematic review

Håkan Geijer[1] · Mats Geijer[1,2]

Received: 2 November 2017 / Revised: 10 January 2018 / Accepted: 15 January 2018 / Published online: 28 March 2018

Abstract

Objectives Double reading in diagnostic radiology can find discrepancies in the original report, but a systematic program of double reading is resource consuming. There are conflicting opinions on the value of double reading. The purpose of the current study was to perform a systematic review on the value of double reading.

Methods A systematic review was performed to find studies calculating the rate of misses and overcalls with the aim of establishing the added value of double reading by human observers.

Results The literature search resulted in 1610 hits. After abstract and full-text reading, 46 articles were selected for analysis. The rate of discrepancy varied from 0.4 to 22% depending on study setting. Double reading by a sub-specialist, in general, led to high rates of changed reports.

Conclusions The systematic review found rather low discrepancy rates. The benefit of double reading must be balanced by the considerable number of working hours a systematic double-reading scheme requires. A more profitable scheme might be to use systematic double reading for selected, high-risk examination types. A second conclusion is that there seems to be a value of sub-specialisation for increased report quality. A consequent implementation of this would have far-reaching organisational effects.

Key Points

- *In double reading, two or more radiologists read the same images.*
- *A systematic literature review was performed.*
- *The discrepancy rates varied from 0.4 to 22% in various studies.*
- *Double reading by sub-specialists found high discrepancy rates.*

Double Readings

- Meta-analysis, 29 studies, > 12K secondary interpretations
- Overall discrepancies: 32%
- Major discrepancies: 20%
- Change in management: 19%
- More common: MRI of body & brain

JACR 2018: 15: 1222

Older Physicians

- 27% of USA physician workforce is > 65 years
- Hospitalists:
  - Higher patient mortality when treated < 200 patients per year
  - Same applies to surgeons
  - Better outcomes immediately after residency
- More errors when burned out & depressed (pandemic) regardless of age
- One solution: continuous medical education

BMJ 2017;357:j1797
JAMA. 2006;296(9):1071-1078

Conclusions

- Errors are unavoidable but can be easily minimized:
  - Good environment in reading room, avoid distractions
  - Appropriate number of cases, avoid fatigue, rest
  - Post interpretation case evaluation & review
  - Structured reports & checklists
  - Adequate supervision of trainees
  - Artificial intelligence?

Conclusions

- Avoid errors of communication:
  - Critical findings to be communicated within 15 min
    - By telephone, EM record or both
    - Documented in report
  - Realistic list of critical findings available at all times in reading room
- Good techniques