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## Original Articles

# EFFECT OF CLINICAL INFORMATION ON BRAIN CT SCAN INTERPRETATION: A BLINDED DOUBLE CROSSOVER STUDY

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### ABSTRACT

Errors and variations in interpretation can happen in clinical imaging. Few studies have examined the biased effect of clinical information on reporting of brain CT scans. In a blinded double crossover design, we studied whether three radiologists were biased by clinical information when making CT scan diagnosis of the brain. Three consultant radiologists in three rounds with at least a one-month interval assessed 100 consecutive cases of brain CT scan. In the first round, clinical information was not available and 100 films without clinical information were given to radiologists. In the second round, the same 100 films were given and true clinical information was available. In the third round, the same 100 films were given and false clinical information was allocated. In 180 cases (60%) the evaluation resulted in the same diagnosis on all three occasions (95% confidence interval (CI): 54.5, 65.5), whereas 120 (40%; 95% CI: 34.5, 45.5) sets were evaluated differently. 48 cases (16%; 95% CI: 11.9, 20.1) had discordant evaluation with true and 33 (11%; 95% CI: 7.5,14.5) with false clinical information. Discordance without and with true and false clinical information was 39 (13%; 95% CI: 9.2, 16.8). Correct clinical information improves the brain CT report, while the report became less accurate after false clinical information was allocated. These results indicate that radiologists are biased by clinical information when reporting brain CT scans.

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**Keywords:** Clinical information, radiology, CT scan, bias, Iran.

### INTRODUCTION

The value of a CT scan in the diagnosis and management of patients with brain disease is widely recognized, and the CT scan diagnosis of it is considered very reliable. However, as in other diagnostic tests, errors and variations in interpretation should be expected to occur.

Bias can influence the evaluation of every diagnostic test.[1-3] Bias among radiologists is especially an area in which no attention has been given in Iran. Although it has been argued for 3 decades that the usefulness of any

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imaging procedure can only be measured objectively when radiologists are blinded to all clinical information,[4,5] only a few reports have investigated this influence on subjective diagnosis.[6-8] Previous reports on the influence of clinical information in plain radiographic reporting have shown inconsistent results.[9-11]

The radiologist who interprets the brain CT scan often has access to the radiography requisition form, which contains clinical information concerning signs and symptoms as reported by the treating clinician. While some radiologists prefer, at least initially, to inspect films without knowledge of the clinical information, others believe that such information is essential for adequate interpretation. It is reasonable to hypothesize that the reporting may be biased, whether consciously or unconsciously, by this information. To our knowledge, however, only two studies from the UK and USA have examined the existence, direction, and magnitude of this bias and evaluated its potential impact on the diagnosis of by CT scan[12,13] and concluded that clinical information affects the CT report. To our knowledge, there are no studies describing the possible effect of clinical information on brain CT scan reporting in developing countries.

In a blinded double crossover design we studied whether three radiologists were biased by clinical information when making brain CT scan diagnoses. The purpose was not to evaluate the accuracy of the diagnoses.

## MATERIAL AND METHODS

The study comprises 100 consecutive brain CT scans. The cases were identified prospectively from those referring to the CT scan Department of Shahid Bahonar Hospital, affiliated to Kerman University of Medical Sciences and Health Services, Iran, which covered a period from December 3, 1999 to October 27, 2000.

The 100 films were assessed three times with intervals of at least one month, by three consultant radiologists who were blinded to their own and the other observers' previous assessments. In the first round, clinical information was not available. One-hundred brain CT scan films without clinical information were given. In the second round, the same 100 films were given to radiologists and true clinical information was available. In the third round, the same 100 films were given, and false clinical information was allocated as in the first and second rounds. Each reader recorded any abnormal findings and their interpretation of these findings in each round. Any changes in interpretation without and with false and true clinical information were noted. The true clinical information was taken from the medical records of the patients and interview with patients. One of the investigators (MZ) made the false clinical information. Any scans requiring review of the images at the time of investigation were excluded.

The diagnosis of 100 cases were as follows: 7 infarctions (6 CVA, 1 post-meningitis), 4 infections (3 abscesses, 1 encephalitis), 17 tumors (2 metastases, 5 meningiomas, 1 meduloblastoma, 1 ependymoma, 3 glioblastoma multiforme, 1 5[th] nerve neuroma, 2 astrocytomas, 1 craniopharyngioma), 2 encephaloceles (1 frontal, 1 occipital), 1 basilar artery aneurysm, 7 normal, 7 post-craniotomy complications (including: intracerebral hemorrhage, subdural hemorrhage, pneumocephalus, bone defect, edema, brain herniation through the bone defect, infection), 4 complicating shunt tube (such as: compressed ventricles, intracerebral hematoma, intraventricular hemorrhage, poor functioning shunt tube), 1 massive basal ganglia calcification, 1 pseudotumor cerebri, 1 senile brain atrophy, 1 massive hydrocephalus and 47 head injuries (including: contusion, hemorrhagic contusion, intracerebral hematoma, subdural hematoma, subdural hygroma, epidural hematoma, subarachnoid hemorrhage, fracture (linear, depressed), soft tissue hematoma, deep axonal injury, generalized brain edema, midline shift, hydrocephalus, sinus fracture, pneumocephalus)

The three radiologists were told that the study was about inter- and intra-observer variation. They did not know that some of the clinical information was misleading or the 100 films were repeated. The radiologists were asked to read the films as routine. They did not keep notes from previous rounds. Each reader recorded any abnormal findings and their interpretation of these findings without clinical information. The images were then reviewed with true and false knowledge of the clinical information on the request form. Any further abnormal findings or changes in interpretation were noted by one of us (M.Z.) who did not participate in the interpretation of CT scans.

For the assessment of bias, the material was regarded as 100 different sets of brain CT scan films. Each of these sets were examined three times by each radiologist, without and with a true and false clinical history attached on each occasion, summing to a total of 300 sets of evaluation.

Evaluations resulting in different diagnoses could belong to one of two categories: (a) those in which there was concordance at all occasions between radiological diagnoses; and (b) those in which there was discordance at one occasion between the radiological diagnosis and the diagnosis which might be inferred from the other occasions. Patients in whom the report was changed after knowledge of true or false clinical information were followed up to determine whether the amended report was more or less accurate.

The reproducibility of the three observers' diagnoses was assessed separately for the 100 films. Two of the

**Table I.** Distribution of 100 sets of brain CT scan in which different diagnoses were made in three rounds by three radiologists.

| | Radiologist A % (95% CI*) | Radiologist B % (95% CI) | Radiologist C % (95% CI) | Total No. (%: 95% CI) |
|---|---|---|---|---|
| Concordance without and with true and false clinical information | 60 (49.7 to 69.7) | 56 (45.7 to 65.9) | 64 (53.8 to 73.4) | 80 (60: 54.5 to 65.5) |
| Discordant with true clinical information | 13 (7.1 to 21.2) | 23 (15.0 to 32.5) | 12 (6.4 to 20.0) | 48 (16: 11.9 to 20.1) |
| Discordant with false clinical information | 10 (4.9 to 17.6) | 8 (3.5 to 15.2) | 15 (8.7 to 23.5) | 33 (11: 7.5 to 14.5) |
| Discordant without and with true and false clinical information | 17 (10.2 to 25.8) | 13 (7.1 to 21.2) | 9 (4.2 to 16.4) | 39 (13: 9.2 to 16.8) |

*CI indicates confidence interval

**Table II.** Changes made by the reader after knowledge of true clinical information in 100 sets of brain CT scans.

| Radiologist | No. of CTs reported correctly without clinical information | No. reported correctly with true clinical information | % Change (95% confidence interval) |
|---|---|---|---|
| A | 60 | 90 | 30 (18.7 to 41.3)* |
| B | 56 | 92 | 36 (24.9 to 47.1)* |
| C | 64 | 85 | 21 (9.3 to 32.7)* |
| Total | 180 | 267 | 29 (22.4 to 35.6)* |

*$p<0.001$

consultant radiologists had 11 years of radiological experience and the third had 9 years. All of the radiologists were faculty members of Kerman University of Medical Sciences and trained to consultant level in cross-sectional imaging.

### Statistical analysis

The biasing effect of the clinical information on the diagnosis of brain CT scan was evaluated by the sign-test (two-sided). 95% confidence interval (CI), based on the normal approximation to the binominal distribution was calculated by confidence interval analysis software.[14]

## RESULTS

Seventy-one of the 100 patients imaged were male and 29 were female. Each scan was triple reported giving a total of 300 CT reports. One-hundred and eighty (60%; 95% CI: 54.5, 65.5) evaluations resulted in the same diagnosis on all three occasions, whereas 120 (40%; 95% CI: 34.5, 45.5) sets were evaluated differently. These 120 were split into 48 (16%; 95% CI: 11.9, 20.1) discordant evaluations with true and 33 (11%; 95% CI: 7.5,14.5) with false clinical information. Discordance without and with true and false clinical information was 39 (13%: 95% CI: 9.2, 16.8) (Table I). Tables II and III show the percentage of reports changed for each reader afterknowing true and false clinical information. Twenty-nine percent (95% CI: 22.4, 35.6) of brain CT reports were changed to more accurate diagnoses after true clinical information was known and 24% (95% CI: 16.2, 31.8) were changed to a less accurate diagnosis after false clinical information was allocated. This was a statistically significant departure from the expected equal split ($p<0.001$). Thus, when the radiologists made different evaluation of a given radiological material, they were prone to do this in accordance with the clinical information. The overall inter-observer agreement for radiological diagnosis of brain CT scans did not change when true or false clinical information was added (Table IV). The difference was not statistically significant.

## DISCUSSION

In this study 40% of interpretations were changed by knowledge of the true or false clinical information. Twenty-nine percent of brain CT reports were more accurate after true clinical information was known and 24% were less accurate after false clinical information was allocated. It is a well-known problem that clinicians may be biased by clinical information in the scientific evaluation of a diagnostic test and this is generally considered undesirable. One out of two doctors was significantly biased by his knowledge of the radiological diagnosis of deformity of the bulbous when making an endoscopic diagnosis.[15] Neurologists were asked to judge a

**Table III.** Changes made by reader after knowledge of false clinical information in 100 sets of brain CT scans.

| Radiologist | No. of CTs reported correctly without clinical information | No. reported correctly with false clinical information | % Change (95% confidence interval) |
|---|---|---|---|
| A | 60 | 33 | 27 (13.7 to 40.3)* |
| B | 56 | 35 | 21 (7.5 to 34.5)* |
| C | 64 | 40 | 24 (10.6 to 37.4)* |
| Total | 180 | 108 | 24 (16.2 to 31.8)* |

*$p$<0.001

**Table IV.** Comparison of 100 sets of brain CT scans in which different diagnoses were made in round 1, 2 and 3 by three radiologists.

| Radiologist | Without and with true clinical information | Without and with false clinical information |
|---|---|---|
| **A** | | |
| Discordant % (95% CI) | 30 (21.2 to 40.0) | 27 (18.6 to 36.8) |
| Concordance % (95% CI) | 70 (60.0 to 78.8) | 73 (63.2 to 81.4) |
| **B** | | |
| Discordant % (95% CI) | 36 (26.6 to 46.2) | 21 (13.5 to 30.3) |
| Concordance % (95% CI) | 64 (53.8 to 73.4) | 79 (69.7 to 86.5) |
| **C** | | |
| Discordant % (95% CI) | 21 (13.5 to 30.3) | 24 (16.0 to 33.6) |
| Concordance % (95% CI) | 79 (69.7 to 86.5) | 76 (66.4 to 84.0) |
| **Total** | | |
| Discordant % (95% CI) | 87 (29.0, 23.9 to 34.1) | 72 (24.0, 19.2 to 28.8) |
| Concordance % (95% CI) | 213 (71.0, 65.9 to 76.1) | 228 (76.0, 71.2 to 80.8) |

*CI indicates confidence interval

number of plantar responses on films preceded by fictitious abstract of history and examination.[1] Two films, showing equivocal toe movements were presented twice with opposing information as to the probability of a plantar reflex (Babinski sign). Interpretation of these identical pictures differed significantly conforming to the information given. In another study, bias from previous knowledge of the duration of amenorrhea was demonstrated in gynecologists' estimation of the size of the uterus in pregnant women.[2] The interpretation of histopathologic findings among pathologists was biased by clinical information given.[3] The review of numerous studies regarding the effect of clinical information on plain radiographic reporting showed inconsistent results. Several of these studies showed a positive effect[7-9,16,17] while others showed no effect.[11] Knowledge of a previous diagnosis influenced all the observers in a study evaluating plain roentgenograms of hands.[16] In another study, radiologists' diagnosis was significantly influenced by the context of interpretation, even when spectrum and verification bias are avoided.[17] Doubilet and Herman[9] found that appropriate clinical information increases the rate of positive reading in chest radiograph. Berbaum et al.[8] found clinical information improved detection and interpretation of abnormalities in a series of pediatric chest and abdomen radiographs. However, Good et al.[11] in a larger series found clinical information did not affect the accuracy of chest radiography reporting and Babcook et al.[7] found that while appropriate information improved the true positive detection, inappropriate information increased false positive detection.

Clinical information plays an extremely important role in the analysis and interpretation of CT scans. Clinical information must be accurate to improve radiological reports. While clinical information has an inconsistent effect on plain radiograph reporting, it was much less marked than that of clinical information on CT reporting even in the studies where it was shown to have a beneficial influence. We found only two other studies that assessed the effect of clinical information on CT reporting. In one of these studies Eldevik et al.[13] considered the effect of clinical bias on the interpretation of myelography and spinal CT. In the other study Leslie et al.[12] reported the effect of clinical information on the interpretation of CT reports. In both of these studies clinical information was found to bias the reports.

We do not believe that our findings can be explained by a practice experience impact in the present study, as the radiologists who made different diagnoses in one set of x-ray films had about 11 years of radiology practice and they were relatively as good as each other.

It would not be well founded to recommend that x-ray diagnoses be made without clinical information; rather, we recommend that x-ray diagnosis be made first without clinical information and then with it. Some knowledge of the clinical problem is necessary to choose the region to be examined.

In conclusion, we demonstrated that radiologists were biased by clinical information when reporting brain CT scans and the biasing effect of clinical information declined when accurate clinical information was added to the requisition form and as Leslie et al.[12] stated "it is the responsibility of the referring physician to ensure that the radiologist is given accurate and legible information".

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## REFERENCES


1. Van Grijn J, Bonke B: Interpretation of plantar reflexes: biasing effect of other signs and symptoms. J Neurol Neurosurg Psychiatry 40: 787-789, 1977.
2. Gjorup T, Saurbrey N, Hermann N: Clinical estimation of the duration of pregnancy in legal abortion–are doctors biased by their knowledge of the duration of amenorrhoea? Meth Inform Med 23: 96-98, 1984.
3. Skov BG, Braendstrup O, Hirsch FR, Lauritzen AF, Nielsen HW, Skov T: Are pathologists biased by clinical information? A blinded crossover study of the histopathological diagnosis of mesothelial tumors versus pulmonary adenocarcinoma. Lung Cancer 11: 365-372, 1994.
4. Schreiber MH: The clinical history as a factor in roentgenogram interpretation. JAMA 185:137-139, 1963.
5. Chalmers TC: PET Scans and technology assessment. JAMA 260: 2713-2715, 1988.
6. McNeil BJ, Hanley JA, Funkenstein HH, Wallman J: Paired receiver operating characteristic curves and the effect of history on radiographic interpretation. Radiology 149: 75-77, 1983.
7. Babcook CJ, Norman GR, Coblentz CL: Effect of clinical history on the interpretation of chest radiographs in childhood bronchitis. Invest Radiol 28: 214-217, 1993.
8. Berbaum KS, el Khoury GY, Franken EAJ, Kathol M, Montgomery WJ, Hesson W: Impact of clinical history on fracture detection with radiography. Radiology. 168: 507-511, 1988.
9. Doubilet P, Harman PG. Interpretation of radiographs: effect of clinical history: AJR 137: 1055-8, 1981.
10. Berbaum KS, Franken EA Jr, Dorfman DD, Lueben KR: Influence of clinical history on perception of abnormalities in pediatrics radiographs. Acad Radiol 1: 217-23, 1994.
11. Good BC, Cooperstein LA, DeMarino GB, Miketic LM, Gennari RC, Rockette HE, et al: Does knowledge of the clinical history affect the accuracy of chest radiographs interpretation? AJR 154: 709-12, 1990.
12. Leslie S, Jones AJ, Goddard PR: The influence of clinical information on the reporting of CT by radiologists. Br J Radiol 73: 1052-1055, 2000.
13. Eldevik OP, Dugstad G, Orrison WW, Haughton VM: The effect of clinical bias on the interpretation of myelography and spinal computed tomography. Radiology 145: 85-89, 1982.
14. Gardner MJ, Altman DG: Statistics with confidence. London: British Medical Association, 1989.
15. Gjoup T, Agner E, Jensen AM, Molmann KM: The endoscopic diagnosis of duodenal ulcer disease. A randomised clinical trial of bias and inter-observer variation. Scand J Gastroentrol 21: 261-267, 1986.
16. Bland JH, Soule AB, van Buskirk FW, Brown E, Clayton RV: A study of inter- and intra-observer error in reading plain roentgenograms of the hands. Am J Rad 105: 853-859, 1969.
17. Egglin TKP, Feinstein AR: Context bias. A problem in diagnostic radiology. JAMA 276: 1752-1755, 1996.