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► **To cite this version:**

Jérémy Dupuis, Géraud Forestier, Antoine Samson Hossou Gbessemehlan, Charbel Mounayer, Julien Magne, et al.. Revised indications for head CT in elderly patients with minor traumatic injuries: A retrospective analysis. *Journal de Neuroradiologie / Journal of Neuroradiology*, 2022, <10.1016/j.neurad.2022.11.006>. <hal-04027168>

HAL Id: hal-04027168

<https://unilim.hal.science/hal-04027168v1>

Submitted on 9 Jul 2025

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**REVISED INDICATIONS FOR HEAD CT IN ELDERLY PATIENTS WITH MINOR
TRAUMATIC INJURIES: A RETROSPECTIVE ANALYSIS.**

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REVISED INDICATIONS FOR HEAD CT IN ELDERLY PATIENTS WITH MINOR TRAUMATIC INJURIES: A RETROSPECTIVE ANALYSIS.

ABSTRACT

Purpose:

The purpose of this study was to assess the performance of a decision-tree for head-CT indication in elderly patients presenting minor traumatic injuries.

Materials and Methods:

A single-centre retrospective study was performed and analyses were based on emergency CT scans of all patients aged 65 and over who experienced minor head trauma due to falls. The primary judgement criteria was the diagnosis of a traumatic intracranial haemorrhagic lesion (tICH) depicted on the CT scan. Focal neurological deficit and history of tICH on a previous CT scan were used to create the decision-tree.

Results:

A total of 1001 patients were included. Ninety-five (9.5%) had tICH on the CT scan. Of these patients, 42 (46.1%) had an abnormal Glasgow Coma Scale, 30 (31.6%) a focal neurological deficit and 13 (13.7%) a history of tICH on a previous CT scan. The presence of at least one of these 3 risk factors was associated with the occurrence of tICH ($p < 0.001$). The decision-tree developed from these risk factors allowed the appropriate classification of 63 of 95 patients (66.3%) with tICH. Undetected haemorrhagic lesions in patients with no clinical severity criteria evolved favourably. The decision-tree correctly identified 97% of patients without any tICH on the CT.

Conclusion:

Systematic head CT for elderly patients presenting minor head trauma could be irrelevant. A decision-tree based on objective clinical severity criteria for the indication of head CT could detect the majority of tICH requiring surgical intervention. Prospective randomized studies are mandatory to confirm these hypotheses.

KEYWORDS

Traumatic brain injury, x-ray computed tomography, emergency, geriatric

ABBREVIATIONS

CART, Classification and regression tree; CT, Computed tomography; NPV, Negative predictive value; PPV, Positive predictive value; GCS, Glasgow Coma Scale; tICH, traumatic intra-cranial haemorrhage

1. INTRODUCTION

Head trauma in the elderly represents a frequent cause for consultation in the Emergency Department¹. Indeed, the ageing population and the increased risk of falling in relation to age makes this a public health problem². The computed tomography (CT) brain scan remains the gold standard for the reliable detection of traumatic intracranial haemorrhage (tICH) in its various forms (subdural haematoma, epidural haematoma, meningeal haemorrhage, haemorrhagic parenchymal contusions and parenchymal haematomas)³ and also allows the detection of traumatic bone lesions⁴. The diagnosis of tICH provides the degree of severity and participates in the evaluation for surgical management⁵.

The current guidelines of the French National Authority for Health for the assessment of traumatic head injury recommend a systematic brain CT scan for patients without loss of consciousness or post-traumatic amnesia if any of the following elements are present: neurological deficit, vomiting, severe headaches, age over 65 years, suspected skull base fracture, Glasgow Scale score (GCS) <15, coagulopathy, and trauma with a dangerous mechanism of injury. According to these recommendations, a brain CT scan is indicated in any patient over 65 years with head trauma without any severity factor⁶.

However, these guidelines are not suitable for reducing imaging orders⁷ even though the number of imaging examinations is constantly increasing in the general population and particularly in elderly subjects, with sometimes excessive use^{8,9,10}. The clinical relevance and rationale for imaging represents a major medico-economic challenge^{11,12}. Furthermore, the waiting time for an imaging examination contributes to the congestion of emergency departments¹³. Better selection of patients for emergency brain CT scans in the context of minor head trauma optimises indications.

A retrospective study carried out in 2019 at the Limoges University Hospital by Pages et al. established the absence of a significant association between the CT scan result and the patient's outcome, with a low diagnostic profitability from systematically conducting a CT scan². In this study, a significant association ($p < 0.001$) was found between the presence of traumatic brain injury and the presence of at least one of the following four criteria: male sex (RR=2.19), GCS<15 (RR=1.56), focal neurological deficit (RR=6.36) and past history of a post-traumatic head lesion (RR=7.17)².

Based on these clinical criteria associated with the occurrence of tICH, the main objective of the present study was to develop and evaluate the performance of a decision tree to guide the indication for head CT scan in the population of patients aged 65 and over consulting the emergency department for minor head trauma. Based on the results of Pages et al., we selected the following criteria: GCS <15, focal neurological deficit, and a history of tICH on a previous brain CT scan.

2. MATERIAL AND METHODS

2.1 Study Population

A total of 1001 consecutive patients aged 65 and over were retrospectively recruited in the Emergency Department of the University Hospital of Limoges (France), where they underwent a head CT scan due to fall from their own height exclusively. The recruitment period was March 2018 to March 2020. Patients under 65, those seen after a minor road traffic accident, and those with a poor pre-existing neurological condition were not included in the study. Patients injured by a blunt object were excluded too. Fig 1. shows the study flow chart.

2.2 Brain Scan

Scanning acquisitions were performed on a GE Optima 600 (General Electric) 64-slice scanner. The scan was performed without injection of contrast medium, with a volume spiral acquisition from the cranio-cervical junction to the vertex, in thin sections (1.25 mm thick). The scanner images were collected via the PACS (Picture Archiving and Communication System) Telemis-Medical version 4.4 and Xplore (EDL, France). All scans were retrospectively reviewed by a junior radiologist (JD) with five years of experience in radiology. The tICH included acute subdural haematoma, epidural haematoma, parenchymal haematoma, subarachnoid haemorrhage, and parenchymal contusion.

2.3 Clinical Data Collection

Data collection at the time of admission to the emergency room was carried out using Crossway software, and the following baseline data were collected: age, sex, GCS, existence of focal neurological deficit, history of tICH on previous CT scan, and previous use of antiplatelet or anticoagulant medication. In addition, from the computerised clinical record, the indication for a neurosurgical procedure linked to the trauma as well as patient outcome (return home, hospitalisation, death) were retrospectively analysed.

2.4 Statistical Analysis

The characteristics of the population were described and compared according to the presence or absence of a tICH as demonstrated on the brain CT scan. Qualitative variables were reported with numbers and frequencies, quantitative variables by median and interquartile range.

For the comparison of qualitative variables, the Chi2 test was used when all theoretical numbers were >5. When this was not the case, the non-parametric Fisher's Test was used. The normality of the distribution of qualitative variables was tested using the Shapiro-Wilk Test. As the age of the patients did not follow a normal distribution, the comparison between the groups was carried out by the non-parametric Wilcoxon/Mann-Whitney Test. The significance level was 5% ($p < 0.05$).

To meet the main objective, a CART (Classification and regression tree) type regression tree, frequently used for decision support, was implemented¹⁴. The construction of such a tree is based on a CART algorithm that aims to identify the most homogeneous groups in order to predict the presence or absence of the event of interest (traumatic intracranial injury, in our study)¹⁵.

The diagnostic performance of the decision tree was assessed by calculating sensitivities, specificities, positive predictive value (PPV), negative predictive value (NPV), false positive and false negative rates. Youden summary indices and accuracy were also calculated. The 'rpart' and 'rpart.plot' packages of the R software were used to perform this analysis.

3. RESULTS

3.1 Descriptive Analysis

Table 1 shows the descriptive data of the study population according to the presence or absence of tICH.

A total of 1001 patients were included, with a mean age of 87 years [80 – 91]. Of these, 95 patients of 1001 (9.5%) who had a tICH on the CT scan were compared to 906 patients (90.5%) who had no lesion. The majority of patients were female (58.7%), with no significant difference between the two groups ($p=0.29$). A GCS <15 was observed in 46% of patients ($n=42/1001$) with tICH. All patients with a focal neurological deficit ($n=30/1001$) had tICH on CT (31.6%). Of the 34 patients with a history of traumatic injury on a previous CT scan, 13 had tICH (38.2%). Each of these three variables presents a significant difference between the 2 groups, with a p -value <0.001 .

More than half of the patients ($n=643$, 64.2%) were treated by antiplatelet or anticoagulation therapy, with no significant difference between the groups with or without tICH ($p=0.258$), representing 58.9% and 64.8% of the total number of patients, respectively.

Almost half of the patients (47.3%) were hospitalised after their emergency care, regardless of the CT-scan result for tICH. Some patients with tICH returned home (7 of 95 patients, 7.4%). Neurosurgical intervention related to the diagnosis of tICH was performed for 15 patients, mostly for evacuation of a subdural haematoma, and 11 of 1001 (1.1%) died in the immediate or nearby aftermath within weeks of the trauma.

3.2 Diagnostic Analysis

Figure 2 shows the decision tree based on the criteria significantly associated with the diagnosis of tICH.

In order to create the most homogeneous groups possible, the algorithm started the classification with the GCS variable. The right side of the nodes represents the branch of the groups that met the

conditions of the node, and the left side represents the branch of the groups where the mentioned condition is not met.

Among the patients with tICH, the most represented data was GCS <15 (4.5% of the total sample). Focal neurological deficit and history of a lesion on a previous CT scan were poorly represented, as described in the descriptive analysis.

Among patients without any of these three criteria, the proportion of patients with tICH on CT scan was 3.5% in total. After applying the decision tree criteria to the 1001 patients in the cohort, 63 of 95 patients (66.3%) were correctly identified with tICH.

In all patients who required neurosurgical intervention, only one patient was not correctly diagnosed by the decision tree.

Concerning the 32 patients with tICH but not detected by the decision tree, the majority had a favorable outcome (30 patients of the 32 [93.7%]), because the haemorrhage detected corresponded in the majority of cases to a minimal meningeal haemorrhage of a cerebral sulcus (14 patients [43.7%]). The patient with an acute subdural haematoma on a chronic haematoma was the only patient not detected by the decision tree who had an indication for neurosurgical intervention (0.09% of the total sample of 1001 patients). The other patient without detection of a lesion by the decision tree died because of an odontoid fracture which was not diagnosed because the CT acquisition did not include the 2nd vertebra. Of the 906 patients without tICH, 883 patients had none of the three clinical signs studied (97.4%). Only two patients with GCS <15, 21 with a history of tICH, and none with a focal neurological deficit were misclassified as being at risk of post-traumatic injury.

3.3 Diagnostic Performance

For diagnostic performance, the decision tree was considered positive if the patient had any of the following variables: GCS <15, focal neurological deficit, and history of haemorrhagic injury on a previous brain CT-scan.

Table 2 shows the contingency table of the result of the decision tree with the status of the subject (tICH or not). The following diagnostic performances were calculated: sensitivity (66%) [CI95%:

56.61 – 75.39], specificity (97%) [95.89 – 98.11], PPV (73%) [63.64 – 82.36], NPV (96%) [94.73 – 97.27], false positive rate in patients with one of the clinical signs studied (26%), false negative rate in patients with none of the clinical signs studied (3%), Youden index (0.64), diagnostic accuracy (95%).

4. DISCUSSION

The prevalence of tICH in the present study (9.49%) is similar to the study of Pages et al. (7.6%)² and other similar studies (J. Bord and L)¹³. The diagnostic performance of the CT scan for the diagnosis of tICH appears poor. The criteria for performing a brain CT scan in this indication needs to be updated. This observation leads us to question the systematic indication for CT scan. In order to better guide the indication for brain CT scan, the clinical neurological criteria seem to be the most objective. The presence of one of the criteria studied in the decision tree (GCS <15, focal neurological deficit, history of traumatic haemorrhagic lesions on a previous CT-scan) allowed the detection of 66.3% of tICH in our study. The sex of the patient is not considered as a study criterion because it contradicts the study of Pages et al., where the male sex was predominant (57.9% vs. 46.3% in our study), demonstrating its lack of relevance. The relationship between gender and the presence of tICH is not statistically significant ($p > 0.05$) and gender is not a determinant for the presence of tICH. Approximately 33.7% of haemorrhagic lesions were not detected, the majority of these being subarachnoid haemorrhages with a favourable evolution (93.7%). Even if the sensitivity of the diagnostic tree for the detection of tICH is poor, its high negative predictive value (96%) would make it possible to avoid CT scan in patients with any of the clinical signs studied. Indeed, the NPV is defined as the probability that a patient without any of the clinical signs in the decision tree does not have tICH. This probability is very high (96%) and reliable (as the proportion of patients with a bleeding lesion in the total sample is low). It makes certain that patients without clinical severity do not have severe lesions. The ability to detect patients without tICH is also important (97%). The PPV is lower (73%), as well as the sensitivity (66%), because the ability of the decision tree to detect lesions is not optimal. Indeed, a number of patients (32) were asymptomatic despite the presence of tICH. In total, 95% of the results from the decision tree are correct.

A very small percentage of patients are operated on for tICH, around 15.7% of those with tICH, linked in particular to the many surgical contraindications in this age group¹⁶. Only one patient who underwent surgery was not detected by the diagnostic tree (0.09% of total sample), as he did not present clinical criteria of severity.

This is a retrospective study, and all the usual limitations apply. However, the the majority of patients were hospitalised for a non-neurological cause and the CT scan results did not seem to determine the patient outcome. The patient outcome and the indication for hospitalisation seem to be more related to the previous clinical patient condition and problems with staying at home. A reduction in the number of scans would relieve congestion in the emergency room, save time for both the emergency physician and the radiologist, enable faster patient referral, and ensure optimal radiation protection.

This study has the limitations of a retrospective study. The clinical data collected extracted from the patient's file were initially completed by the emergency physician, whose accuracy and completeness could not be verified and may have been the source of a selection bias. As Pages' study, we did not find an association between tICH and anticoagulants/antiplatelet therapy, but this association is debated in the literature¹⁷, and some anticoagulants might increase the risk of tICH¹¹. But, to confirm these hypotheses, future studies should collect more precisely the antiplatelet/anticoagulant treatments used, their dosage and their effects with blood samples. Although patients with a deteriorated baseline neurological status (advanced dementia) were excluded from the study, a patient may present an acute deterioration of his neurological status (temporo-spatial disorientation) due to an intercurrent pathology preceding the fall, which may cause a classification bias. Hospitalised patients over 65 years of age with a head injury were excluded to avoid interference with an intercurrent pathology that would confuse the clinical examination, making it impossible to extrapolate to this population.

The actual national guidelines of some countries like Finish have more focused on the presence of the surgical tICH to make the triage¹⁸. Although the study identifies patients requiring surgery, this outcome was not taken as the main objective. We acknowledge that undetermined factors may have influenced patient's outcome and are not considered in the decision tree. However, it is important to emphasize that purpose of the study was to consider all tICH, even the smallest, to assess their evolution.

Moreover, this study only considered tICH, whereas other potential post-traumatic lesions such as facial bone fractures require a CT scan for evaluation. The indication for these examinations may

however be guided by the clinical examination, in particular the presence of facial hematoma or pain on palpation of the facial bones.

In conclusion, systematic head CT for elderly patients presenting minor head trauma could be irrelevant. A decision-tree based on objective clinical severity criteria (GCS <15, focal neurological deficit, history of tICH on a previous brain CT-scan) for the indication of head CT could detect the majority of tICH requiring surgical intervention. The use of these criteria would reduce the number of CT scans in this indication by 91%, while maintaining significant relevance. This study has limitations because only clinical severity criteria were considered. Prospective randomized studies are mandatory to confirm these hypotheses.

HUMAN RIGHTS

The authors declare that the work described has been carried out in accordance with the Declaration of Helsinki of the World Medical Association revised in 2013 for experiments involving humans.

INFORMED CONSENT AND PATIENT DETAILS

The authors declare that this report does not contain any personal information that could lead to the identification of patients.

FUNDING

This work did not receive any grants from funding agencies in the public, commercial, or not-for-profit sectors.

AUTHORS' CONTRIBUTIONS

All authors attest that they meet the current International Committee of Medical Journal Editors (ICMJE) criteria for Authorship.

DISCLOSURE OF INTEREST

The authors declare that they have no competing interests.

AUTHORS' AGREEMENT

All authors take responsibility for all aspects of the reliability and freedom from bias of the data presented and their interpretation.

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TABLES AND FIGURES

Table 1: Descriptive characteristics of the study population according to the presence or absence of tICH

| Features | n (%) | Traumatic injuries | | P-value |
|---------------------------------------|--------------|--------------------|--------------|------------------|
| | | Yes (n=95) | No (n=906) | |
| Age (years) | 87 [80 – 91] | 84 [74 -90] | 87 [80 – 91] | 0.0128 |
| Gender | | | | |
| Female | 588 (58.7) | 51 (53.7) | 537 (59.3) | 0.2926 |
| GCS | | | | |
| <15 | 44 (4.5) | 42 (46.1) | 2 (0.2) | <0.001 |
| Focal neurological deficit | | | | |
| Yes | 30 (3) | 30 (31.6) | 0 (0) | <0.001 |
| History of tICH | | | | |
| Yes | 34 (3.4) | 13 (13.7) | 21 (2.3) | <0.001 |
| Antiplatelet /anticoagulation therapy | | | | |
| Yes | 643 (64.2) | 56 (58.9) | 587 (64.8) | 0.258 |
| Neurosurgical intervention | | | | |
| Yes | 15 (1.5) | 15 (15.8) | 0 (0) | <0.001 |
| Patient outcome | | | | <0.001 |
| Home | 528 (52.7) | 7 (7.4) | 521 (57.5) | |
| Hospitalised | 462 (46.2) | 79 (83.2) | 383 (42.3) | |
| Deceased | 11 (1.1) | 9 (9.5) | 2 (0.2) | |

Table 2: Contingency table of the decision tree result with the status of the subject (tICH or not), which is the basis for the calculation of the diagnostic performance markers.

| | Presence of tICH | Absence of tICH | Total |
|----------|------------------|-----------------|-------|
| Positive | 63 | 23 | 86 |
| Negative | 32 | 883 | 915 |
| Total | 95 | 906 | 1001 |

Table 3: Establishing the type of traumatic intracranial haemorrhage and patient outcome in patients with tICH not detected by the decision tree.

| Number of patients with tICH not detected by decision tree (32) | Type of tICH not detected by decision tree | Patient outcome |
|---|---|------------------------------------|
| 14 | Isolated meningeal haemorrhage | 14: Favorable evolution |
| 8 | Isolated acute subdural haematoma (sometimes on chronic subdural haematoma) | 7: Favorable evolution 1: Death |
| 1 | Isolated intra-parenchymal haematoma | 1: Favorable evolution |
| 1 | Isolated parenchymal contusion | 1: Favorable evolution |
| 1 | Odontoid fracture | 1: Death |
| 7 | Association of haemorrhagic lesions | 7: Favorable evolution |

Figure 1: Flow chart of the study

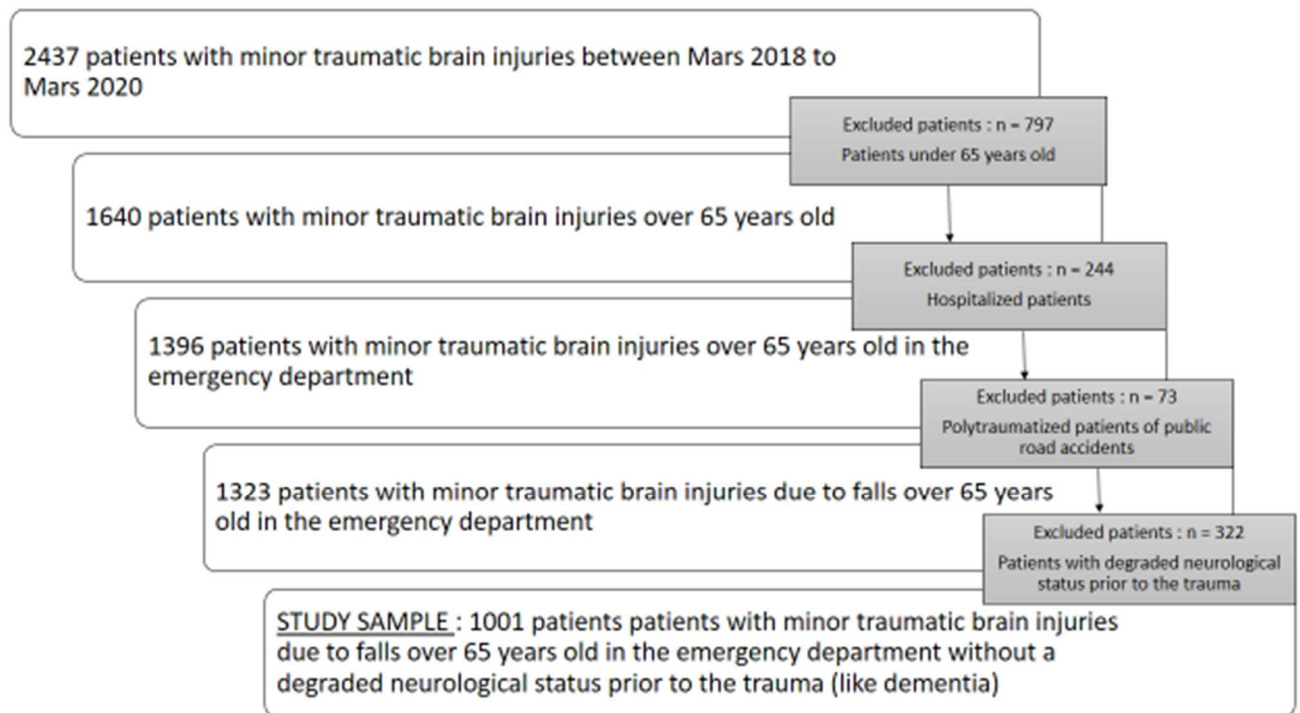


Figure 2: Decision tree using clinical severity criteria

