

## ORIGINAL RESEARCH

# Diagnostic Yield of Head Computed Tomography for the Hospitalized Medical Patient With Delirium

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**BACKGROUND:** Delirium is common in hospitalized patients and warrants early diagnosis and treatment. Often the evaluation of delirium includes head computed tomography imaging. However, in hospitalized medical patients, the yield of head computed tomography is unknown.

**OBJECTIVE:** To determine the diagnostic yield of head computed tomography when evaluating a hospitalized medical patient with delirium in the absence of a recent fall, head trauma, or new neurologic deficit.

**DESIGN AND SETTING:** Retrospective medical record review at a large academic medical center in Boston, Massachusetts.

**PARTICIPANTS:** We reviewed all medical records for head computed tomography scans performed from January 2010 through November 2012 in patients on the general medicine or medical subspecialties units.

**MAIN OUTCOMES:** A “positive” head computed tomography was defined as an intracranial process that could

explain delirium. An “equivocal” head computed tomography was defined as the presence of a finding of unclear significance in relation to delirium.

**RESULTS:** There were 398 patients hospitalized for >24 hours who underwent head computed tomography for delirium. Two hundred twenty head computed tomography studies met eligibility criteria, with 6 (2.7%) positive and 4 (1.8%) equivocal results. All positive and equivocal findings resulted in change in management.

**CONCLUSIONS:** The diagnostic yield of head computed tomography in determining the cause of delirium in hospitalized patients is low. Due to the low rate of positive findings, head imaging is unnecessary in the majority of cases of delirium. However, there may be a subset of high-risk individuals in which head imaging is indicated. *Journal of Hospital Medicine* 2014;9:497–501. © 2014 Society of Hospital Medicine

Delirium is a common and costly problem in hospitalized medical patients. It is present on admission in 10% to 31% of cases and develops in up to 56% of patients during hospitalization.<sup>1,2</sup> Prompt identification and treatment of the cause of delirium is important, because delirium is associated with increased morbidity and mortality, long-term cognitive impairment, higher cost of care, increased length of stay, and more frequent discharge to an extended care facility.<sup>3–6</sup>

Delirium can be caused or worsened by a variety of factors including adverse drug events, metabolic abnormalities, infections, immobilization, the use of restraints (eg, physical restraints, bladder catheters, telemetry), and disruption of sleep–wake cycle.<sup>7</sup> An appropriate history, medication review, physical

examination, and tailored laboratory evaluation is sufficient workup in the majority of cases.<sup>8</sup> However, neurologic processes, such as intracranial mass, intracranial hemorrhage, or stroke, can also present as delirium and require head imaging for diagnosis.

Because head imaging is a costly limited resource, a number of studies have aimed to determine which patients with delirium require this evaluation. The majority of research has focused on head computed tomography (CT) in patients presenting for evaluation to the emergency department (ED). In ED patients presenting with delirium, acute confusion, or altered mental status, head imaging identifies acute intracranial pathologic findings in 14% to 39% of cases.<sup>9–14</sup> Only 2 studies have evaluated patients with delirium who have already been admitted to the hospital. One study involved patients admitted to a neurology unit with acute confusion and found that the yield of head imaging (head CT and magnetic resonance imaging) was 14% for acute intracranial pathology.<sup>15</sup> Another study reviewed patients admitted to an acute delirium unit and found a similar rate of positive findings on head CT (14.5%).<sup>16</sup> Neither study specified whether the head imaging occurred during initial presentation or later in the hospitalization.

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Factors that increase the likelihood that delirium is caused by acute intracranial pathology include acute neurologic deficit, recent history of fall or head trauma, and significantly impaired consciousness.<sup>9–17</sup> Based on these findings, current guidelines and expert clinical statements recommend head imaging for patients with acute neurologic deficit, recent head trauma, or recent fall.<sup>18–20</sup>

Expert clinical statements also recommend imaging in cases where the cause is unidentified after appropriate medical testing or where delirium continues despite treatment.<sup>8,21</sup> Yet the utility of head CT performed for nonresolving delirium or delirium that develops during hospitalization in the absence of recent fall, head trauma, or new neurologic deficits is not known. Our study aimed to determine the diagnostic yield of performing a head CT in this patient population. We hypothesized that the diagnostic yield of head CT in this population would be low.

## METHODS

### Study Design

We conducted a retrospective medical record review of hospitalized general medicine patients with head CT imaging performed for the evaluation of delirium. The study was reviewed by the internal review board and determined to be exempt.

### Setting and Eligibility Criteria

The study was conducted at a large academic medical center in Boston, Massachusetts. All patients admitted to general medicine, nephrology, hepatology, cardiology, or oncology services with head CT studies performed from January 1, 2010 through November 30, 2012 were included in this retrospective, observational cohort study. Data were extracted using a defined instrument developed for this study with outcome measures predefined. Head CT imaging acquired for patients in the intensive care unit were not included in the review. The medical records were evaluated to determine indication. To be included in the study, the indication for the scan had to be delirium, altered mental status, confusion, encephalopathy, somnolence, or unresponsiveness. In addition, the patient must have been admitted for at least 24 hours prior to the completion of the head CT scan. Scans were excluded if there was documentation in the medical record of a fall, head trauma, or new neurologic deficit within the preceding 2 weeks, or an admitting diagnosis of intracranial pathology (eg, stroke or subdural hematoma). If a patient had multiple head CT studies completed for the indication of delirium, each study was included. However, once a head CT study returned “positive” or “equivocal” for an acute intracranial process, subsequent head CT studies for the indication of delirium were not included in the analysis.

## Outcome Measures

A “positive” head CT was defined as an intracranial process that could explain delirium (eg, intracranial hemorrhage or stroke). An “equivocal” head CT was defined as the presence of a finding of unclear significance in relation to delirium (eg, hypodensity of unknown etiology or clinical significance). “Chronic” head CT findings were noted to be intracranial pathologic findings of a chronic nature that did not meet criteria for either a “positive” or “equivocal” image (eg, chronic small vessel ischemic disease or atrophy). A “normal” study was without positive, equivocal, or chronic findings.

## Data Collection and Statistical Analysis

Using the medical center’s clinical informatics infrastructure, an experienced clinical informaticist (R.A.) compiled a list of all head CT imaging studies performed during the study period in hospitalized medical patients. An experienced hospital medicine physician (J.T.) conducted the medical record review and determined if each head CT performed met eligibility criteria. For each included study, the following information was collected: date of admission, date of head CT, date of onset of delirium, indication for obtaining head CT scan, head CT results, age, gender, race/ethnicity (patient reported), presence of dementia (if documented in the medical record), active cancer, use of anticoagulants (defined as factor Xa inhibitors, low molecular weight heparin, direct thrombin inhibitor, or vitamin K antagonist) with documentation of internationalized normalized ratio (INR), partial thromboplastin time (PTT) prothrombin time and platelet count, active infection, history of stroke, and change in clinical management. Descriptive statistics were used to analyze data. Median and interquartile range were used to describe results for age and time from admission to head CT performed due to skewed distribution of results.

## RESULTS

Of 1714 head CT studies performed on hospitalized medical patients from January 1, 2010 to November 30, 2012, 398 studies were performed for an indication of delirium, altered mental status, confusion, encephalopathy, somnolence, or unresponsiveness in patients who were admitted for >24 hours. One hundred seventy-eight studies were excluded (137 for admitting diagnosis of intracranial process, recent fall, or head trauma, and 41 for new neurologic deficit). There were 220 scans included in the study performed on 210 patients.

Table 1 displays characteristics of the 210 patients who underwent CT head imaging. Of the 42 patients on anticoagulation, 15 were potentially supratherapeutic; 10 were on warfarin (INR range, 3.3–7.7) and 5 were on intravenous heparin infusion (PTT range,

**TABLE 1.** Characteristics of Patients Undergoing Head Studies Conducted for the Indication of Delirium

Characteristic	N = 210
Age, median (IQR)	70 (59–80)
Male, n (%)	96 (45.7)
Race/ethnicity, n (%)	
White	147 (70.0)
African American	44 (21.0)
Hispanic	4 (1.9)
Asian	3 (1.4)
Unknown	9 (4.3)
Other	3 (1.4)
Comorbidities, n (%)	
Dementia	30 (14.3)
Active cancer	49 (23.3)
Anticoagulation	42 (20.0)
Active infection	105 (50.0)
History of stroke	41 (19.5)
Days from admission to head CT, median (IQR)	4 (3–8)
Days from delirium onset to head CT, median (IQR)	2 (1–4)

NOTE: Abbreviations: CT, computed tomography; IQR, interquartile range (25th percentile–75th percentile).

101–>150 seconds). None of these individuals had positive or equivocal findings on head CT.

The main outcomes of the 220 included head CT scans and a separate analysis of the 60 head CT scans performed for indications of somnolence or unresponsiveness are shown in Table 2. The 6 (2.7%) positive and 4 (1.8%) equivocal head CT findings are listed in Table 3. Of the 3 positive results in patients on anticoagulation, 2 were on warfarin with an INR of 2.1 and 2.4, respectively, and another was on warfarin and therapeutic enoxaparin (dosed 1 mg/kg twice daily) with an INR of 1.6. The median time from admission to positive head CT was 8 days, with a range of 2 to 28 days. All of the positive head CT studies resulted in change of management. All equivocal head CT studies resulted in repeat imaging. None of these repeat head imaging studies diagnosed acute intracranial pathology. Chronic findings identified included 111 (50.5%) involution or atrophy, 95 (43.2%) small vessel ischemic disease, 31 (14.1%) prior stroke, and 18 (8.2%) other chronic abnormalities (eg, cyst or meningioma).

## DISCUSSION

In this retrospective review, we determined that there is a low diagnostic yield of head CT imaging for identifying the cause of nonresolving or new-onset delirium in hospitalized medical patients. Only 2.7% of head CT scans resulted in identifying an acute intracranial process. Because of the low number of positive results, no risk factor associations could be made from our study.

The low diagnostic yield of head imaging in hospitalized patients with delirium is particularly important for clinicians who care for hospitalized medical

**TABLE 2.** Results of Head Computed Tomography Studies

Indication	Delirium, N = 220 (100%)*	Somnolence or Unresponsiveness, N = 60 (27.2%)
Outcome		
Positive	6 (2.7)	0
Equivocal	4 (1.8)	1 (1.6)
Chronic	162 (73.6)	41 (68.3)
Normal	48 (21.8)	18 (30.0)

NOTE: \*Delirium indication includes delirium, altered mental status, confusion, encephalopathy, somnolence, or unresponsiveness. Positive is defined as a head computed tomography (CT) with an intracranial process that could explain delirium, equivocal finding is defined as head CT with an intracranial process of unclear significance in relation to delirium, chronic findings are head CT with findings chronic in nature that do not meet criteria for positive or equivocal findings, and normal is defined as head CT without positive, equivocal, or chronic findings.

patients. Prior to this study, the yield of head CT scans in hospitalized medical patients with nonresolving or new-onset delirium was unknown. In cases with known risk factors, such as recent fall, head trauma, or acute neurologic deficit, the guidelines recommend head CT imaging.<sup>18–20</sup> However, in the absence of these findings, the guidelines do not make any recommendation regarding when and in whom to perform head imaging. Expert statements recommend considering head CT imaging when the cause is not identified after appropriate testing or delirium continues despite treatment.<sup>8,21</sup> Given these recommendations and lack of data, there is no clear standard of care for ordering head CT imaging when hospitalized patients experience delirium in the absence of known risk factors. The low diagnostic yield in this study suggests that head CT imaging is unlikely to diagnose the cause of delirium in hospitalized patients with nonresolving or new-onset delirium.

The diagnostic yield of head CT for diagnosis of acute intracranial process in delirium was lower in our study than prior studies, which found between 14.0 and 39.1%.<sup>9–16</sup> This was expected, as our study excluded patients with new neurologic deficits, recent fall or trauma, or an admitting diagnosis of an intracranial process. Even with these exclusions, we still allowed for a number of findings that prior studies considered to be high risk for intracranial pathology, such as age over 73 years, use of anticoagulation, and deterioration in consciousness level or Glasgow coma score under 14.<sup>10,11,16</sup> The inclusion and exclusion criteria were designed to create a generalizable study population without a clear standard of care based on current guidelines and expert statements.

Though the rate of positive findings found in our study is low, it likely overestimates the overall yield of head CT in hospitalized patients with delirium. This is because most hospitalized patients with delirium never receive head imaging. Presumably, ordering clinicians have deemed these patients to be at higher risk for intracranial processes than the average hospitalized

**TABLE 3.** Case Review of all Positive and Equivocal Head CT Main Outcomes for the Indication of Delirium Including CT Head Findings, Age and Sex, Comorbidities, and Change in Management

	CT Head Findings	Age (Sex)	Days From Onset	Change in Management	Outcome
<b>Positive</b>					
Case 1	Subarachnoid hemorrhage in right frontal and temporal lobes	64 (M)	2	Neurosurgery consult, AC reversal	Discharged with outpatient follow-up
Case 2	Intraparenchymal hemorrhage with mild shift and vasogenic edema	62 (M)	1	Neurosurgery consult, AC reversal	Discharged with outpatient follow-up
Case 3	Subacute subdural hematoma	62 (M)	5	Neurosurgery consult	Discharged with outpatient follow-up
Case 4	Acute infarct or mass	73 (F)	2	Neurology consult, palliative care consult	Transitioned to comfort-focused care, discharged
Case 5	4 mm focus concerning for hemorrhagic metastatic focus	50 (M)	3	Neurosurgery consult, MRI	Discharged with outpatient follow-up
Case 6	Left occipital lobe parenchymal hemorrhage	81 (F)	1	Neurosurgery consult, neurology consult	Transitioned to comfort-focused care, died 6 days later
<b>Equivocal</b>					
Case 1	Several white matter hypodensities of uncertain etiology	70 (F)	1	MRI	MRI with chronic small vessel ischemia
Case 2	Colloid cyst likely although cannot rule out intraventricular hemorrhage	59 (F)	1	Repeat head CT	Repeat imaging with equivocal findings, no additional evaluation
Case 3	Questionable hypodensity, either hemorrhagic contusion or artifact	52 (M)	3	Repeat head CT	Repeat imaging normal
Case 4	Ill-defined hypodensity in left basal ganglia, no clear acute process	74 (F)	0	MRI	MRI with chronic small vessel ischemia

NOTE: Days to onset of 0 indicates new onset. Abbreviations: AC, anticoagulation; CT, computed tomography; F, female; M, male; MRI, magnetic resonance imaging.

patient with delirium who does not receive a head CT. Thus, the true rate of positive findings in head CT imaging in delirious hospitalized medical patients is likely lower than what we identified.

Although head CT had a low diagnostic yield, the positive and equivocal studies had a high impact on clinical care. All of the positive and equivocal head CT results produced a change in management. The equivocal findings led to repeat head imaging; however, none of the repeat images identified the cause of delirium. The positive results produced a more significant change in management, ranging from a higher platelet transfusion target, reversal of anticoagulation, repeat advanced head imaging, neurosurgery consultation, and a change in goals of care to a focus on comfort. No patients in our study underwent neurosurgical intervention.

The challenge for inpatient clinicians is to weigh the low diagnostic yield of head CT with the consequences of a missed or delayed diagnosis of an acute intracranial process. The low diagnostic yield leads to unnecessary cost, resource utilization, radiation exposure, and downstream evaluation of insignificant or indeterminate results when head CT is performed. Alternatively, a missed or delayed diagnosis can lead to potentially reversible morbidity and mortality. Given this, we feel that the routine use of head CT in the evaluation of delirium in hospitalized patients is unnecessary. However, there may be a subset of patients with delirium with an increased risk of acute intracranial processes that would benefit from head imaging. Further research is needed to identify this high-risk population.

There are a number of limitations to our study. It is a retrospective chart review, which introduces a possibility of bias and relies on proper and thorough documentation. In addition, the diagnosis of delirium was made by individual clinicians without the use of a

standardized delirium assessment tool. Furthermore, it is possible there may have been CT scans that were not identified due to mischaracterization of indication, or studies may have been included in individuals with new neurologic deficit or recent fall or trauma that were not documented or clinically appreciated. Finally, the study was conducted on medicine and medical subspecialty patients at a single academic tertiary care institution, potentially limiting the generalizability to patients in other settings.

In conclusion, our study suggests that the diagnostic yield of head CT to evaluate delirium in hospitalized patients in the absence of recent fall, head trauma, or new neurologic deficit is low. The routine use of head CT in evaluation of these individuals is unnecessary. However, there may be a subset of high-risk individuals in which head CT imaging would be indicated. Further research is needed to identify these high-risk individuals.

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## References

- Siddiqi N, House OH, Holmes JD. Occurrence and outcome of delirium in medical in-patients: a systemic literature review. *Age Ageing*. 2006;35:350–364.
- Inouye SK. Delirium in hospitalized older patients. *Clin Geriatr Med*. 1998;14:745–764.
- Davis DH, Muniz Terrera G, Keage H, et al. Delirium is a strong risk factor for dementia in the oldest-old: a population-based cohort study. *Brain*. 2012;135:2809–2016.
- Inouye SK, Schlesinger MJ, Lydon TJ. Delirium: a symptom of how hospital care is failing older persons and a window to improve quality of hospital care. *Am J Med*. 1999;106:565–573.
- Marcantonio E, Ta T, Duthie E, Resnick NM. Delirium severity and psychomotor types: their relationship with outcomes after hip fracture repair. *J Am Geriatr Soc*. 2002;50:850–857.
- Pandharipande PP, Girard TD, Jackson JC, et al. Long-term cognitive impairment after critical illness. *N Engl J Med*. 2013;369:1306–1316.
- Brown TM, Boyle MF. Delirium. *BMJ*. 2002;325:644–647.

8. Inouye SK. A practical program for preventing delirium in hospitalized elderly patients. *Cleve Clin J Med*. 2004;71:890–896.
9. Brown G, Warren M, Williams JE, Adam EJ, Coles JA. Cranial computed tomography of elderly patients: an evaluation of its use in acute neurological presentations. *Age Ageing*. 1993;22:240–243.
10. Naughton BJ, Moran M, Ghaly Y, Michalakes C. Computed tomography scanning and delirium in elder patients. *Acad Emerg Med*. 1997;4:1107–1110.
11. Lim BL, Lim GH, Heng WJ, Seow E. Clinical predictors of abnormal computed tomography findings in patients with altered mental status. *Singapore Med J*. 2009;50:885–888.
12. Hardy JE, Brennan N. Computerized tomography of the brain for elderly patients presenting to the emergency department with acute confusion. *Emerg Med Australas*. 2008;20:420–424.
13. West WM, Ali A, West KP, Stultz R. Acute computed tomography findings in patients with acute confusion of non-traumatic aetiology. *West Indian Med J*. 2011;60:571–575.
14. Leong LB, Wei Jian KH, Vasu A, Seow E. Identifying risk factors for an abnormal computed tomographic scan of the head among patients with altered mental status in the Emergency Department. *Eur J Emerg Med*. 2010;17:219–223.
15. Hufschmidt A, Shabarin V. Diagnostic yield of cerebral imaging in patients with acute confusion. *Acta Neurol Scand*. 2008;118:245–250.
16. Lai MM, Wong Tin Niam DM. Intracranial cause of delirium: computed tomography yield and predictive factors. *Intern Med J*. 2012;42:422–427.
17. Segard J, Montassier E, Trewick D, Le Conte P, Guillon B, Berrut G. Urgent computed tomography brain scan for elderly patients: can we improve its diagnostic yield? *Eur J Emerg Med*. 2013;20:51–53.
18. Guideline Development Group. Guidelines for the prevention, diagnosis and management in older people in hospital. British Geriatrics Society. Available at: <http://www.bgs.org.uk/index.php/clinicalguides/170-clinguidedeliriumtreatment>. Published January 2, 2006. Accessed July 2, 2013.
19. Delirium Clinical Guidelines Expert Working Group. Clinical practice guidelines for the management of delirium in older people. Victorian Government Department of Human Services. Available at: [http://docs.health.vic.gov.au/docs/doc/A9F4D074829CD75ACA25785200120044/\\$FILE/delirium-cpg.pdf](http://docs.health.vic.gov.au/docs/doc/A9F4D074829CD75ACA25785200120044/$FILE/delirium-cpg.pdf). Published October 2006. Accessed July 2, 2013.
20. Work Group on Delirium. American Psychiatric Association practice guideline for the treatment of patients with delirium. *Am J Psychiatry*. 1999;156:1–20.
21. Francis J, Young GB. Diagnosis of delirium and confusional states. UpToDate website. Available at: [http://www.uptodate.com/contents/diagnosis-of-delirium-and-confusional-states?source=search\\_result&search=Francis+J%2C+Young+GB.+Diagnosis+of+delirium+and+confusional+states.&selectedTitle=1~150](http://www.uptodate.com/contents/diagnosis-of-delirium-and-confusional-states?source=search_result&search=Francis+J%2C+Young+GB.+Diagnosis+of+delirium+and+confusional+states.&selectedTitle=1~150). Accessed July 2, 2013.