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Value of CT scans in ED dizziness visits: Analysis from a nationally-representative sample

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Abstract

Objective—To assess measures of the clinical value of computerized tomography (CT) scans in dizziness presentations at the aggregate level.

Methods—Using Emergency Department (ED) dizziness presentations captured in the National Hospital Ambulatory Medical Care Survey, the proportion of dizziness visits with a CT scan that received a central nervous system (CNS) diagnosis was measured yearly (1995–2004) and assessed for a trend over time. The independent association of having a CT scan with ED length of stay was examined using multivariable linear regression models.

Results—The proportion of dizziness visits with a CT scan that received a CNS diagnosis dropped 62% from 1995 to 2004 ($P < 0.05$). By 2004, 94.1% (95% CI, 89.4%–96.7%) of dizziness visits with a CT did not receive a CNS diagnosis. Having a CT scan was associated with a substantial increase in the length of stay with the effect modified by the number of other tests performed (range of increase 40 minutes to 77 minutes).

Conclusion—The clinical value of CT scans in dizziness presentations at the aggregate level may be very low and appears to have dropped over time. CT scans in the general dizziness population could also be an important contributor to ED length of stay. Use of CT scans in dizziness presentations should be a target for efforts to optimize the effectiveness and efficiency of care.

Keywords

Dizziness; vertigo; CT; emergency department

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Introduction

When patients present with dizziness, physicians want to be confident that central nervous system (CNS) causes are “ruled-out.”^{1, 2} Though serious CNS causes of dizziness are uncommon,^{3–5} the consequences of misdiagnosis lower the testing threshold for brain imaging.⁶ The most common type of brain imaging used in the acute setting is a computerized tomography (CT) scan. A recent study found that the proportion of dizziness patients presenting to the ED who undergo a CT scan increased from less than 10% in 1995 to more than 25% in 2004 – a 169% increase in utilization.⁴

However, the increasing use of CT as a diagnostic tool in dizziness presentations has major shortcomings because serious CNS causes are uncommon,^{3–5} the sensitivity of CT for ischemic stroke – the typical target disorder of the test – is very low,^{7–9} “silent” or incidental findings are common,^{10, 11} and the test is expensive. In addition, having a CT scan may increase the emergency department length of stay.^{12, 13} These shortcomings may adversely impact the clinical value (i.e., usefulness) of the test since the value of a test is largely dependent upon the prevalence (or the clinician’s estimate of the pre-test probability) of the target disorder, the accuracy of the test for the target disorder, and the relative benefit to harm ratio.¹⁴ A CT scan is a highly accurate test for intracranial hemorrhage⁷ but intracranial hemorrhage is a very unlikely cause in a general dizziness sample.^{3, 4} Defining the value of tests in clinical care is a goal of healthcare reform efforts because use of tests contributes to cost and quality of care.

In the current study, we aim to measure some other factors related to CT use in dizziness presentations which might help to estimate the value of CT scans when considered at the aggregate level. Specifically, we aim to measure the yield of CT scans for CNS diagnoses, to test for a trend in yield over time, and to measure the effect of CT scans on ED length of stay using a nationally representative sample.

Methods

Study Design and Setting

This study presents a secondary analysis of the data collected for the National Hospital Ambulatory Medical Care Survey (NHAMCS). Details of the NHAMCS methodology are available elsewhere.¹⁵ In brief, the NHAMCS is a cross-sectional, annual, four-stage probability sample of visits to randomly selected, non-institutionalized, general, and short-stay hospitals in the United States with EDs. The medical charts of patients are abstracted onto a structured data entry form by trained hospital staff during a randomly assigned 4-week data period for each sampled hospital. Completed forms are sent to a central location where data abstraction and medical coding are performed.

Study sample

The variable “reason for visit” was used to identify sample ED visits where patients presented with the symptoms of ‘vertigo-dizziness’ in any of the three allowed reasons for visiting the ED. Vertigo and dizziness are grouped by NHAMCS into the single variable of ‘vertigo-dizziness’ so that types of dizziness symptoms can not be analyzed separately. Exclusion criteria were age < 18 years, death on arrival or in the ED, leaving before being evaluated or against medical advice, or referral out from triage.

Data collection and processing—We collected the following data: sociodemographic variables (age, sex, race, ethnicity, and insurance status), hospital and provider variables (metropolitan statistical area, region of the country, health provider type), clinical and presentation variables (triage score, injury visit, reasons for visit, year of visit, arrival time),

process measure variables (medications, tests performed), discharge diagnoses, admission status, and length of stay in ED. Length of stay was calculated by subtracting the time of arrival from the time of discharge. For years 2001–2004, CT scan data were only available as a variable combined with magnetic resonance imaging (MRI). Preliminary analysis of the 1995–2000 dataset found that MRI accounted for <5% of these imaging tests in the population of interest, so this variable will only be referred to as “CT scan.” A visit was determined to have a relevant CNS diagnosis if one of the following diagnoses was recorded in one of the up to three ED discharge diagnoses: cerebrovascular diagnosis (i.e., International Classification of Diseases, Ninth Revision [ICD-9] codes 430–434, 436, or 437), brain tumor (ICD-9 codes 191, 192, or 239.6), vertigo of central origin (ICD-9 code 386.2), obstructive hydrocephalus (ICD-9 code 331.4), multiple sclerosis (ICD-9 code 340), or non-specific cerebral disorder diagnosis (ICD-9 codes of 348.9 or 349.9). Transient ischemic attacks (ICD-9-CM of 435) and late effects of cerebrovascular disease (ICD-9-CM of 438) were not counted as relevant CNS diagnoses in the main analysis because the CT scan results were inferred to be negative for acute findings in patients receiving these diagnoses. Review of the diagnoses recorded for all eligible visits did not reveal other potentially relevant CNS diagnoses.

To create the variable “number of other tests”, we first combined similar types of tests that frequently co-occur into the following categories: routine blood test (any of complete blood count, blood urea nitrogen, glucose, electrolytes, or other blood test), x-ray (any of chest or other x-ray), and cardiac tests (electrocardiogram or cardiac monitoring). Other tests considered included electroencephalogram, blood culture, ultrasound, and urinalysis. If a test (or at least one test within a test category) was performed, then the value of 1 was assigned to the test variable. We combined tests in this manner to reduce potential problems with multicollinearity when fitting the multiple regression models. The “number of other tests” for each visit was then determined by summing the number of tests from these variables. Based on a preliminary assessment of the distribution of the variable “number of other tests”, five categories were generated for the analysis. In addition, four categories were generated for the number of medications variable.

Data analysis

Weighted estimates of frequencies, percentages, and means for characteristics of the sample visits were calculated. The proportion of dizziness visits with a CT scan that had a CNS diagnosis was calculated for each year from 1995 to 2004. The trend over time was assessed using weighted least squares regression analysis.

The length of stay (LOS) analysis was limited to years 2001–2004 because 2001 was the first year that NHAMCS included LOS. LOS was used as the dependent variable for analyses involving our second aim. This time in minutes was log transformed for all analyses. Principal independent variables included CT scan and the number of other tests.

The bivariate association among the principal independent variables with LOS was assessed using linear regression. A multivariable linear regression model was then constructed to adjust for potential confounding. The model included the independent variables (i.e., CT scan and number of other tests) and covariates that we hypothesized a priori to influence LOS. The covariates included sociodemographic variables, hospital and provider variables, clinical and presentation variables, and process measure variables. Interaction terms were tested. A strong interaction was found between CT scan and number of other tests, so the interaction terms were retained. Based on regression diagnostics, the model was refit after removing visits with LOS of ≤ 5 minutes (3 visits) because this is an extraordinarily brief LOS and these visits had large residuals. Final regression diagnostics found that the assumption of normality for the residuals seemed justified. Multiple imputation was performed for item-missing data using the “ice” command in STATA but no changes in inferences based on the results of multivariable analyses

were found. To check if results were sensitive to nonlinear effects, the model was also constructed using multivariable logistic regression with the cutpoint set at the median length of stay (185 minutes), but inferences did not differ significantly so we report only the linear regression model results.

All data management and analysis was performed using the STATA software (Version 10 IC), using methods appropriate for NHMACS subpopulation analyses and accounting for the multistage study design.¹⁵ This study was determined to be exempt from review by the University of Michigan Institutional Review Board.

Results

A total of 6,589 sample visits from 1995 to 2004 met the criteria for this study, translating to a weighted estimate of 24 million ED visits for dizziness in the United States. Additional weighted estimates of statistics describing this subpopulation are in Table 1. CT scans were obtained in 17% (95% CI, 15.8% – 18.4%) of all visits.

The proportion of dizziness visits with a CT that had a relevant CNS diagnosis over this 10 year period was 9.6% (95% CI, 7.5%–12.1%). The analysis of the trend over time revealed a drop from 15.2% (95% CI, 7.0%–29.7%) in 1995 to 5.9% (95% CI, 3.3%–10.6%) in 2004, representing a 62% decrease in the proportion of dizziness visits with a CT that had a CNS diagnosis (Figure 1). The weighted least squares regression analysis suggested that the linear trend over the 10 year period was significant ($P < 0.05$). The results of the trend analysis did not change when the diagnosis of transient ischemic attack was included as a relevant CNS diagnosis.

Bivariate analyses showed that both CT scan and number of other tests were significantly associated with LOS (Table 2). In the multivariable model, the regression coefficients representing the change in the effect of CT scan corresponding to increases in the number of other tests performed were found to be significant, indicating that the CT scan effect was being moderated by the number of other tests performed. When no additional tests were performed (the referent category for number of tests performed), CT retained a positive association with LOS (β coefficient = 0.5440, $\exp(\beta) = 1.72$, $P < 0.001$). This estimate suggests that when no other tests are performed and all other covariates are fixed at their means, having a CT scan will increase the expected length of stay by 72%. The adjusted increase in LOS associated with a CT scan declined from 77 minutes in visits with no other tests to 40 minutes in visits with ≥ 4 other tests (Figure 2). Values plotted in Figure 2 represent predicted length of stay values accounting for the relevant number of other tests and interaction terms, with all other predictors fixed at their means.

Limitations

This study has several important limitations. Medical record review studies are susceptible to certain types of error. The NHAMCS addresses these potential sources of error by using explicit protocols for case selection, trained abstractors, well-defined variables, blinding of chart reviewers to hypotheses, and quality control measures.¹⁵ It is possible that CT scans in some dizziness patients could be used for reasons other than brain imaging. This issue can be investigated in the future because beginning in 2007 NHAMCS created a new subcategory for CT that classifies the study as one of the “head” or “other than head.” Future studies using NHAMCS data could also be used to determine how much bias is introduced by MRI scans since the 2001 to 2004 NHAMCS data combines CT and MRI into one variable. In assessing the true value of CT in ED dizziness presentations, more detailed studies that can not be performed using current NHAMCS data are also required. For example, it is important to measure both the clinician’s estimate of the pre-test probability of target disorders and also the

validity of those estimates. Certain subgroups of patient visits are likely to have a higher risk of CNS pathology (e.g., those with increased age and stroke risk factors) and thus an increased yield of the CT scan. Future work should use a multivariable analysis to estimate which patient visits are more likely to have a higher yield of the CT scan. Using the recorded diagnoses to infer the CT scan results may not be valid. Future research on the value of CT needs to consider actual, rather than inferred, CT results since actual results are not currently available in NHAMCS. This study was cross-sectional in nature, making it more tenuous to draw conclusions about causality in regression models. Residual bias can occur from factors either not measured or not measured well. Though reasoning supports that having a CT scan will increase length of stay, in some cases the opposite may be true (i.e., patients who stay longer get more tests). The measure of length of stay used in this analysis was limited by the information available from the source database. Analyzing how CT scans are associated with more narrow time measures (e.g., physician evaluation time), rather than the entire length of stay in the ED, may provide additional insights into how CT scans may influence time in the ED. A potential confounder of the relationship between CT and length of stay that could not be measured using NHAMCS is the effect of neurological consultation in the ED for dizziness patients. If neurological consultations are common in routine ED dizziness presentations then this factor could be related both to CT scans and length of stay, and should be explored in future research. Ultimately, the value of a test may differ based on the perspective taken and the measures used. We used a traditional perspective for estimating the value of the test at the aggregate level.¹⁴ We did not use a non-dizzy comparator in this analysis. Though use of a comparison group may have provided interesting insights, we believe dizziness has unique attributes which justify an analysis without a non-dizzy comparator.

Discussion

We have previously demonstrated that the rates of neurologic diagnosis in ED dizziness presentations are stable over time, even though the rates of CT scanning are rising.⁴ This study contributes two new observations about the use of CT scans in acute dizziness presentations: 1) the proportion of dizziness visits with a CT scan that have a CNS diagnosis has dropped substantially over time such that currently 94% of dizziness visits with a CT scan do not result in a CNS diagnosis, and 2) visits with a CT scan are associated with an increased ED length of stay compared to visits without a CT scan. These findings suggest that the clinical value of CT scans in ED dizziness visits may be low when considered at the aggregate level and that efforts are needed to define the patients that are likely to meaningfully benefit from a CT scan. This will enable efforts to optimize effectiveness and efficiency of care for dizziness, one of the most common reasons for an ED presentation.

The value of a test is traditionally considered to be largely dependent upon the prevalence (or the clinician's estimate of the pre-test probability) of the target disorder among the population of interest, the accuracy of the test for the target disorder, and the relative benefit to harm ratio.¹⁴ At the aggregate level, one reason that the value of CT scans is likely to be low is that the prevalence of serious CNS causes of dizziness is low. In prior studies, serious CNS causes occur in about 4% of the general ED dizziness population.³⁻⁵ In the current analysis, which limited the population of interest to dizziness patients that underwent a CT scan and considered a more broad definition of CNS diagnoses, less than 6% of patients seemed to have a positive CNS disorder at the most up-to-date time period. Some may feel that even a 6% "positive" yield of the test indicates an overall good value of the test. However, the yield of CT in this study is likely to be a gross overestimation because of three important factors: 1) clinicians listing previously established diagnoses that are not causative of the current dizziness, 2) erroneous recording of a diagnosis based on a CT report of a non-causal finding (e.g., old stroke),^{10, 11} and 3) stroke diagnoses made based on clinical features alone. Benign disorders, such as specific peripheral vestibular disorders and general medical disorders, are much more

likely causes of dizziness in the ED and do not require a head CT for diagnosis.^{3–5, 16} Common peripheral vestibular disorders all have key presentation and examination characteristics allowing for a bedside diagnosis.^{17, 18} Not recognizing these characteristics may lead physicians to inaccurate estimates of the pre-test probability of CNS disorders.^{19, 20} Though CNS disorders can masquerade as a peripheral vestibular disorder, the probability of a CNS disorder in a patient with the key characteristics of a peripheral vestibular disorder is extremely low.^{21–23}

Another important reason that the value of CT may be low in ED dizziness presentations is that the accuracy of the test for the most common CNS cause of acute dizziness (i.e., ischemic stroke) is very poor.^{7–9} Because the sensitivity of CT scans for ischemic stroke is dismal (26%, 95% CI, 20%–32%),⁷ a negative CT scan has little impact on the probability of a serious CNS cause. The value of a test is low whenever the test is not accurate at determining the target disorder – regardless of the pre-test probability of the target disorder.¹⁴

Despite the possible low value of CT use at the aggregate level, CT scans can still be valuable in some individual level presentations. Determining the small, select group of patients who would benefit from a CT scan is a needed next step. For example, a negative CT scan is valuable if the treating physician assesses an important probability of any type of intracranial hemorrhage (e.g., subarachnoid hemorrhage or cerebellar hematoma) since the accuracy of CT for intracranial hemorrhage is excellent.⁷ But, the pre-test probability of intracranial hemorrhage in most dizziness presentations should be low because intracranial hemorrhage was a very uncommon etiology (1 out of 1,666 dizziness cases = 0.06%) in the most detailed population-based study of ED dizziness visits.³

The finding that CT scans are associated with increased ED length of stay was not surprising. However, the multivariable model now demonstrates the magnitude of the association with data collected from a routine care and nationally representative sample. If it is true that ordering a CT scan increases the ED length of stay, then this important “harm” should reduce the value of the test.

Conclusions

The current study provides provocative results from a robust and nationally-representative sample about CT scans in dizziness presentations. If true, then these findings add to previously reported concerns about the routine use of CT scans in dizziness presentations.^{1, 4, 6, 16} At the aggregate level, the clinical value of CT scans seems to be very low in acute dizziness presentations. Increasing use of the test does not seem justifiable. More research is needed to support ED physicians in the task of sorting through large numbers of dizziness presentations to determine which patients are likely to benefit from a CT scan and, more broadly, to determine optimal strategies to identify serious disorders. This seems to be an important target in efforts to optimize care because dizziness is common in the ED⁴ and ED physicians have called for more research on dizziness presentations.²

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Figure 1.

Estimated yield over time of CT scans for central nervous system diagnoses (i.e., percent of all dizziness visits with a CT scan having a central nervous system diagnosis) and estimated number of CT scans over time among weighted Emergency Department visits for dizziness. Trends significant at $P < 0.05$.

CT= computerized tomography; CNS = central nervous system; ED = Emergency Department.

Figure 2.

Predicted length of stay (minutes) for dizziness visits to the Emergency Department, 2001–2004. Values plotted represent predicted length of stay values accounting for the relevant number of other tests and interaction terms, with all other predictors fixed at their means.

CT = computerized tomography.

* $P < 0.001$; ** $P < 0.01$; *** $P = 0.10$

^Tests considered include routine blood test (any of complete blood count, blood urea nitrogen, glucose, electrolytes, or other blood test), x-ray (any of chest x-ray or other x-ray), cardiac test (any of electrocardiogram or cardiac monitoring), electroencephalogram, blood culture, ultrasound, and urinalysis.

Table 1

Weighted population estimates of Emergency Department dizziness visit characteristics.

Characteristic	Weighted Estimates (95% Confidence Interval)	
	Years 1995–2004 (n=6,589)*	Years 2001–2004 (n=3,607)*
Age, yr, mean	51.6 (50.9–52.4)	52.5 (51.5–53.5)
Female (%)	60.5 (58.9–62.0)	60.0 (57.8–62.3)
Race/ethnicity (%)		
White (non-Hispanic)	67.9 (65.6–70.2)	67.1 (64.2–70.0)
Black (non-Hispanic)	19.6 (17.6–21.7)	19.4 (17.0–22.1)
Hispanic	9.2 (7.9–10.7)	10.0 (8.4–11.8)
Asian	2.2 (1.7–2.9)	2.5 (1.8–3.5)
Other	1.1 (0.7–1.7)	1.0 (0.7–1.4)
Triage score (%)		
Less than 15 minutes	NA	21.1 (18.8–23.5)
15–60 minutes	NA	41.1 (38.4–43.9)
>1 hour – 2 hours	NA	16.3 (14.3–18.6)
>2 hours – 24 hours	NA	5.0 (4.0–6.3)
Unknown or no triage	NA	16.5 (13.9–19.5)
Related to injury (%)	NA	16.8 (15.2–18.5)
CT scan performed (%)	17.0 (15.8–18.4)	22.5 (20.8–24.4)
Number of additional tests (%)		
0	NA	19.6 (17.8–21.5)
1	NA	20.1 (18.2–22.0)
2	NA	26.4 (24.7–28.3)
3	NA	25.4 (23.6–27.3)
≥4	NA	8.6 (7.3–10.1)
Number of medications		
0	NA	25.5 (23.2–27.9)
1–2	NA	45.8 (43.5–48.1)
3–4	NA	17.9 (16.2–19.7)
5 or more	NA	10.9 (9.2–12.8)
Length of visit, minutes, mean	NA	238 (227–249)
CNS diagnoses (ICD-9 codes)(%)		
Stroke diagnoses (430–434, 436, 437)	2.4 (2.0–3.1)	NA
Brain tumor (191,192)	0.08 (0.02–0.23)	NA
Vertigo of central origin (386.2)	0	NA
Obstructive hydrocephalus (331.4)	0.09 (0.03–0.30)	NA
Multiple Sclerosis (340)	0.1 (0.05–0.22)	NA
Non-specific cerebral disorder (348.9, 349.9)	0.10 (0.03–0.33)	NA

Characteristic	Weighted Estimates (95% Confidence Interval)	
	Years 1995–2004 (n=6,589)*	Years 2001–2004 (n=3,607)*
Yield of CT scan for CNS diagnoses (%)	9.6 (7.5–12.1)	NA

CT = computerized tomography; CNS = central nervous system; NA = not applicable; ICD-9 = International Classification of Disease, Ninth Revision (ICD-9) codes.

* Weighted estimate: 24 million visits (years 1995–2004); 11 million visits (years 2001–2004),

Table 2

Regression models for the effect of CT scan on length of stay in the Emergency Department in 3,607 sampled visits (weighted estimate, 11 million visits) for dizziness, 2001–2004.

	Unadjusted (bivariate)	Multivariable Model [‡]
CT scan	0.3883**	0.5440**
Number other tests		
0	Ref	Ref
1	0.4263**	0.4031**
2	0.6037**	0.6080**
3	0.7233**	0.6708**
4 or more	0.8663**	0.7358**
Interaction terms [†]		
CT × 0 test	–	Ref
CT × 1 test	–	–0.2766*
CT × 2 tests	–	–0.3853**
CT × 3 tests	–	–0.3160**
CT × ≥4 tests	–	–0.3795*

CT = computerized tomography

* P < 0.05

** P < 0.001

[†] Wald test < 0.05

[‡] R² = 0.2828

Multivariable model covariates: sociodemographic variables (age (continuous), sex, race-ethnicity, and insurance status), hospital and provider variables (metropolitan statistical area, region of the country, and health provider type), clinical and presentation variables (triage score, injury visit, accompanying symptoms (i.e., headache, nausea, vomiting, shortness of breath, fainting), year of visit, and arrival time), and process measure variables (number of other tests, number of medications, and admission status).