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ORIGINAL RESEARCH

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Predictors of computed tomography imaging in patients presenting with sudden hearing loss

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Abstract

Objective: Sudden sensorineural hearing loss (SSNHL) is a rare presentation requiring timely diagnosis and treatment. Despite recommendations against obtaining computed tomography (CT) imaging of the head in clinical practice guidelines, this investigation is often completed in patients with sudden hearing loss. The aim of this study was to determine the proportion of patients undergoing CT imaging of the head for SSNHL at our center and identify predictive factors for the use of CT imaging.

Methods: Retrospective chart review of adult patients referred for SSNHL to two academic otology/neurotology practices between January 2018 and May 2021. Patient demographics, comorbid medical conditions, associated symptoms, location of initial presentation, audiologic results, and completed imaging studies were collected. Statistical analysis was performed with SPSS software.

Results: Ninety-eight patients with audiologically confirmed SSNHL were included. Twenty-two patients (22.4%) underwent CT imaging as an investigation for SSNHL. The presence of vertigo (odds ratio 6.90; 95% confidence interval 2.43, 19.56) and presentation to the emergency room (odds ratio 8.71; 95% confidence interval 3.02, 25.16) were significantly associated with undergoing CT imaging. These two variables were statistically significant independent predictors of CT imaging on multivariate regression analysis ($p = .01$, $p = .001$, respectively).

Conclusion: A significant proportion of patients with SSNHL undergo low-yield CT imaging of the head, particularly patients presenting to the emergency room with vertigo. These results highlight an opportunity for focused education and quality improvement initiatives.

Level of evidence: 4.

KEYWORDS

clinical practice guidelines, computed tomography, sudden hearing loss, sudden sensorineural hearing loss

1 | INTRODUCTION

Sudden sensorineural hearing loss (SSNHL) is a rare presentation with an incidence of approximately 27 cases per 100,000 people per year.[1] The diagnosis of SSNHL is defined as sensorineural hearing loss of 30 dB or greater in three contiguous frequencies on audiogram, occurring over the course of 72 h or less.[2]

Current clinical practice guidelines published by the American Academy of Otolaryngology-Head and Neck Surgery (AAO-HNS) strongly recommend against routine computed tomography (CT) imaging of the head being ordered as part of the initial evaluation of patients presenting with SSNHL.[2] Exceptions to this recommendation include patients with focal neurologic findings, chronic ear disease, or history of trauma. Additionally, Choosing Wisely Canada recommends against the routine use of CT imaging in patients with SSNHL.[3] Ruling out a vestibular schwannoma or other retrocochlear pathology as an underlying cause is the main goal of imaging in patients presenting with SSNHL.[4–7] Due to the greater sensitivity and specificity of magnetic resonance imaging (MR) at detecting retrocochlear pathology, MR is the imaging modality of choice in patients presenting with SSNHL.[4–9]

However, the initial evaluation of patients with this presentation commonly occurs in primary care in both outpatient clinics and the emergency room (ER) by physicians that may not be familiar with the diagnosis or management of this condition.[10] As such, despite the guideline recommendations and the low utility of CT imaging in this presentation, many patients will have CT scans performed as part of their evaluation for sudden hearing loss.

No studies to date have evaluated clinical and system factors that are associated with the use of CT imaging in SSNHL. Furthermore, no Canadian studies have specifically evaluated the use of CT imaging in SSNHL. The aim of this study was to investigate the use of CT imaging in patients presenting with SSNHL. Our objectives were to determine the proportion of patients undergoing CT imaging of the head for SSNHL at our center and to identify predictive factors for the use of CT imaging.

2 | MATERIALS AND METHODS

This study is a retrospective chart review set in two outpatient otology/neurotology practices at a Canadian academic tertiary referral center. Institutional Review Board approval by the Human Ethics Research Online system was obtained prior to commencing the study (Pro00110218). All patients presenting with SSNHL between January 2018 and May 2021 were identified through a search of the electronic medical records of the two practices using diagnosis and procedural codes.

All patients, 18 years of age or older, were included that presented with an episode of SSNHL occurring over the course of 72 h or less, and resulting in a 30 dB or greater decrease at 3 or more contiguous frequencies compared to either their contralateral ear or a prior audiologic evaluation. This diagnostic definition is consistent with the AAO-HNS sudden hearing loss clinical practice guideline.[2] Patients were excluded if they had a history of fluctuating hearing loss or developed fluctuating hearing loss over the course of their treatment or follow up. Patients with active autoimmune disease, focal neurological deficits, or significant head trauma or barotrauma at the time of the sudden hearing loss were excluded.

Data collected for each patient included patient age, sex, location of initial presentation, and documentation of an otolaryngologist on-call being contacted about the patient. The affected ear, the degree of hearing loss (including pure tone average), the presence of vestibular symptoms, the presence of other associated otologic symptoms, and comorbid medical conditions were also collected. The completion of all CT and MR imaging studies of the head and temporal bones was collected by a data analyst on review of the picture archiving and communication system and review of a provincial hospital electronic medical record system (Connect Care). Imaging studies were retrieved for a 6-month period following each patient's sudden hearing loss episode. The findings of each of the CT studies completed were also collected.

Descriptive statistics were calculated to characterize the patient population. The number of completed CT scans was calculated and reported as a frequency and a percentage. Odds ratios (ORs) with 95% confidence intervals (CI) were calculated to assess the association between variables and the completion of CT imaging. A multivariate stepwise regression analysis was performed to identify independent predictors of CT imaging utilization. Statistical analysis was conducted using IBM SPSS Statistics, version 26 (IBM Corp., Armonk, N.Y., USA). Statistical significance was accepted as $p < 0.05$ in all cases.

TABLE 1 Patient demographics and hearing loss characteristics.

Characteristic	*n*
Total patients	98
Sex	
Female (%)	41 (40.8)
Male (%)	58 (59.2)
Side of hearing loss	
Left (%)	51 (52.0)
Right (%)	45 (45.9)
Bilateral (%)	2 (2)
Age, mean ± SD (range)	56.6 ± 16.9 years (18–87 years)
Mean PTA in affected ear ± SD (range)	80.4 ± 27.9 dB (13–120 dB)

Abbreviations: PTA, pure tone average; SD, standard deviation.

3 | RESULTS

One hundred and eighty patients were identified through a search of outpatient medical records as patients referred regarding sudden hearing loss. Ninety-eight patients met the diagnostic criteria for

TABLE 2 Completion of computed tomography (CT) imaging by location of initial patient presentation.

Location of initial presentation	Number of patients	CT head completed	Odds ratio
Outpatient primary care physician	48	5 (10.4%)	0.23 [0.08, 0.68]
Emergency room	30	15 (50%)	8.71 [3.02, 25.16]
Audiologist	17	1 (5.8%)	0.18 [0.02, 1.43]
Other	3	1 (33.3%)	1.76 [0.15, 20.40]
Total	98	22 (22.4%)	

TABLE 3 Patient characteristics and association with computed tomography (CT) imaging.

Variable	Odds ratio [95% CI]	Proportion with CT
Female sex	1.62 [0.62, 4.21]	11/29 (38%)
Age >70 years	1.98 [0.71, 5.51]	8/25 (32%)
Diabetes	0.90 [0.26, 3.07]	4/19 (21%)
Stroke history	0.77 [0.69, 0.86]	0/3 (0%)
Anticoagulation	3.70 [0.49, 27.9]	2/4 (50%)
Smoker	0.28 [0.03, 2.31]	1/12 (8.3%)
Hypertension	1.26 [0.48, 3.32]	9/36 (25%)
History of myocardial infarction	1.76 [0.15, 20.40]	1/3 (33%)

Abbreviation: CI, confidence intervals.

TABLE 4 Presenting symptoms and association with computed tomography (CT) imaging.

Symptom	Odds ratio [95% CI]	Proportion with CT
Tinnitus	0.40 [0.15, 1.07]	12/69 (17.4%)
Vertigo	6.90 [2.43, 19.56]	15/33 (45.5%)
Paresthesia	2.43 [0.38, 15.57]	2/5 (40%)
Headache	0.77 [0.69, 0.86]	0/1 (0%)

Abbreviation: CI, confidence intervals.

SSNHL and were included in the study (Table 1). There were 41 women and 57 men included. The mean age was 56.6 ± 16.9 years (range 18–87 years). Two patients presented with bilateral SSNHL. Of the 96 patients with unilateral SSNHL, the left ear was affected in 51 and the right ear in 45.

The most common comorbidity was hypertension ($n = 36$, 36.7%) followed by diabetes ($n = 19$, 19.4%). Three patients had a prior history of stroke and three had a history of prior myocardial infarction. None of the patients had a history of chronic ear disease pertinent to their presentation. Twelve patients (12.2%) were smokers.

The most common location of initial presentation was a primary care outpatient clinic ($n = 48$), followed by the ER ($n = 30$), and audiology clinics ($n = 17$) (Table 2). CT imaging of the head was completed in 22 patients (22.4%). Fifteen of 30 patients (50%) presenting initially to the ER had a CT head performed. OR were calculated for the completion of CT imaging based on location of patient presentation. Patients presenting to the ER were more likely to have a CT scan performed with statistical significance (OR = 8.71, 95% CI = 3.02, 25.16). Forty patients had documentation of a conversation with the otolaryngology consult service regarding patient management. Of those patients, 10 had CT scans performed, but this was not a significant predictor of whether CT imaging was completed (OR = 1.28 95% CI = 0.49, 3.33).

Patient characteristics and presenting symptoms were also evaluated for their association with the completion of CT imaging (Table 3 and Table 4). Age, sex, and comorbid conditions were not associated with the completion of CT imaging of the head. Vertigo had a statistically significant association with CT imaging (OR = 6.90, 95% CI = 2.43, 19.56). Tinnitus, paresthesia, and headache were not significantly associated with the completion of CT imaging.

A multivariate regression analysis was performed to identify independent predictors for the completion of CT imaging in patients with SSNHL. The presence of vertigo as a symptom and presentation to the ER were statistically significant independent predictors in our model (Table 5). Age over 70 years, sex, anticoagulation, hypertension, diabetes, history of stroke, history of myocardial infarction, smoking status, tinnitus, paresthesia, and headache were all excluded by the multivariate regression model.

Of the included patients in the study, 22 patients had CT head scans performed. All studies reported no acute findings that would change management of the presenting symptoms and sudden hearing loss. Seven of the imaging studies noted small vessel ischemic changes or subcortical white matter hypoattenuation, five studies noted age-appropriate cortical atrophy, and one study reported evidence of a prior small left lacunar infarct.

4 | DISCUSSION

CT scans are frequently completed unnecessarily in patients presenting with SSNHL. Our study found that 22.4% of patients referred to our tertiary otology/neurotology practices for SSNHL underwent low-yield CT imaging of the head. This is despite current clinical practice guidelines recommending against routine CT imaging of the head as part of the initial evaluation of patients presenting with SSNHL.[2] Furthermore, a recommendation against completing CT scans to evaluate patients with SSNHL was one of five recommendations made by the Otology/Neurotology group of the Choosing Wisely Canada Campaign to reduce unnecessary tests and treatments.[3] Unnecessary CT imaging exposes patients to the radiation,[11,12] adds cost to the health

Variable	Regression coefficient [95% CI]	Standard error	*p*-value
Constant	0.057 [−0.039, 0.152]	0.048	
Vertigo	0.224 [0.053, 0.396]	0.087	.01
Presentation to ER	0.301 [0.125, 0.477]	0.089	.001

Abbreviations: CI, confidence intervals; ER, emergency room.

TABLE 5 Multivariate regression analysis showing independent predictors of computed tomography imaging being performed.

care system,[13] and does not preclude the need for an MR with detailed evaluation of the internal auditory canals to rule out retrocochlear pathology.[2,4–9]

Our analysis revealed that presentation to the ER and the presence of vertigo were statistically significant independent predictors of CT imaging of the head being completed. Fifty percent of patients presenting to the ER had a CT scan of their head performed and were 8.71 times more likely to have this unnecessary testing compared to other patients. There are likely several reasons for the high rate of CT imaging in the emergency department. This imaging modality is immediately available in the emergency department, as opposed to primary care clinics or an outpatient otolaryngology office. Furthermore, emergency medicine and family medicine-trained physicians working the in ER may be unaware of the inadequacy of CT imaging in diagnosing vestibular schwannomas and other cerebellopontine lesions.

The presentation of vertigo in conjunction with SSNHL may influence clinicians to order head CT imaging due to a clinical concern for stroke. Head CT has a low sensitivity for acute stroke in comparison to an emergent MR with diffusion-weighted imaging.[14–16] However, a non-contrast enhanced CT scan is helpful in differentiating hemorrhagic and ischemic stroke in patients presenting within the window for treatment with thrombolytics.[16] The American College of Radiology has published appropriateness criteria for imaging in patients with hearing loss and vertigo and recommended that a head CT in the scenario of acute hearing loss and vertigo is usually not appropriate with an unfavorable risk–benefit ratio.[12]

A thorough clinical evaluation of patients presenting with acute vertiginous symptoms is certainly warranted. The HINTS oculomotor physical exam, including horizontal head impulse testing, examination for nystagmus, and test of skew, may have a higher sensitivity for acute stroke than MR with diffusion-weighted imaging in patients presenting with acute vertiginous syndrome.[14] A thorough history and physical exam cannot be substituted with CT imaging, which may provide false reassurance in the setting of an acute cerebrovascular accident. It is important to note that it is appropriate to consider CT imaging of the head in patients with focal neurological deficits or a dedicated temporal bone CT scan in patients with suspected temporal bone pathology as the underlying cause for their hearing loss based on history and physical exam.[2]

A study performed by Witsell et al.[17] evaluated the compliance of clinicians in following the AAO-HNS clinical practice guidelines for patients with sudden hearing loss. Five of 19 patients (26.3%) presenting to the ER, two out of 20 patients (10%) presenting to urgent care, and one of 56 patients (1.8%) presenting to primary care clinics had CT imaging of the head performed.[17] Their rate of CT imaging was lower in comparison to our ER and primary care outpatient presentation groups. Their study did not further evaluate patient characteristics or predictive factors of imaging being completed and did not compare the locations of presentation statistically. In a retrospective chart review of patients with SSNHL treated within the Department of Defense, 28 of 204 patients (13.7%) with SSNHL had head CT imaging performed.[18] The setting in which the CT imaging was ordered or characteristics of these patients was not further explored by the study. In the study by Witsell et al.,[17] 43.9% of patients presented initially to otolaryngology. The requirement for a referral to access specialist care by an otolaryngologist within the Canadian health system is a key difference in our study, with many patients in Witsell et al.'s[17] study having direct access to an otolaryngologist. However, a similar conclusion can be drawn in that there is an opportunity to reduce the frequency of completion of unnecessary CT imaging of the head in patients with SSNHL.

Cottrell et al.[19] proposed 11 quality indicators for the diagnosis and management of SSNHL. There was consensus agreement by the expert panel on a quality indicator using the number of patients not undergoing CT imaging as the numerator and all patients diagnosed with SSNHL as the denominator.[19] The findings from our study fill an important gap in quantifying adherence to this guideline recommendation in a Canadian setting in consideration of benchmarks for this quality indicator or similar quality indicators.

Ng et al.[20] surveyed primary care physicians regarding management of SSNHL. Most of those surveyed would initiate appropriate management with 76.9% of respondents prescribing corticosteroids for a patient with audiologically confirmed SSNHL and 80.8% referring the patient for an otolaryngology consultation.[20] Interestingly, 69.2% of primary care physicians responding to the survey were not comfortable with interpreting an audiogram in patients presenting with hearing loss.[20] This survey did not include any questions regarding appropriate use of imaging or the physicians' routine clinical practice in obtaining imaging in patients with this presentation. The study demonstrates that there is an awareness of SSNHL and basic management in primary care, but that there are knowledge gaps and opportunities for further education.

Collaboration in the development of quality improvement and education initiatives with family medicine and emergency physicians may prove beneficial in decreasing the number of head CT imaging studies performed for patients with SSNHL. The publication of SSNHL clinical practice guidelines in a specialty journal not regularly accessed by primary care physicians is one potential barrier to dissemination and implementation.[10] Awareness of existing clinical practice guidelines and health care utilization recommendations such as the

Choosing Wisely Campaign would enhance evidence-based decision-making in these settings.

Our study has several limitations. The study was a single-center study and practice patterns may vary at other institutions. However, it is felt that the issue of inappropriate use of low-yield CT scans is not unique to our center. This study was retrospective in nature and is subject to selection bias, as all patients included in the study were ultimately seen in a subspecialty otology/neurotology clinic. The number of patients presenting with sudden hearing loss or vertigo as part of an acute cerebrovascular accident and how the use of imaging contributed to their diagnosis and management was not evaluated.

A unique feature of this study is that it was conducted at a Canadian tertiary referral center where patients do not have direct access to specialist care. Like other specialists in Canada, evaluation by an otolaryngologist requires the patient to obtain a referral. The nature of our health care system directs patients to seek emergent care for sudden hearing loss through primary care clinics, emergency departments, and even audiology clinics. Many physicians in these settings may be unfamiliar with the diagnosis and management of SSNHL.

5 | CONCLUSIONS

A significant proportion of patients with SSNHL undergo low-yield CT imaging, particularly patients presenting to the ER and with vertigo. These results highlight an opportunity for focused education and quality improvement initiatives.

CONFLICT OF INTEREST STATEMENT

On behalf of all authors, the corresponding author states that there is no conflict of interest.

DATA AVAILABILITY STATEMENT

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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