


The Yield of Computed Tomography of the Head Among Patients Presenting With Syncope: A Systematic Review

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ABSTRACT

Background: Overuse of head computed tomography (CT) for syncope has been reported. However, there is no literature synthesis on this overuse. We undertook a systematic review to determine the use and yield of head CT and risk factors for serious intracranial conditions among syncope patients.

Methods: We searched Embase, Medline, and Cochrane databases from inception until June 2017. Studies including adult syncope patients with part or all of patients undergoing CT head were included. We excluded case reports, reviews, letters, and pediatric studies. Two independent reviewers screened the articles and collected data on CT head use, diagnostic yield (proportion with acute hemorrhage, tumors or infarct), and risk of bias. We report pooled percentages, I^2 , and Cochran's Q-test.

Results: Seventeen articles with 3,361 syncope patients were included. In eight ED studies ($n = 1,669$), 54.4% (95% confidence interval [CI] = 34.9%–73.2%) received head CT with a 3.8% (95% CI = 2.6%–5.1%) diagnostic yield and considerable heterogeneity. In six in-hospital studies ($n = 1,289$), 44.8% (95% CI = 26.4%–64.1%) received head CT with a 1.2% (95% CI = 0.5%–2.2%) yield and no heterogeneity. In two articles, all patients had CT (yield 2.3%) and the third enrolled patients ≥ 65 years old (yield 7.7%). Abnormal neurologic findings, age ≥ 65 years, trauma, warfarin use, and seizure/stroke history were identified as risk factors. The quality of all articles referenced was strong.

Conclusion: More than half of patients with syncope underwent CT head with a diagnostic yield of 1.1% to 3.8%. A future large prospective study is needed to develop a robust risk tool.

Syncope is defined as a sudden and brief loss of consciousness (LOC) due to transient global cerebral hypoperfusion, followed by spontaneous and complete recovery.¹ It accounts for 1% to 3% of emergency department (ED) visits.^{1–4} Among ED patients with syncope, 7% to 23% will have serious underlying conditions identified either in the ED or within 30 days of their index visit.^{5–8} Previous studies have reported 2.3% to 4.4% incidence of serious intracranial conditions (subarachnoid hemorrhage, subdural hematoma, space-occupying lesion, or intraparenchymal infarct or hemorrhage) among

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patients with syncope.^{9,10} However, up to two-thirds of patients with syncope continue to have computed tomography (CT) of the head performed as part of their workup.¹¹ The Choosing Wisely Campaign in Canada and the United States both recommend against using CT of the head for low-risk ED patients with syncope.^{12,13} Additionally, the Society for Academic Emergency Medicine in the United States, through consensus conferences in 2015 and 2016, aimed to optimize ED diagnostic imaging utilization and reduce unnecessary diagnostic testing to reduce health care costs and unintended consequences.^{14,15} While clinical decision tools such as the NEXUS-II, Canadian CT Head Rule, and New Orleans Criteria exist for patients with head injury related to the fall during syncope, there is a lack of appropriate synthesis of preexisting literature regarding the usefulness of CT head to identify a serious underlying intracranial conditions potentially related to syncope.^{16–18} With the Choosing Wisely Campaign in mind, the objective of this systematic review is to determine the frequency with which head CT is being performed for patients with syncope, with predominant focus on its yield in identifying serious intracranial conditions. Additionally, we aimed to report any risk factors associated with the serious intracranial conditions identified in studies reviewed.

METHODS

Systematic Review Protocol

For this review, we adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Guidelines (Data Supplement S1, Appendix S1, available as supporting information in the online version of this paper, which is available at <http://onlinelibrary.wiley.com/doi/10.1111/acem.13568/full>).¹⁹

Search Strategy

A database search was conducted under the guidance of a research librarian at the University of Ottawa using the following major databases from their inception until June 2016: Medline (via OVID), Embase (via OVID), and Cochrane Database of Systematic Reviews. An updated search was conducted in all three databases between June 2016 and June 2017. Our search strategies used a combination of MeSH headings and keywords and are detailed in Data Supplement S1, Appendixes S2 and S3. Article selection

was restricted to English and French articles. A citation search was also conducted on Google Scholar from each of the final articles included in the systematic review to ensure the inclusion of missed articles during the initial database searches. Authors were contacted to obtain unpublished data or further articles that may have been missed by the initial database search.

Study Selection

Our search included prospective and retrospective observational cohort studies that met the following inclusion criteria: studies involving adult patients with syncope (or other commonly accepted synonym thereof) as their presenting complaint, of which part, or all received head CT and for whom the head CT results were reported. We excluded studies involving only children, case reports, letters to the editor, narrative reviews, articles in languages other than English or French, and abstracts which had neither sufficient data nor a complete article available. Articles that included patients with obvious non-syncope-related LOC (e.g., head trauma resulting in LOC, seizure, alcohol or drug intoxication, LOC > 5 minutes, or patients with altered mental status from baseline) were also excluded. However, based on literature reports and our prior experience conducting prospective studies sometimes it is difficult to differentiate seizure from syncope. Hence, all studies that enrolled patients with a transient LOC followed by spontaneous complete recovery were included in our review. Duplicates with titles that matched exactly were eliminated using Mendeley, a reference management software program. In Phase I, after removal of duplicates, inclusion and exclusion criteria were applied by two investigators (JAV and HC), each reviewing all articles at the title and abstract level. In Phase II, both reviewers applied the same criteria to the full-text articles selected at the end of Phase I. For included studies, data for literature synthesis was documented in a standardized data collection form (Data Supplement S1, Appendix S4). Disagreements were resolved by consensus.

Data Abstraction

The following data were collected: author information, year of publication, study type, specific characteristics of patients included or excluded in the study, whether the cohort was from an ED or inpatient population, number of patients enrolled, number of head CT scans performed, the nature and number of serious

intracranial conditions identified, the risk factors associated with the serious intracranial conditions, and any additional interesting findings.

Outcome Measures

The outcomes of interest included “acute intracranial conditions” (subarachnoid hemorrhage, subdural hematoma, new or rapidly progressive space occupying lesion, parenchymal hemorrhage, intraventricular hemorrhage, or parenchymal infarct). We defined “yield” as the proportion of patients with the above outcomes identified among those who had CT head performed.

Risk of Bias Assessment

The Quality Assessment Tool for Quantitative Studies (QATQS), produced by the Effective Public Health Practice Project (EPHPP), was used to determine the quality of each article included in this systematic review.²⁰ The tool assesses for selection bias, study design, confounding variables, blinding, data collection methods, and withdrawal or dropout rate. Subheadings for “integrity” and “analyses” are also included in the design of the QATAS tool but they do not contribute to the numerical global rating. Studies are rated as “1-Strong,” “2-Moderate,” or “3-Weak” for each of the above items, and a similar final rating of strong, moderate, or weak is given for an overall global rating of the article taking into consideration all the above tool items. The performance of EPHPP quality assessment tool was found to have higher and more reliable inter-rater agreement than the Cochrane Collaboration Risk of Bias Tool.²¹ Risk of bias assessment was independently assessed by two investigators (JAV and HC) and discrepancies were resolved by consensus.

Data Analysis

For meta-analysis, we pooled the data from studies that included a similar subgroup of patients (e.g., ED patients or patients who were hospitalized). A proportion meta-analysis was carried for each subgroup to calculate the pooled proportion (expressed as a percentage with 95% confidence interval [CI]) of patients who received head CT and the proportion of these patients with serious intracranial conditions. I^2 was used as a measure of inconsistency across studies, i.e., the percentage of the variability in effect estimates due to heterogeneity rather than sampling error, with I^2 values of <25% considered low levels of heterogeneity, >75% high, and levels in between

moderate. The Cochrane Q-test was used as the statistical test for heterogeneity, with random-effects models used where there was evidence of significant heterogeneity and fixed-effects models used where there was no evidence of significant heterogeneity. Meta-analysis calculations were performed, and graphical plots were created using StatsDirect software.

RESULTS

Figure 1 depicts the flow diagram describing the number of articles identified and the Phases I and II of the article selection for inclusion in the systematic review. The initial search of the databases Embase, Medline, and Cochrane, from their inception until June 2016 were conducted by JAV under the guidance of the research librarian (MB). This yielded a total of 3,202 articles. The article search was updated in June 2017, with an additional 576 articles identified between June 2016 and June 2017. Hence, a total of 3,778 articles were identified for this review, and after removal of duplicates, 2,951 articles remained. Two investigators (JAV and HC) independently reviewed the title and abstract of these 2,951 articles and found that 2,799 articles did not meet the inclusion criteria and an additional 108 articles met the exclusion criteria leaving 44 articles for Phase II, full review ($\kappa = 0.833$ [95% CI = 0.790–0.875]). The reasons for exclusion during Phase I were as follows: 63 case reports, 15 articles in a language other than English or French, 16 educational reviews, one letter to the editor, one audit, and 12 abstracts that did not provide sufficient information for data synthesis and the full article for the same not found. A total of 44 articles were reviewed in full, of which 27 were excluded for the following reasons: 19 articles in which syncope was not the primary focus, six studies that did not report the head CT results, one in which syncope was actively induced in their cohort, and one that was a cost analysis. At the end of Phase II, 17 articles were included in this systematic review ($\kappa = 0.923$ [95% CI = 0.856–0.989]).^{9,10,22–36}

Table 1 shows the characteristics of the 17 studies included in this review involving 3,361 patients with syncope: 15 studies were retrospective chart reviews,^{10,22,24–36} two were prospective cohort studies,^{9,25} 13 studies were North American,^{9,10,22,24,25,27,29–35} and four were conducted outside North America.^{23,26,28,36} Fourteen of the 17 studies enrolled two specific subgroups of

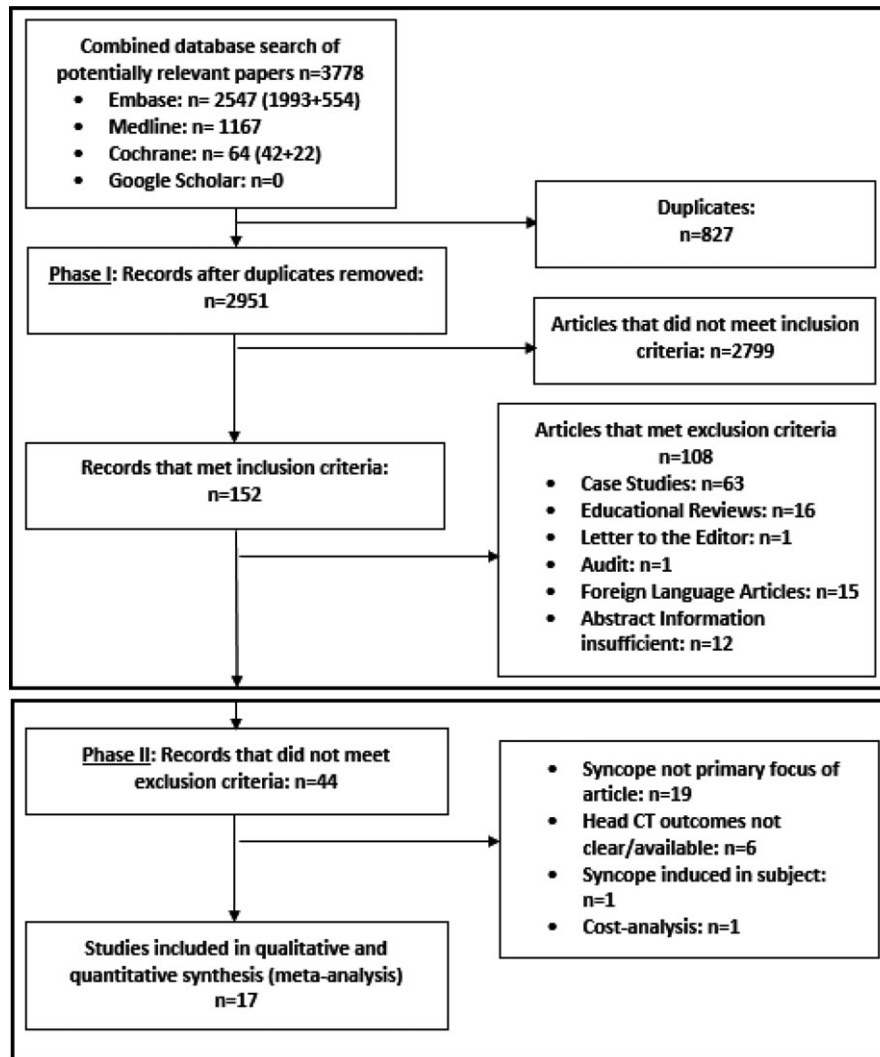


Figure 1. Identification of studies for the systematic review: flow diagram.

patients with syncope: eight studies included patients who presented to the ED^{9,10,22–27} and six studies included hospitalized patients with syncope.^{28–33} Hence, a meta-analysis was performed for the two subgroups and the data from three remaining articles were not pooled for meta-analysis. Of the three, two studies (Goyal et al.³⁴ and Kaneko et al.³⁵) enrolled only syncope patients that had head CT performed in their studies, and the third study by Bodhit et al.³⁶ enrolled only syncope patients aged 65 years or older.

Eight studies enrolling a total of 1,669 ED patients with syncope (Table 2) reported the proportion who had CT head performed and the diagnostic yield among these patients. The pooled proportion receiving a head CT across these studies using a random-effects model was 54.4% (95% CI = 34.9%–73.2%; Figure 2). There was considerable heterogeneity in the proportion receiving head CT across studies ($I^2 = 98.5\%$; Cochran's Q $p < 0.0001$). Of the 870

ED patients with syncope who received a head CT, the pooled proportion using a fixed-effects model for serious underlying intracranial condition was 3.8% (95% CI = 2.6%–5.1%; Figure 2). There was moderate heterogeneity in the proportion of patients with serious intracranial conditions across studies ($I^2 = 34.2\%$, Cochran's Q $p = 0.16$).

Six studies with a total of 1,289 patients hospitalized with syncope reported the proportion who received a head CT and those with serious underlying intracranial conditions (Table 3). The pooled proportion receiving head CT across these studies using a random-effects model was 44.8% (95% CI = 26.4%–64.1%; Figure 3). There was high heterogeneity in the proportion receiving head CT across studies ($I^2 = 97.6\%$; Cochran's Q $p < 0.0001$). Of the 607 patients hospitalized for syncope and who received a head CT, the pooled proportion using a fixed-effects model for serious intracranial condition was 1.2%

Table 1
Characteristics of Included Studies

Author, Year	Study Type	Patient Population	Patients Enrolled	Head CT Performed	Acute Outcomes Identified	Risk Factors Identified
<i>ED Patients</i>						
Aggarwal, 2011 ²²	Retrospective	ED syncope patients	408	185	5	Nil
Al-Nsoor, 2010 ²³	Prospective	ED (true) syncope patients	254	221	12	Abnormal neurologic findings
Ansari, 2013 ²⁴	Retrospective	ED syncope patients	108	88	3	Nil
Day, 1982 ²⁵	Retrospective	ED syncope patients	198	37	4	History of focal seizures or focal deficit on physical examination
Giglio, 2005 ¹⁰	Retrospective	ED syncope patients	128	44	1	Nil
Grossman, 2007 ⁹	Prospective	ED syncope patients \geq 18 years old	293	113	5	Age > 65 Signs/symptoms of neurologic disease including headache, trauma above the clavicles or taking warfarin
Vanbrabant, 2011 ²⁶	Retrospective	ED syncope patients	117	41	0	Nil
Velez, 2009 ²⁷	Retrospective	ED syncope patients	163	141	2	Nil
<i>Hospitalized Patients</i>						
Ben-Chetrit, 1985 ²⁸	Retrospective	Syncope patients > 20 years old	101	16	0	Nil
Eagle, 1983 ²⁹	Retrospective	Syncope patients > 16 years old	100	24	0	Nil
Gebreselassie, 2016 ³⁰	Retrospective	Discharge diagnosis of syncope	151	114	1	Nil
Johnson, 2014 ³¹	Retrospective	Admit diagnosis of syncope	167	131	0	Nil
Kapoor, 1982 ³²	Retrospective	Admit/discharge diagnosis of syncope	121	39	0	Nil
Pires, 2001 ³³	Retrospective	Patients \geq 18 years admitted with syncope	649	283	5	History of seizures and/or stroke
<i>Others</i>						
Bodhit, 2011 ³⁴	Retrospective	ED syncope patients \geq 65 years old	189	130	10	Nil
Goyal, 2006 ³⁵	Retrospective	ED syncope patients \geq 18 years old + head CT	117	117	0	Nil
Kaneko, 2012 ³⁶	Retrospective	Syncope patient + GCS 14/15	97	97	5	Diastolic blood pressure > 80 mm Hg

GCS = Glasgow Coma Scale.

Table 2
CT Head Among ED Patients With Syncope

Study	Total Sample Size	Patients Who Had Head CT Performed	Patients With Serious Intracranial Conditions Identified on CT	Proportion (%) Receiving Head CT (95% CI)	Percentage With Serious Intracranial Conditions (95% CI)
Aggarwal 2011 ²²	408	185	5	45.3 (40.4–50.3)	2.7 (0.9–6.2)
Al-Nsoor 2010 ²³	254	221	12	87.0 (82.2–90.9)	5.4 (2.8–9.3)
Ansari 2013 ²⁴	108	88	3	81.5 (72.9–88.3)	3.4 (0.7–9.6)
Day 1982 ²⁵	198	37	4	18.7 (13.5–24.8)	10.8 (3.0–25.4)
Giglio 2005 ¹⁰	128	44	1	34.4 (26.2–43.3)	2.3 (0.06–12.0)
Grossman 2007 ⁹	293	113	5	38.6 (33.0–44.4)	4.4 (1.5–10.0)
Vanbrabant 2011 ²⁶	117	41	0	35.0 (26.5–44.4)	0 (0–8.6)
Velez 2009 ²⁷	163	141	2	86.5 (80.3–91.3)	1.4 (0.2–5.0)
Total	1,669	870	32	54.4 (34.9–73.2)	3.8 (2.6–5.1)

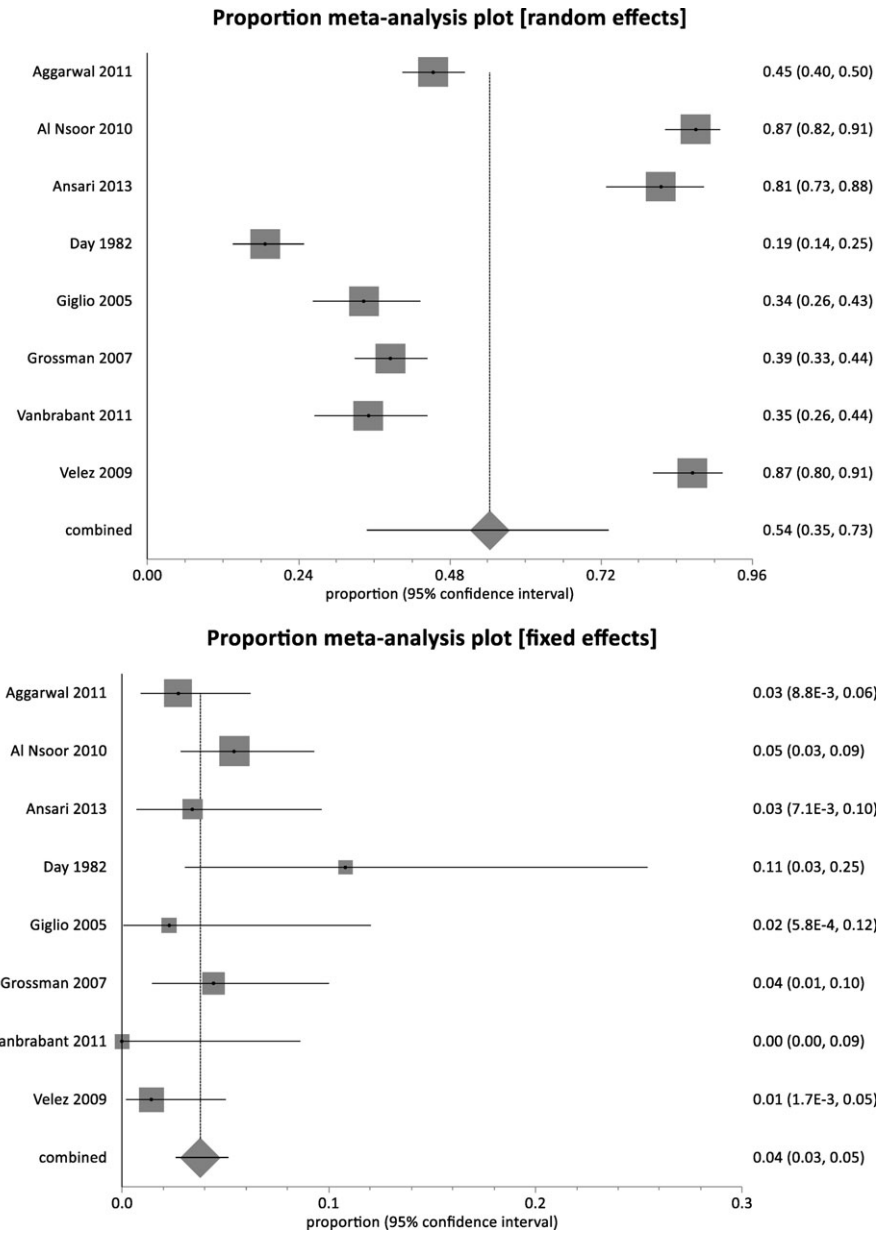


Figure 2. Forest plots for the proportion of ED patients with syncope who received a head CT (*top*) and its diagnostic yield (*bottom*).

Table 3
CT Head Among Patients Hospitalized for Syncope

Study	Total Sample Size	Patients Who Had Head CT Performed	Patients With Serious Intracranial Conditions Identified on CT	Percentage Receiving Head CT (95% CI)	Percentage With Serious Intracranial Conditions (95% CI)
Ben-Chetrit 1985 ²⁸	101	16	0	15.8 (9.3–24.4)	0 (0–20.6)
Eagle 1983 ²⁹	100	24	0	24.0 (16.0–33.6)	0 (0–14.2)
Gebreselassie 2016 ³⁰	151	114	1	75.5 (67.8–82.1)	0.9 (0.02–4.8)
Johnson 2014 ³¹	167	131	0	78.4 (71.4–84.4)	0 (0–2.8)
Kapoor 1982 ³²	121	39	0	32.2 (24.0–41.3)	0 (0–9.0)
Pires 2001 ³³	649	283	5	43.6 (39.7–47.5)	1.8 (0.6–4.1)
Total	1,289	607	6	44.8 (26.4–64.1)	1.2 (0.5–2.2)

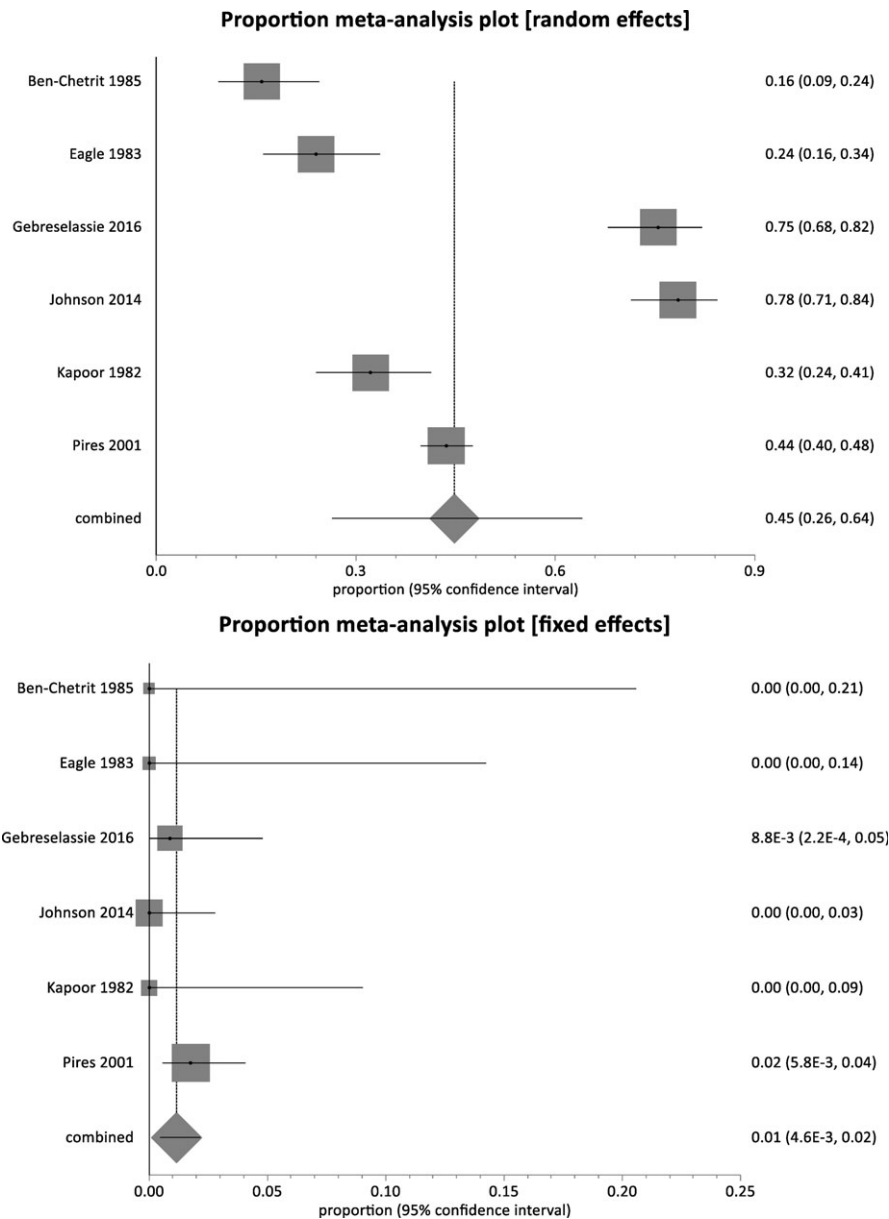


Figure 3. Forest plots for the proportion of patients who received a head CT (*top*) and its diagnostic yield (*bottom*) among those hospitalized for syncope.

Table 4
Types of Serious Intracranial Conditions Identified Among Patients With Syncope in the Included Studies

	Subarachnoid Hemorrhage	Subdural Hematoma	Space Occupying Lesion	Intraparenchymal Hemorrhage	Intraparenchymal Ischemia/Infarct	Unspecified	Group Total
ED	4	3	9	6	8	2†	32
Hospitalized	1	0	0	0	5	0	6
Others*	4	0	0	8	3	0	15
Totals	9	3	7	14	16	4	53

*Others includes articles by Goyal et al.,³⁵ Kaneko et al.,³⁶ and Bodhit et al.³⁴

†Velez et al.²⁷ report two patients with serious intracranial conditions as listed in the above, but the specific abnormality was not reported.

(95% CI = 0.5%–2.2%; Figure 3). There was no heterogeneity in the proportion with serious intracranial condition across studies ($I^2 = 0\%$, Cochran's Q $p = 0.63$; Figure 3).

Of the three studies not included in the meta-analysis, two studies, Goyal et al.³⁵ and Kaneko et al.,³⁶ only enrolled patients who had CT head performed. Of the 214 patients in these two studies, five (2.3%) patients

had a serious intracranial condition identified. The study by Bodhit et al.,³⁴ included only ED patients 65 years or older with syncope. Of the 189 patients in this study, 130 (68.8%) received a head CT and 10 (7.7%) patients had a serious intracranial condition identified.

Of the 3,361 patients from the 17 studies included in this review, a total of 1,821 patients (54.2%) underwent CT head, of whom 53 patients (2.9% [95% CI = 2.2%–3.8%]) had serious intracranial conditions identified. Of the eight articles that enrolled ED patients, seven studies (except Vanbrabant et al.²⁶) found patients with serious underlying conditions; among the five that enrolled hospitalized patients with syncope, one (Pires et al.³³) included patients with serious intracranial conditions. The serious underlying conditions among syncope patients identified in this review include subarachnoid hemorrhage, subdural hematoma, space occupying lesions, parenchymal ischemia or infarction, and intraparenchymal hemorrhage (Table 4). Meta-analysis of data from the articles included in this study showed that 54.4% of ED patients with syncope had CT head performed with a yield of 3.8%, and 44.8% of hospitalized patients with syncope had CT head performed with a diagnostic yield of 1.2%.

Five articles identified risk factors (see Table 1) that were associated with serious underlying intracranial serious condition on CT head among patients with syncope. Three studies (Al-Nsoor and Mhearat,²³ Day et al.,²⁵ and Grossman et al.⁹) observed that these serious intracranial conditions were more likely to be found among patients that presented with neurologic deficit or headache in their history or examination. Of these three studies, Day et al.²⁵ was the only one that reported statistical significance ($p < 0.0001$) for neurologic deficits. Grossman et al.⁹ also found that patients taking warfarin and those with concomitant signs of trauma above the clavicles are more likely to have serious underlying intracranial conditions.⁹ Day et al.²⁵ observed that focal seizure activity or focal neurologic findings among patients with syncope were associated with space-occupying lesions found on head CT, while Pires et al.³³ observed that history of stroke was associated with a higher likelihood of serious underlying intracranial conditions among patients with syncope. Kaneko et al.³⁶ identified serious intracranial outcomes among patients with a diastolic blood pressure > 85 mm Hg. However, this finding was not statistically significant ($p = 0.010$).³⁶ The cohort in Gebreselassie et al.³⁰ was composed of approximately 85% black patients but there was no increased risk for

intracranial event found to be associated with this population. Except for the specific studies indicated above, none of the other studies reported statistical significance for the identified risk factors. The above-listed risk factors were the only ones evaluated in the included studies. Bodhit et al.³⁴ in their study found that warfarin was not significantly associated with intracranial hemorrhage in patients 65 years or older with syncope. However, warfarin was identified as a risk factor by Grossman et al.⁹

Risk of Bias Within Studies

For the six distinct items in the QATQS tool, the quality of all the included studies were rated as strong or moderate (Table 5). There was an initial disagreement on only one item in two studies with the rest of the 100 independent evaluations being identical between the two investigators (JAV and HC). The kappa was 0.96 (95% CI = 83.4–99.7). The disagreement on these two items was resolved by consensus. For the global rating, all included studies were rated strong by the two investigators with 100% agreement.

DISCUSSION

In our review, we found that a high proportion of all patients with syncope have a CT head performed with a diagnostic yield of 1.2% for hospitalized patients and 3.8% for ED patients. We believe that the results of our review will aid in choosing wisely and facilitate shared decision making for performing CT head in the management of patients with syncope.

One previous review by Pournazari et al.³⁷ reported the diagnostic value of neurologic studies among patients with syncope and reported that 57.3% of patients had CT head performed with a diagnostic yield of 1.2%. However, this review did not clearly report the conditions that constituted a positive diagnostic yield. A previous study by our team observed that a very low proportion (0.4%) have serious neurologic conditions identified during the syncope evaluation.³⁸

The six intracranial outcomes included in the study were selected based on clinical relevance, previous literature, and consensus among the coauthors. With respect to the risk factors associated with serious intracranial conditions among patients with syncope, we found only one common theme: the presence of neurologic deficits. The included studies found it challenging to identify risk factor associations for all the serious

Table 5
The Effective Public Health Practice Project (EPHPP) Quality Assessment Tool for Quantitative Studies

Study characteristic	Aggarwal ²²	Al-nsoor ²³	Ansari ²⁴	Ben chetrit ²⁸	Bodhit ³⁴	Day ²⁵	Eagle ²⁹	Gebrese lassie ³⁰	Giglio ¹⁰	Goyal ³⁵	Gross man ⁹	Johnson ³¹	Kaneko ³⁶	Kapoor ³²	Pires ³³	Vanbrabant ²⁶	Velez ²⁷
A) Selection bias	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1
B) Study selection	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
C) Con founders	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
D) Blinding	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
E) Data collection methods	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
F) Withdrawals and dropouts	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2
Global rating	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

*Rating 1 = Strong, 2 = Moderate, and 3 = Weak

intracranial conditions: subarachnoid hemorrhage, subdural hematoma, or brain tumors due to diversity in their pathophysiology. Five articles identified potential risk factors indicating a need for head CT; however, there is little agreement among them. A higher proportion of patients with a diastolic blood pressure of >85 mm Hg and those taking warfarin were observed to have subarachnoid hemorrhage, intraparenchymal hemorrhage, or subdural hematoma but these factors have no known impact on the incidence of brain tumors. Three articles identified some degree of neurologic deficit as being a strong indicator for head CT; however, such would be the case even in the absence of a syncopal event.³⁹ Two studies in our review reported underlying parenchymal or intraparenchymal infarct, which likely is the cause of neurologic deficits among patients enrolled in these studies.^{40,41} It is also very likely that these patients suffered an acute cerebrovascular accident rather than true syncope, which is caused by transient global hypoperfusion.¹ Day et al.²⁵ recognized that patients with focal seizure or focal neurologic deficits on presentation were much more likely to have an underlying serious intracranial condition as the cause for their syncope. It is, however, sometimes difficult to distinguish seizure from syncope on initial ED presentation. A thorough yet focused history and examination is invaluable in identifying patients with true syncope and those who will likely benefit from CT of the head based on the above risk factors reported.²³ Additionally, among patients who sustain head trauma after syncope can be assessed using the published risk tools (NEXUS-II, Canadian CT Head Rule, or the New Orleans Rule) to identify those who will benefit from a CT head.¹⁶⁻¹⁸

In our review we included only articles that enrolled patients with syncope and assessed the role of CT head. One article by Mitsunaga et al.⁴² reported the role of CT head among both syncope and presyncope patients. We excluded this article as we were unable to extract the results for the syncope subgroup. In each of the 17 included studies, a high proportion of enrolled patients had CT head performed with the clear majority being negative. For every 26 scans carried out on ED patients and for every 83 scans among patients hospitalized for syncope, an estimated one scan reported positive findings. None of the studies succeeded in establishing a common set of characteristics for identifying patients with serious underlying intracranial conditions when presenting with syncope.

Injudicious use of head CT to investigate syncope is not only costly but also exposes patients to high levels of

radiation (2 mSv; 8-month background dose accumulation). It is therefore imperative to establish a robust set of guidelines that aids in the identification of patients that are likely to be at high risk for a serious intracranial condition. A prospective study involving a larger cohort of patients with syncope is needed to develop such a risk tool. Our review results support the recommendations of the Choosing Wisely Campaign that advocate against overuse of CT head among low-risk patients with syncope.^{12,13} The 2015 Academic Emergency Medicine (AEM) Consensus Conference, with input from multidisciplinary experts, aimed to develop a research agenda for optimize ED diagnostic imaging by identifying opportunities, knowledge gaps, and develop priorities.¹⁴ The content areas identified by this expert panel were clinical decision rules and comparative research for alternatives to CT use. The results of our review identify that a knowledge gap exists, and future research for appropriate use of CT head in syncope is needed. The results of our review also indicate that the choice of CT head among patients with syncope will be amenable to shared decision making (SDM), as usually a worst-case scenario approach is taken rather than the most likely scenario. The issue of CT head in syncope also fulfills the SDM appropriateness criteria (e.g., pretest probability can be estimated, testing equipoise exists, test performance data are emerging about risks, and benefits are available) identified at the 2016 AEM consensus conference on SDM in the ED on diagnostic testing.¹⁵

We believe that the results of our review can be used in clinical practice in the following manner: The probability of finding any important abnormalities in CT head among patients with syncope is 3.8% during ED evaluation and 1.2% when hospitalized after ED evaluation. This probability is higher if any of the risk factors identified in our review are present and lower if absent. Pretest probabilities estimated from the above results can be shared with the patient in addition to the fact that no clear-cut evidence for optimal approach exists. A potential alternate approach to defer CT head and watch for development of any of the above risk factors can be offered to patients who have none of the risk factors identified.

Based on the results of our review, we are unable to qualify the yield of CT head among patients with syncope as low or modest. Decisions regarding testing threshold are beyond the scope of this review. Future studies should provide more reliable estimates of diagnostic yield and derive testing threshold for CT head among patient with syncope by addressing pretest

probability, risks, and benefits of CT head. Furthermore, guidelines for CT head in syncope can be developed based on the testing threshold and input from an expert consensus panel.⁴³

LIMITATIONS

The limitations of our study are consistent with the design of a systematic review. In our review, the majority of the studies were retrospective in nature, and several studies enrolled a small number of patients. The studies were conducted on different populations and settings, with substantial heterogeneity on several aspects included the types of serious intracranial conditions listed as outcomes. Further, some of the earlier studies (Day et al.,²⁵ Kapoor et al.,³² and Eagle and Black²⁹) had relatively small patient cohorts, which may not have fully represented the use and yield of head CT accurately for this time period. Despite this, we believe that the studies we have included are, collectively, an accurate representation of the frequency of CT head use among adult syncope patients. Furthermore, the results that half of all patients with syncope have CT head performed and the yield is 1% to 3% is consistent. We considered the risk of spectrum bias as not all patients in several included studies had CT head performed. The studies, however, represent the spectrum of patients with syncope that present to the ED and it is also not ethical to subject all patients to CT head. The aim of our systematic review is to provide an overview of the use of CT head among adult patients with syncope and the proportion that were positive for the outcomes listed in the study. We stratified our results by setting, but the reporting of the studies limited further stratification or meta-regression. It could be argued that patients found to have intraparenchymal ischemia on head CT likely did not suffer true syncope. Hence, our study results likely overestimate the diagnostic yield for CT head as approximately one-third of intracranial conditions identified in our review were intraparenchymal ischemia or infarction. Grossman et al.⁹ reported trauma above the clavicles as a risk factor associated with a positive finding on CT head. It is possible that these patients who sustained trauma would have a received a head CT regardless of their syncope. The risk factors identified are very varied and based on very small number of patients with serious outcomes. Our review was limited to the use of CT head among adult patients with syncope and excluded pediatric patients. All organizations, including Choosing Wisely and the American College of

Emergency Physicians, highlight the overuse of CT head among adult syncope patients. Hence, we focused our review on adult patients. Due to resource limitations, for this review we focused solely on articles in English and French. It could be argued that including articles from the 1980s might not be in line with the current ethos for diagnosing and treating syncope, but we deemed it necessary to include these studies for completeness. However, our synthesis of the literature on the use and yield of CT head among patients with syncope is one of the very few to date on this topic.

CONCLUSION

Our systematic review found that half of all patients with syncope have computed tomography head performed with a yield of 1.2% to 3.8%. Caution should be exercised against indiscriminate use of computed tomography head in the evaluation of patients with syncope. A few studies identified presence of neurologic deficits as a risk factor for underlying serious intracranial conditions. Future large-scale studies are needed to provide more reliable estimates for diagnostic yield for computed tomography of the head among patients with syncope, develop a robust prediction tool to guide physicians for optimal use of computed tomography of the head, and expert clinical consensus regarding acceptable miss rate.

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Supporting Information

The following supporting information is available in the online version of this paper available at <http://onlinelibrary.wiley.com/doi/10.1111/acem.13568/full>

Data Supplement S1. Supplemental material.