Intern Emerg Med (2015) 10:619–627
DOI 10.1007/s11739-015-1237-1

EM - ORIGINAL

Emergency department management of syncope: need for standardization and improved risk stratification

Venkatesh Thiruganasambandamoorthy[1,2,3] · Monica Taljaard[2,3] · Ian G. Stiell[1,2,3] · Marco L. A. Sivilotti[4,5] · Heather Murray[4,6] · Aparna Vaidyanathan[2] · Brian H. Rowe[7] · Lisa A. Calder[1,2,3] · Eddy Lang[8] · Andrew McRae[8] · Robert Sheldon[9] · George A. Wells[3]

Received: 19 January 2015 / Accepted: 27 March 2015 / Published online: 28 April 2015

Abstract Variations in emergency department (ED) syncope management have not been well studied. The goals of this study were to assess variations in management, and emergency physicians' risk perception and disposition decision making. We conducted a prospective study of adults with syncope in six EDs in four cities over 32 months. We collected patient characteristics, ED management, disposition, physicians' prediction probabilities at index presentation and followed patients for 30 days for serious outcomes: death, myocardial infarction (MI), arrhythmia, structural heart disease, pulmonary embolism, significant hemorrhage, or procedural interventions. We used descriptive statistics, ROC curves, and regression analyses. We enrolled 3662 patients: mean age 54.3 years, and 12.9 % were hospitalized. Follow-up data were available for 3365 patients (91.9 %) and 345 patients (10.3 %) suffered serious outcomes: 120 (3.6 %) after ED disposition including 48 patients outside the hospital. After accounting for differences in patient case mix, the rates of ED investigations and disposition were significantly different ($p < 0.0001$) across the four study cities; as were the rates of 30-day serious outcomes ($p < 0.0001$) and serious outcomes after ED disposition ($p = 0.0227$). There was poor agreement between physician risk perception and both observed event rates and referral patterns ($p < 0.0001$). Only 76.7 % (95 % CI 68.1–83.6) of patients with serious outcomes were appropriately referred. There are large and unexplained differences in ED syncope management. Moreover, there is poor agreement between physician risk perception, disposition decision making, and serious outcomes after ED disposition. A valid risk-stratification tool might help standardize ED management and improve disposition decision making.

Keywords Syncope · Emergency department · Management · Practice variation · Risk perception · Serious outcomes outside the hospital · Disposition decision making · Mortality

✉ Venkatesh Thiruganasambandamoorthy
vthirug@ohri.ca

1 Department of Emergency Medicine, University of Ottawa, Ottawa, ON, Canada

2 Clinical Epidemiology Unit, The Ottawa Hospital Research Institute, The Ottawa Hospital, Civic Campus, 1053 Carling Avenue, 6th Floor, Rm F650, Ottawa, ON K1Y 4E9, Canada

3 Department of Epidemiology and Community Medicine, University of Ottawa, Ottawa, ON, Canada

4 Department of Emergency Medicine, Queen's University, Kingston, ON, Canada

5 Department of Biomedical and Molecular Sciences, Queen's University, Kingston, ON, Canada

6 Department of Public Health Sciences, Queen's University, Kingston, ON, Canada

7 Department of Emergency Medicine and School of Public Health, University of Alberta, Edmonton, AB, Canada

8 Department of Emergency Medicine, University of Calgary, Calgary, AB, Canada

9 Department of Medicine, University of Calgary, Calgary, AB, Canada

Objective

Syncope is defined as a sudden transient loss of consciousness followed by spontaneous complete recovery [1]. Syncope is a common emergency department (ED) presenting complaint and can be caused by a wide range of serious conditions (e.g. dysrhythmias, myocardial

infarction, pulmonary embolism, or significant hemorrhage) that can lead to death and morbidity [2–10]. Among ED syncope patients, 7–23 % will suffer serious outcomes within 7–30 days with approximately half suffering after ED disposition either as an inpatient or outside the hospital [7, 10–13]. When published studies are compared, variations in ED management of syncope are evident among institutions and countries [6, 7, 10, 11, 13–19]. Nevertheless, there are no studies that actually compare management among centers and examine reasons for variations in ED syncope management. One study evaluated emergency physician disposition decision making in the USA which is a highly litigious environment and found that most low-risk patients were admitted [20]. However, in most western countries, health care is partially or fully publically funded and the medico-legal risks are lesser than in the USA. The risk perception and disposition decision making in such a practice environment have not been studied.

We conducted a multicenter prospective cohort study to assess the need for standardization of ED management and improved risk stratification in the care of syncope patients. The specific objectives of this study were to: (1) describe the short-term (30-day) prognosis; (2) assess the variations in ED management across the study sites after accounting for patient case mix; (3) assess the variations in risk-adjusted outcomes across the study sites; and (4) analyze emergency physicians' risk perception and disposition decision making.

Methods

Study design and setting

Our study was conducted between October 2010 and May 2013 at six Canadian academic EDs with a combined annual ED volume of approximately 300,000 patient visits (Ottawa Hospital Civic and General Campuses—Ottawa, ON; Kingston General Hospital and Hotel Dieu Hospital—Kingston, ON; Foothills Medical Centre—Calgary, AB; University of Alberta Hospital—Edmonton, AB).

Participants

We included adult patients (≥16 years of age) who suffered syncope, and presented to the ED within 24 h of the event. We excluded patients who were previously enrolled and those with any of the following exclusion criteria: prolonged loss of consciousness (>5 min); change in their mental status from baseline after the event; obvious witnessed seizure; significant trauma requiring admission; patients with alcohol/illicit drug abuse or language barrier. We excluded patients with prolonged loss of consciousness as seizure is more likely, and also excluded those who sustained significant trauma as it would be difficult to attribute the serious outcome to syncope [7, 21]. The study was approved by the hospital research ethics boards at all the study sites.

Study protocol and data collection

On-duty ED staff including physicians as well as on-site research personnel screened consecutive patients presenting with syncope, pre-syncope, fainting, black out, loss of consciousness, fall, collapse, seizure, dizziness or lightheadedness. ED physicians applied the above-mentioned inclusion and exclusion criteria to confirm eligibility, and obtained consent before inclusion in the study. We collected patient demographics, event characteristics, medical history, investigations performed in the ED and their results, presumed cause of syncope at the end of the ED visit, patients' disposition, ED length of stay, and information on outpatient referrals for investigations and consultations. We asked the treating physician to estimate the probability of serious outcome occurring within 30 days on a scale of 0–100 %. This physician prediction probability is a measure of risk perception by emergency physicians for a given patient. All clinical decisions including ED investigations, disposition and referral for further outpatient referral were left to the treating physician's discretion. We classified the emergency physicians' disposition decision based on referral to consultants in the ED and the appropriateness and timeliness of outpatient investigations and consultation referrals. For study patients who suffered serious outcomes after ED disposition, we categorized the disposition decision as appropriate and timely if the patient was referred correctly for consultation or investigations and the serious outcome was detected during such follow-up.

Outcome measures

The location of occurrence of serious outcomes was categorized into three groups: (1) the prehospital setting or in the ED during the index visit; (2) as inpatient (hospitalized during the index visit), or (3) outside the hospital, for all serious outcomes that were not part of the above two groups. We defined the outcomes in the study as per the previously published standardized reporting guidelines for ED syncope research [1]. We defined our primary outcome as any serious condition related to syncope occurring or detected within 30 days of index ED visit after ED disposition and included any of the following ("Appendix 1"): death, myocardial infarction, dysrhythmia, serious structural heart disease, aortic dissection, pulmonary embolism, severe pulmonary hypertension, significant hemorrhage, subarachnoid hemorrhage, any other serious

condition causing syncope or procedural interventions for treatment of syncope. For patients who died, if death was related to the underlying serious condition that caused the syncope or due to an unknown cause, they were then deemed to have suffered a serious outcome. Our serious outcome list excluded hospitalization on a return ED visit due to social reasons without any of the above serious conditions [7, 22]. The secondary outcome was defined as detection or occurrence of the above-mentioned serious conditions in the ED before disposition decision.

We ascertained the outcome occurrence by structured medical record review of all available documents (index and subsequent ED visits; inpatient, follow-up clinic; results of all investigations, and hospital death records). We also conducted a scripted telephone follow-up immediately after 30 days. All serious outcomes were confirmed by an Adjudication Committee comprised of two physicians, with a third physician adjudicating in cases of disagreement.

Statistical analysis

We calculated descriptive statistics for continuous variables using means and range or standard deviation, or medians and inter-quartile range as appropriate for the distribution of the data. We reported categorical or dichotomous variables as frequencies with proportions, together with 95 % confidence intervals (CI) for main outcomes. Differences in proportions were assessed using Chi-squared tests or Fisher's exact tests as appropriate. For the purposes of comparing the ED management among centers, we combined data from hospitals in Kingston and Ottawa as a substantial number of physicians work at both study sites in these cities. We analyzed inter-site variations in ED investigations and disposition using multivariable logistic regression analysis adjusting for patient case mix and accounting for clustering by physician using generalized estimating equations (GEE) assuming an exchangeable correlation coefficient. We analyzed differences in the ED length of stay among the study cities using a generalized linear regression model with a gamma distribution and log link function to account for the skewed distribution. Risk-adjusted rates for each city were calculated using least square means with covariates set to their mean values; thus, risk-adjusted rates reflect management and disposition for an "average" patient across the cities. We adjusted for the following patient characteristics: age, gender, history of coronary artery disease, valvular heart disease, atrial fibrillation, diabetes, hypertension and heart failure. Risk-adjusted rates were ranked and displayed together with 95 % CI with the identity of the sites masked.

To analyze physicians' risk perception and disposition decision making, we conducted logistic regression analyses. First, we assessed the agreement between physician risk perception and outcomes by comparing observed versus predicted outcomes within categories of perceived risk using the Hosmer–Lemeshow test; we calculated the C-statistic, i.e., the area under the receiver operating characteristic (ROC) curve, as a measure of the extent to which physicians were able to discriminate between high and low-risk patients. Second, we assessed the agreement between physician risk perception and physician disposition decision making (referrals both in ED and as outpatient), using a similar approach. To quantify the ability of physicians to accurately identify serious outcomes, we calculated the proportion of patients with serious outcomes who were appropriately referred, and the proportion of patients without serious outcomes who were referred. SAS (SAS Institute, Inc., Cary, NC version 9.2) software was used for all data analysis.

Sample size

The sample size was determined by the need to estimate the incidence of serious outcomes with acceptable precision. Based on previous studies, conservatively estimating the anticipated rate of serious outcomes of 7 %, we calculated that a sample size of 3600 gives a margin of error of ± 0.8 %, thus, limiting the total width of the confidence interval around the serious outcome rate to <2 % [7, 10–13].

Results

There were 560,950 ED visits during the study period at the six study hospitals, and 4944 visits (0.9 %) were due to syncope (Fig. 1). After excluding patients who were previously enrolled in the study and those who refused to participate, 4724 patients were eligible to be enrolled in the study. Among those eligible, 3662 patients (77.5 %) were included in the study. The characteristics of the 1062 missed potentially eligible patients were similar to the enrolled cohort ("Appendix 2").

Table 1 shows the baseline characteristics, ED management, diagnosis at ED disposition, and 30-day outcomes for the study patients. A total of 3188 patients (87.1 %) were discharged home from the ED, with emergency physicians directly discharging 2885 patients (78.8 %) and the rest after consultation. We were able to obtain 30-day follow-up data for 3365 patients (91.9 %). The patients who were lost to follow-up were younger with a lower proportion having concomitant medical problems when compared to those with successful follow-up ("Appendix 3").

There were 31 deaths (0.9 %) within 30 days and five were adjudicated as not related to the cause of syncope

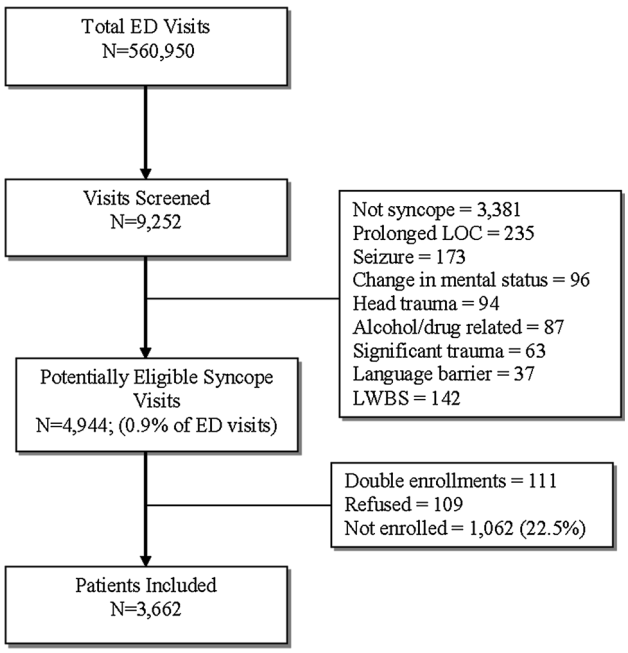


Fig. 1 Patient flow

(Table 2). Among the 26 patients (0.8 %) who died related to a cause of syncope, the cause of death among 18 patients was known. A total of 12 patients (0.4 %) died outside the hospital with the cause of death identified among five patients: one patient died secondary to pulmonary fibrosis, one due to sepsis, and three due to cardiac causes (two patients with underlying serious structural heart disease and one suffered severe bradycardia). The proportion of patients who suffered serious outcomes and deaths (15.2 and 2.7 %) was significantly higher ($p < 0.0001$) among those who were admitted than those who were discharged home (1.7 and 0.4 %, respectively). There were 225 patients (6.7 %) who suffered serious cardiac outcomes and 112 patients (3.3 %) who suffered serious non-cardiac outcomes. Cardiac dysrhythmias (168 patients; 5.0 %) were the most common serious outcome among the study patients. The time of occurrence of serious outcomes after ED disposition for 116 of 120 patients is shown in "Appendix 4". Seventy-three patients (62.9 %) suffered serious outcomes within 7 days of ED disposition, with the remainder occurring between 7 and 30 days after the ED visit. Seven patients died from an unknown cause outside the hospital between the 14th and 28th day after ED disposition.

We compared the risk-adjusted ED management of syncope patients across the four study cities (Fig. 2). We found significant differences ($p < 0.0001$) in ED investigations, referral to consultants, and hospitalizations across the study sites, even after adjusting for differences in case mix (age, sex, coronary artery disease, valvular heart disease, atrial fibrillation, diabetes, hypertension and heart failure). The overall serious outcomes ($p < 0.0001$) and serious outcomes after ED disposition ($p = 0.0227$) were significantly different across sites after accounting for differences in patient case mix and clustering by physician.

Table 1 Demographics, clinical characteristics, management and outcomes among 3662 emergency department syncope patients

Characteristics	$N = 3662$ (%)
Demographics	
Age (mean, SD)	54.3 (23.1)
Range	16–101
Female	2013 (55.0)
Arrival by ambulance	2415 (66.0)
Witnessed syncope	2193 (70.8)
Medical history	
Hypertension	1177 (32.1)
Diabetes	373 (10.2)
Coronary artery disease	471 (12.9)
Atrial fibrillation/flutter	228 (6.2)
Valvular heart disease	153 (4.2)
Congestive heart failure	141 (3.9)
ED management	
Electrocardiogram performed	3351 (91.5)
Blood tests performed	3173 (86.7)
Chest X-ray performed	1188 (32.4)
Computed tomography of head performed	808 (22.1)
Median ED length of stay in hours (IQR)	4.6 (3.1–6.7)
Referred for consultation in the ED	777 (21.2)
Admitted to hospital	474 (12.9)
Cause of syncope at ED disposition*	$N = 3437$ (%)
Vasovagal	1918 (52.4)
Orthostatic hypotension	391 (10.7)
Cardiac	238 (6.9)
Medication related	78 (2.1)
Unknown	812 (23.6)
30-day outcomes†	$N = 3365$ (%)
Serious outcomes	345 (10.3)
Serious outcomes in the ED before disposition	225 (6.7)
Serious outcomes after ED disposition‡	120 (3.6)
Serious outcomes while hospitalized	72 (2.1)
Serious outcomes outside the hospital	48 (1.4)

SD standard deviation, *ED* emergency department, *IQR* inter-quartile range

* Of the 3662 enrolled patients, 225 patients had serious conditions detected during ED evaluation. The presumed cause of syncope among the remaining 3437 patients is detailed above

† 30-day follow-up was achieved for 3365 patients (91.9 %)

‡ Includes patients who suffered serious outcomes either as an in-patient or outside the hospital

Table 2 Serious adverse events among 3365 Canadian emergency department syncope patients and their location of occurrence

Serious outcomes	Total ($N = 345$)	Prehospital/in ED ($N = 225$)	As inpatient ($N = 72$)	Outside the hospital ($N = 48$)
Total deaths*	26	1	13	12
Deaths cause unknown	8	0	1	7
Cardiac serious outcomes				
Arrhythmias				
Sinus node dysfunction	49	34	8	7
New/uncontrolled atrial fibrillation	31	27	0	4
High grade atrioventricular block	34	25	6	3
Ventricular dysrhythmia	22	8	10	4
Supraventricular tachycardia	8	6	1	1
Pacer/defibrillator malfunction	3	3	0	0
Pacemaker insertion	21	0	20	1
Myocardial infarction	25	19	3	3
Structural heart disease	30	20	8	2
Aortic dissection	2	1	1	0
Non-cardiac serious outcomes				
Significant hemorrhage	48	41	4	3
Pulmonary embolism	16	9	5	2
Other				
Renal conditions[†]	3	3	0	0
Intracranial conditions[‡]	12	6	2	4
Intra-abdominal conditions[§]	8	4	1	3
Intra-thoracic conditions[¥]	8	5	1	2
Sepsis	7	5	0	2
Anemia/thrombocytopenia requiring transfusions	6	6	0	0
Idiopathic hypovolemia	1	1	0	0
Amyloidosis	1	1	0	0
Ulcerative esophagitis requiring endoscopy and transfusion	1	1	0	0
Subclavian steal syndrome	1	0	1	0

ED emergency department

*18 patients died secondary to cardiac or non-cardiac serious outcomes listed in the table and hence not counted towards the total

[†] Renal failure requiring dialysis and renal mass

[‡] Subarachnoid/intracranial hemorrhage, subdural hematoma, brain tumor/metastasis, Arnold–Chiari malformation with brainstem herniation, posterior circulation stroke and aseptic meningitis

[§] Small bowel obstruction, appendicitis, cholangitis, ectopic pregnancy and ovarian carcinoma

[¥] Severe pulmonary fibrosis, large pleural effusion, lung/oesophageal carcinoma, severe pulmonary hypertension

After excluding 225 patients who suffered serious outcomes in the ED from the 3365 study patients with follow-up data, we analyzed the emergency physicians' risk perception (prediction probability) and disposition decision among 3140 patients. Table 3 shows the relationships between physician risk perception and both serious outcomes and referrals. There was poor agreement between physician risk perception and both observed event rates ($p < 0.0001$), and referral patterns ($p < 0.0001$). Analysis of the actual emergency physician disposition decision showed 832 of 3140 patients referred to consultants (571 patients referred in the ED, and additionally 261 patients referred as outpatients), and 28 of the 48 patients who suffered outcomes outside the hospital did not have an appropriate and timely referral. We found that 76.7 % (95 % CI 68.1–83.6) of patients with serious outcomes were appropriately referred and 24.5 % (95 % CI 23.9–25.1) of patients without serious outcomes were referred.

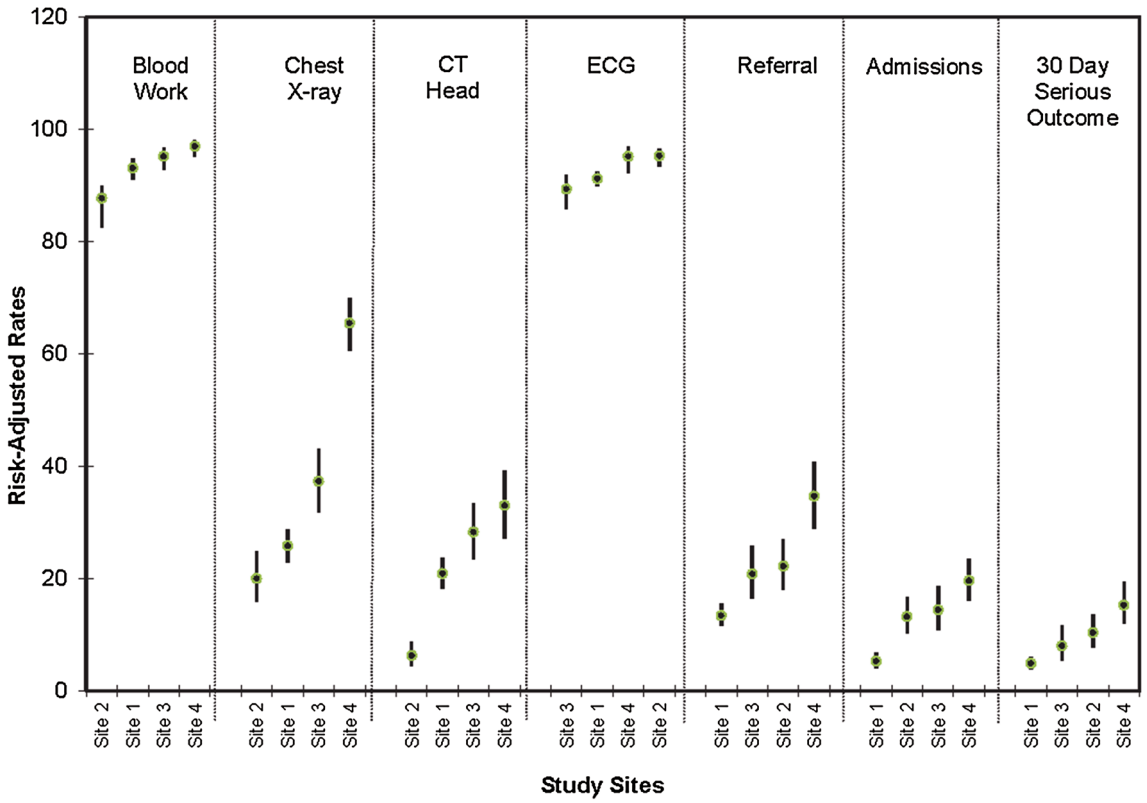


Fig. 2 Management of emergency department syncope patients—practice variation across study sites

Table 3 Agreement between physician risk perception, physician behavior, and risk of serious outcomes after ED disposition

MD perceived risk* (%)	No. of patients	Agreement between ED physician risk perception and serious outcomes		Agreement between ED physician risk perception and disposition decision	
		Observed outcomes	Expected outcomes† (%)	Observed referral	Expected referral‡ (%)
0	314	2 (0.6 %)	2.55	14 (4.5 %)	11.3
1	930	10 (1.1 %)	2.64	52 (5.6 %)	11.9
2	478	7 (1.5 %)	2.74	40 (8.4 %)	12.5
3–4	238	5 (2.1 %)	2.87	38 (16.0 %)	13.4
5	365	21 (5.8 %)	3.05	103 (28.2 %)	14.6
10–20	312	32 (10.3 %)	4.13	127 (40.7 %)	21.7
30 or more	195	33 (16.9 %)	17.2	116 (59.5 %)	67.0
		Hosmer–Lemeshow $p < 0.0001$		Hosmer–Lemeshow $p < 0.0001$	
		C-statistic: 0.79		C-statistic: 0.79	

* Intervals were categorized to create equal sized groups

† Calibrated to the overall level of risk in the population

‡ Calibrated to the overall rate of referral in the population

Discussion

Our study shows that among those who suffered serious outcomes after ED disposition, a significant proportion suffers outside the hospital, and wide variations exist in the ED management of syncope patients. These practice variations were not explained by the patient demographic or clinical characteristics. While the emergency physicians' ability to perform risk stratification is fair, the poor correlation between emergency physician risk perception and both actual serious outcome occurrence and referral patterns suggests that standardization and improved risk stratification are needed.

The proportion of patients hospitalized for syncope in our study is among the lowest in the reported literature, with published studies reporting 33–83 % hospitalization [6, 7, 10, 12, 14, 15, 18, 19, 23]. Among patients who suffered serious outcomes, one-fourth suffered outside the hospital with no appropriate follow-up. In contrast, three USA studies with admission rates four- to six-fold higher (51–83 %) report adverse events post discharge of between 0 and 0.4 % [12, 18, 19]. While increased hospitalizations may be a solution for identification of those at-risk, lowering the threshold for inpatient admission will lead to worsening of the ED and hospital crowding and possibly, also inefficient use of healthcare resources.

While inference regarding practice variations can be made by comparing previously published studies, our study is the first to directly compare practice variations between study sites [6, 7, 10, 11, 13–19]. At the heart of clinical judgement for syncope is finding the best balance between investigations, hospital admission and missed diagnosis. It is this trade-off that drives bedside clinical decisions. The wide variations in ED management seen in our study emphasize the need for standardized ED evaluation of syncope patients.

The STePS study reports 10-day mortality and recommends early risk stratification in dedicated inpatient syncope units as most deaths occur within 48 h of the sentinel event [6, 24]. In our study, among those who suffer serious outcomes after ED disposition, more than one-third including a substantial number of deaths occur 7 days after the sentinel syncopal event.

In our study, nearly one in four patients with serious outcomes is not appropriately referred, and approximately one in four patients without serious outcomes is referred. The results reveal the challenge faced by emergency physicians in risk perception and this in turn leads to inaccurate disposition decisions with patients suffering morbidity and mortality outside the hospital. This finding also suggests that a well-validated risk-stratification tool that performs better than clinician gestalt might improve risk perception among ED physicians and subsequent disposition decision making.

Rigorous and large studies are needed to develop a robust risk tool that standardizes the ED care of syncope patients. The tool should incorporate information available at first presentation, and stratify those at high-risk in the immediate future for hospitalization, those at intermediate-risk for urgent outpatient follow-up and low-risk patients who can be discharged with no further follow-up. Such a tool would have a meaningful impact in ED syncope management, particularly in countries with health care systems similar to the study hospitals.

Limitations

This study does, however, has some potential limitations. Approximately one-fifth of potentially eligible patients were not enrolled, despite efforts to enroll consecutive patients. This proportion overestimates the missed fraction, as cases that cannot be clearly classified as ineligible on medical record review were retained as potentially eligible. We are not aware of any systematic reasons for non-recruitment of patients, and the characteristics of those missed and those recruited were similar. It is possible that some outcomes were missed among the study patients who were lost to follow-up. The characteristics of those lost to follow-up indicate that they are likely lower risk to suffer a serious outcome. Hence, we believe that it is unlikely that a significant proportion of patients who were lost to follow-up suffered serious outcomes to alter the conclusions of the study. We advised emergency physicians to complete the prediction probabilities at the end of ED visit. But it is possible that the probabilities could have been completed after initial assessment before test results were reported, particularly when transferring care at the end of their shift. When examining the actual disposition decision making by emergency physicians, we analyzed whether the referral was appropriate and timely only among patients with serious outcomes after ED disposition and not among those without serious outcomes. For patients without serious outcomes after ED disposition, we report the proportion referred only to illustrate emergency physician disposition decision making. As the majority of patients were discharged directly from the ED and had no further follow-up, confirmation for the etiology of syncope was unavailable.

Conclusions

This multicenter syncope study finds that a significant proportion of patients, who suffer serious outcomes after ED disposition, suffer outside the hospital due to challenges in risk prediction among emergency physicians. There are wide variations in ED management of syncope that are not explained by patient characteristics. We believe that a robust risk tool could optimize ED management including investigations, risk perception and discharge decision making for syncope patients.

Acknowledgments We acknowledge members of our research team: Pam Ladouceur RN, Mackenzie Eaton RN, Sarah Gaudet RN, Karen Pratt RN, Dr. Muhammad Mukarram MBBS, MPH, Natacha Leduc, Soo-Min Kim BScH, Cynthia Campbell, Marco Guarino, My-Linh Tran, Sheryl Domingo, Catherine Clement RN and Angela Marcantonio for their help. Funding: this study was funded by grants from the Physicians Services Incorporated Foundation and the

Canadian Institutes of Health Research. Dr. Thiruganasambandamoorthy was supported by Heart and Stroke Foundation of Canada through the Jump Start Resuscitation Scholarship.

Conflict of interest None.

Ethical standard The study was approved by the hospital research ethics boards at all the study sites.

Appendix 1: definitions for outcome measures

The list of serious outcome measures collected and their definitions are detailed below:

a) *Death* related to a cause of syncope or due to unknown causes;

b) *Arrhythmias*:

- sustained (>30 s) or polymorphic ventricular tachycardia;
- sinus bradycardia <40 beats/min;
- sick sinus with alternating sinus bradycardia and tachycardia;
- sinus pause >3 s;
- Mobitz type II atrioventricular heart block;
- complete heart block or junctional/idioventricular rhythm;
- alternating left and right bundle branch block;
- symptomatic (light-headedness/dizziness, hypotension—systolic BP <90 mmHg) supraventricular tachycardia with rate >100/min;
- symptomatic atrial flutter or fibrillation with fast (>100/min) or slow (RR interval >3 s) ventricular rate;
- pacemaker or implantable cardioverter-defibrillator (ICD) malfunction with cardiac pauses, or
- an abnormal electrophysiological study (corrected sinus node recovery time >550 ms; his-ventricular intervals >100 ms; inducible ventricular tachycardia for >30 s; polymorphic ventricular tachycardia/ventricular fibrillation in patients with Brugada or ventricular dysplasia or previous cardiac arrest; symptomatic supraventricular tachycardia, or infra-Hisian block);

c) *Myocardial infarction*: defined as a clinically important elevation in troponin or ECG change and must have been confirmed by the emergency physician or cardiologist or the most responsible physician;

d) *Serious structural heart disease*:

- aortic stenosis with valve area ≤ 1 cm^2;
- hypertrophic cardiomyopathy with outflow tract obstruction;
- left atrial myxoma or thrombus with outflow tract obstruction; or
- pericardial effusion with ventricular wall motion abnormalities or pericardial tamponade;

e) *Aortic dissection*—confirmed by computerized tomography of the chest, trans-esophageal echocardiogram, MRI or angiography;

f) *Pulmonary embolism*—confirmed by ventilation-perfusion (VQ) scan, computed tomography scan of the chest or angiography;

g) *Severe pulmonary artery hypertension*—detected by cardiac catheterization or echocardiography with a mean pulmonary arterial pressure >30 mmHg and was responsible for the syncope;

h) *Subarachnoid hemorrhage*—confirmed by computed tomography/magnetic resonance imaging of the brain with or without spinal fluid analysis by lumbar puncture;

i) *Significant hemorrhage*—defined as syncope associated with detected source of bleeding such as gastrointestinal bleeding, ruptured abdominal aortic aneurysm, or ectopic pregnancy that is clinically significant to cause syncope in the opinion of the treating physician or that required transfusion;

j) *Any other serious condition*: includes conditions such as ectopic pregnancy, pneumothorax, sepsis that will require treatment and will cause the patient to return to the emergency department if not detected;

k) *Procedural interventions*—any interventions used to treat a cause of syncope. The procedural interventions include pacemaker and/or defibrillator insertion, cardioversion for arrhythmias, surgery for valvular heart disease, dialysis for electrolyte abnormalities causing arrhythmia, chest tube/pig tail catheter insertion for pneumothorax or pleural effusion, or surgery for abdominal aortic aneurysm or ruptured spleen.

Appendix 2

See Table 4.

Table 4 Characteristics of 1062 potentially eligible syncope patients not enrolled in the study

Characteristic	Patients no. (%)
Age (mean, SD) (in years)	56.3 (22.8)
Age (range) (in years)	16–99
Female	580 (54.6)

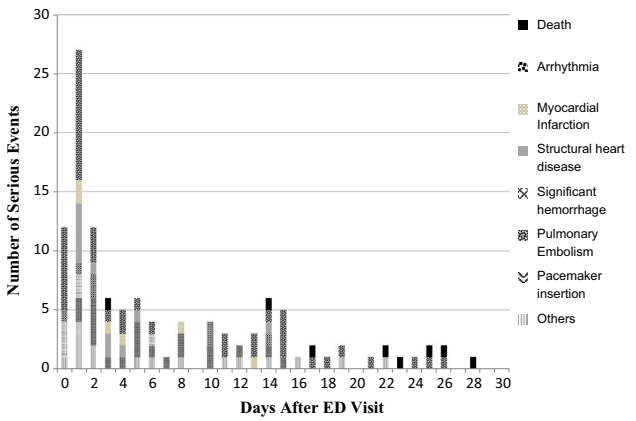
Appendix 3

See Table 5.

Table 5 Characteristics of 297 study patients lost to follow-up

Characteristic	Patients no. (%)
Age (mean, SD) (in years)	42.9 (20.1)
Age (range) (in years)	17–101
Female	176 (59.3)
Arrival by ambulance	208 (70.0)
Witnessed syncope	215 (72.4)
Medical history	
Hypertension	40 (13.5)
Diabetes	10 (3.4)
Coronary artery disease	15 (5.1)

Appendix 4: timing of occurrence of 30 day serious outcomes among syncope patients after emergency department disposition



Among 120 patients who suffered serious outcomes after ED disposition, the specific time of of serious outcome within 30-days was known for 116 patients

References

1. Sun BC, Thiruganasambandamoorthy V, Cruz JD (2012) Consortium to standardize ED syncope risk stratification, reporting. standardized reporting guidelines for emergency department syncope risk-stratification research. Acad Emerg Med 19(6):694–702
2. Soteriades ES, Evans JC, Larson MG et al (2002) Incidence and prognosis of syncope. N Engl J Med 347(12):878–885
3. Colman N, Nahm K, Ganzeboom KS et al (2004) Epidemiology of reflex syncope. Clin Auton Res 14(Suppl 1):9–17
4. Sun BC, Emond JA, Camargo CA Jr (2004) Characteristics and admission patterns of patients presenting with syncope to U.S. emergency departments, 1992–2000. Acad Emerg Med 11(10):1029–1034
5. Kapoor WN (1990) Evaluation and outcome of patients with syncope. Medicine 69(3):160–175
6. Costantino G, Perego F, Dipaola F et al (2008) Short- and long-term prognosis of syncope, risk factors, and role of hospital admission: Results from the STePS (short-term prognosis of syncope) study. J Am Coll Cardiol 51(3):276–283
7. Quinn JV, Stiell IG, McDermott DA, Sellers KL, Kohn MA, Wells GA (2004) Derivation of the San Francisco syncope rule to predict patients with short-term serious outcomes. Ann Emerg Med 43(2):224–232
8. Martin TP, Hanusa BH, Kapoor WN (1997) Risk stratification of patients with syncope. Ann Emerg Med 29(4):459–466
9. Thiruganasambandamoorthy V, Hess EP, Turko E, Perry JJ, Wells GA, Stiell IG (2013) Outcomes in Canadian emergency department syncope patients—are we doing a good job? J Emerg Med 44(2):321–328
10. Reed MJ, Newby DE, Coull AJ, Prescott RJ, Jacques KG, Gray AJ (2010) The ROSE (risk stratification of syncope in the emergency department) study. J Am Coll Cardiol 55(8):713–721
11. Thiruganasambandamoorthy V, Hess EP, Alreesi A, Perry JJ, Wells GA, Stiell IG (2010) External validation of the San Francisco syncope rule in the Canadian setting. Ann Emerg Med 55(5):464–472
12. Quinn J, McDermott D, Stiell I, Kohn M, Wells G (2006) Prospective validation of the San Francisco syncope rule to predict patients with serious outcomes. Ann Emerg Med 47(5):448–454
13. Grossman SA, Fischer C, Lipsitz LA et al (2007) Predicting adverse outcomes in syncope. J Emerg Med 33(3):233–239
14. Blanc JJ, L'Her C, Touiza A, Garo B, L'Her E, Mansourati J (2002) Prospective evaluation and outcome of patients admitted for syncope over a 1 year period. Eur Heart J 23(10):815–820
15. Cosgriff TM, Kelly AM, Kerr D (2007) External validation of the San Francisco syncope rule in the Australian context. CJEM Can J Emerg Med Care 9(3):157–161
16. Ben-Chetrit E, Flugelman M, Eliakim M (1985) Syncope: a retrospective study of 101 hospitalized patients. Isr J Med Sci 21(12):950–953
17. Quinn J, McDermott D (2007) External validation of the San Francisco syncope rule. Ann Emerg Med 50(6):742–743
18. Sun BC, Mangione CM, Merchant G et al (2007) External validation of the San Francisco syncope rule. Ann Emerg Med 49(4):420–427
19. Birnbaum A, Esses D, Bijur P, Wollowitz A, Gallagher EJ (2008) Failure to validate the San Francisco syncope rule in an independent emergency department population. Ann Emerg Med 52(2):151–159
20. Quinn JV, Stiell IG, McDermott DA, Kohn MA, Wells GA (2005) The San Francisco syncope rule vs physician judgment and decision making. Am J Emerg Med 23(6):782–786
21. Hoefnagels WA, Padberg GW, Overweg J, van der Velde EA, Roos RA (1991) Transient loss of consciousness: the value of the history for distinguishing seizure from syncope. J Neurol 238(1):39–43
22. Moya A, Sutton R, Ammirati F et al (2009) Guidelines for the diagnosis and management of syncope (version 2009). Eur Heart J 30(21):2631–2671. doi:10.1093/eurheartj/ehp298. [Epub 2009 Aug 27 2009;30(12)]
23. Ammirati F, Colivicchi F, Santini M (2000) Diagnosing syncope in clinical practice. Implementation of a simplified diagnostic algorithm in a multicentre prospective trial—the OESIL 2 study (osservatorio epidemiologico della sincope nel lazio) [see comment]. Eur Heart J 21(11):935–940
24. Shen WK, Decker WW, Smars PA et al (2004) Syncope evaluation in the emergency department study (SEEDS): a multidisciplinary approach to syncope management. Circulation 110(24):3636–3645