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Do serial troponins predict the need for cardiac evaluation in trauma patients after ground-level fall?

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ABSTRACT

Purpose Troponin T levels are routinely checked in trauma patients after experiencing a ground-level fall to identify potential cardiac causes of syncope. An elevated initial troponin prompts serial testing until the level peaks. However, the high sensitivity of the test may lead to repeat testing that is of little clinical value. Here, we examine the role of serial troponins in predicting the need for further cardiac workup in trauma patients after sustaining a fall.

Methods Retrospective review of all adult trauma activations for ground-level fall from January 1, 2021 to December 31, 2021 in patients who were hemodynamically and neurologically normal at presentation. Outcomes evaluated included need for cardiology consult, admission to cardiology service, outpatient cardiology follow-up, cardiology intervention and in-hospital mortality.

Results There were 1555 trauma activations for ground-level fall in the study period. The cohort included 560 patients evaluated for a possible syncopal fall, hemodynamically stable, Glasgow Coma Scale score of 15, and with a troponin drawn at presentation. The initial median troponin was 20 ng/L (13–37). Second troponin values were drawn on 58% (median 33 ng/L (22–52)), with 42% of patients having an increase from first to second test. 29% of patients had a third troponin drawn (median 42 ng/L (26–67)). The initial troponin value was significantly associated with undergoing a subsequent echo (p=0.01), cardiology consult (p<0.01), admission for cardiac evaluation (p<0.01), cardiology follow-up (p<0.01), and in-hospital mortality (p=0.01); the initial troponin was not associated with cardiac intervention (p=0.91). An increase from the first to second troponin was not associated with any of outcomes of interest. Analysis was done with cut-off values of 30 ng/L, 50 ng/L, 70 ng/L, and 90 ng/L; a troponin T threshold of 19 ng/L was significant for cardiology consult (p=0.01) and cardiology follow-up (p=0.04). When the threshold was increased to 50 ng/L, it was also significant for admission for cardiac issue (p<0.01). When the threshold was increased to 90 ng/L, it was significant for the same three outcomes and in-hospital mortality (p=0.04).

Conclusion The initial serum troponin has clinical value in identifying underlying cardiac disease in patients who present after ground-level fall; however, that serial testing is likely of little value. Further, using a cut-off of >50 ng/L as a threshold for further clinical evaluation would improve the utility of the test and likely reduce unnecessary hospital stays and costs for otherwise healthy patients.

Level of evidence Level III.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ The medical workup for patients after a syncopal fall and identification of any contributing modifiable diseases is challenging, time-consuming, and expensive. Serum troponin tests are widely used to evaluate for cardiac causes of syncope but high sensitivity of the test may lead to further workup and tests that contribute to prolonged hospital stays and increased costs.

WHAT THIS STUDY ADDS

⇒ An initial serum troponin has clinical value in identifying cardiac syncope, but serial testing is of little value. Further, current tests are likely too sensitive for this purpose, so higher thresholds should be established.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The use of serum troponin testing in patients who fall can be safely narrowed. This has the potential to significantly reduce hospital costs.

INTRODUCTION

Falls are the most common mechanism of injury in US trauma centers,[1] with an estimated annual cost of US$50 billion in 2015.[2] The majority of patients who present after ground-level fall are not injured.[1] However, a subset of patients have life-threatening injuries that must be rapidly identified, and in some, the fall is a symptom of an underlying illness that must be identified to prevent further complications.[3] Given the increasing prevalence of falls in our aging population, modest improvements in the evaluation have the potential to improve both patient care and reduce healthcare costs.

The initial goals in the evaluation of a patient after ground-level fall are twofold, to rapidly identify and treat injuries, and to determine the cause of the fall. Falls are classically divided into mechanical (eg, tripping over a rug in the dark) and syncopal in etiology (a loss of consciousness leading to fall). For syncopal or pre-syncopal falls, 10% are estimated to be from a cardiac etiology. It is critically important to identify this group as they have the greatest association with subsequent sudden cardiac death.[4 5 6] Thus, many institutions have developed a 'syncopal workup' protocol which is applied liberally in patients with any suspicion of syncope.[7]

At our urban level 1 trauma center, all patients with suspected syncope after fall undergo a full history and physical examination, ECG, chest

X-ray, and basic laboratory testing including troponin level testing using a highly sensitive assay. Some of these patients also undergo transthoracic echocardiography (TTE). Patients with an initial serum troponin T level above the laboratory-defined normal value (19 ng/L) have repeat levels drawn every 4–6 hours until the troponin level peaks. This practice for the troponin levels was adapted from the approach to patients with concern for non-ST-elevation myocardial infarction. However, although elevated troponins have been shown to be associated with increased adverse events after syncope,[8] the optimum use of serum troponin levels in patients after ground-level fall is not well defined. Therefore, the aims of our study were (1) to understand the relationship between initial troponin level and need for further cardiac workup or adverse cardiac outcomes, (2) to understand the impact of serial troponin values on the same outcomes, and (3) to clarify the relative association of higher cut-off troponin values with the outcomes of interest.

METHODS

Study design and population

This study is a retrospective review of adult patients (age >18 years) who presented to a single urban level 1 trauma center after ground-level fall between January 1, 2021 and December 31, 2021 with a systolic blood pressure of >90 mm Hg, Glasgow Coma Scale (GCS) score of 15 at presentation and suspected of syncopal fall. This group was selected as these are the patients in whom an improved understanding of the utility of troponin values would have the greatest impact on clinical management. Patients who were hemodynamically unstable or with GCS score of <15 were excluded.

Data collection

All trauma patients are prospectively enrolled in our institutional trauma registry by dedicated nursing staff. The trauma registry was queried and data including patient age, gender, dates of admission and discharge, vital signs upon trauma surgery evaluation, health conditions, cardiac enzymes, GCS and Injury Severity Scale scores were collected. Retrospective chart review was done by the authors to obtain additional data including serial troponin values, reason for admission, cardiac procedure, in-hospital mortality and need for cardiology follow-up or intervention. Admission for a cardiac issue included all patients admitted to cardiology or medicine and followed by cardiology for the primary concern being workup, diagnosis, or treatment of a cardiac issue. Cardiac intervention includes any procedure done during the hospital encounter or 2 years after discharge. Additional patient factors collected included: chest pain on presentation concerning for cardiac etiology and history of cardiac problem (included in this variable is arrhythmia, coronary artery disease, congestive heart failure, valve abnormality, or history of pacemaker). Missing data points were rare (<1%) and assumed to be missing at random.

Criteria for defining results of diagnostic tests

Our institution standard is to use a highly sensitive troponin assay with abnormal serum troponin T defined as >19 ng/L per institutional standards. Our institutional protocol is to obtain initial troponin on all patients concerning for syncopal fall and then repeat test if elevated (>19 ng/L) until it peaks or downtrends. Initial ECGs were independently reviewed by two blinded physicians (ARB and JTR) with conflicts resolved through consensus. ECGs were considered 'abnormal' if they showed atrial fibrillation with rapid ventricular response, ST changes, right or left bundle branch blocks, bradycardia (heart rate <50), sinus pause (>3 s), Mobitz II or third-degree atrioventricular block, or supraventricular tachycardia. As this study was designed to inform the evaluation of stable patients upon presentation to the emergency department, we considered all bundle branch blocks to be concerning, even if they were later found in prior records.

Table 1 Characteristics of study patients

	N (%)	Initial troponin T median (IQR)
Patients	560	20 ng/L (13–37)
Age (years), median (IQR)	77 (69–84)	
Women	280 (50)	
ISS, median (IQR)*	9 (4–10)	
Chest pain	47 (8)	
Cardiac history	291 (52)	
Arrhythmia	170 (58)	
CAD	137 (47)	
CHF	97 (33)	
Pacemaker	50 (17)	
Valve abnormality	40 (14)	
Chronic kidney disease	96 (17)	45 ng/L (25–73)
Abnormal ECG	123 (22)	19 ng/L (14–34)
Abnormal TTE	128 (23)	32 ng/L (18–58)
Outcomes		
TTE	286 (51)	22 ng/L (14–42)
Cardiology consult	80 (14)	31 ng/L (17–59)
Admit for cardiac issue	52 (9)	26 ng/L (16–71)
New diagnosis	23 (8)	30 ng/L (15–104)
Cardiac intervention	35 (6)	21 ng/L (14–34)
Cardiology follow-up	86 (15)	29 ng/L (16–54)
In-hospital mortality	10 (2)	39 ng/L (28–93)

*Only calculated for inpatients.
CAD, coronary artery disease; CHF, congestive heart failure; ISS, Injury Severity Scale; TTE, transthoracic echocardiography.

Statistical analysis

Statistical analysis was performed in SAS Studio (V.9.1). Yields were reported as percentages. Univariate analysis was completed with two-sided Mann-Whitney Wilcoxon test. Multiple linear regression was performed for determining odds ratios (OR). A p value of <0.05 was used to indicate statistical significance. Clinically relevant variables were evaluated with exploratory univariate analysis. To identify independent predictors of the outcomes, we performed multiple logistic regression using all statistically significant predictor variables identified on univariate analysis. Troponin cut-offs were developed based on the institution's normal value of <19 ng/L and evaluated every 10-point increase to identify thresholds that were statistically significant for the outcomes.

RESULTS

There were 1555 trauma activations for ground-level fall in the study period. Of these, 322 patients were not hemodynamically stable or had a GCS score less than 15 and were excluded. 673 patients had a mechanical fall, did not receive a syncopal workup and were excluded. The study population was 560 patients who had a possible syncopal fall with initial troponin level drawn. Characteristics of the group are presented in table 1. The syncopal group included 50% women, 70% white with a median

Table 2 Individual troponin value analysis

	TTE	Cardiology consult	Admission for cardiac issue	Cardiac intervention	Cardiology follow-up	In-hospital mortality
Troponin 1*	**p=0.01**	**p<0.01**	**p<0.01**	p=0.91	**p<0.01**	**p=0.01**
Troponin 2*	p=0.18	**p<0.01**	**p=0.02**	p=0.81	**p=0.02**	p=0.14
Troponin 3*	p=0.5	**p=0.01**	p=0.08	p=0.38	p=0.8	p=0.57
Troponin 2 inc/dec from troponin 1†	1 (0.6–1.5) p=0.9	1.2 (0.7–2.2) p=0.46	1.9 (0.9–3.9) p=0.08	1.2 (0.5–2.9) p=0.66	1.5 (0.9–2.7) p=0.14	0.3 (0–2.8) p=0.3

statistically significant p-values bolded
*Two-sided Mann-Whitney Wilcoxon.
†Logistic regression with OR.
TTE, transthoracic echocardiography.

age of 77 years (69–84) and median Injury Severity Scale score for admitted patients of 9 (4–10). 52% of the patients had a cardiac history (most commonly arrhythmia 58%, coronary artery disease 47%, and congestive heart failure 33%). 17% of patients had known chronic kidney disease.

A normal troponin at our institution was ≤19 ng/L. The initial median troponin T was 20 ng/L (13–37). 58% patients had a second troponin drawn (median 33 ng/L (22–52)), with 42% of patients having an increase from first to second test. 29% of patients had a third troponin drawn (median 42 ng/L (26–67)). Of these patients, 51% received TTE, 14% received a cardiology consult within 24 hours of admission, 9% were admitted for a cardiac diagnosis (44% for a new diagnosis), 6% had a cardiac intervention within 2 years after the fall, 15% needed cardiology follow-up, and in-hospital mortality was 2%. The initial median troponin T for each outcome variable is shown in table 2.

The value of the initial troponin T was significantly associated with performance of a TTE (p=0.01), cardiology consult (p<0.01), admission for cardiac issue (p<0.01), cardiology follow-up (p<0.01), and in-hospital mortality (p=0.01), but not cardiac intervention (p=0.91) (table 2). To evaluate the impact of serial troponin T values on the outcomes, univariate analysis was done for the second and third troponins (table 2). The second troponin value was statistically significant for admission for cardiac issue (p=0.02) and need for cardiology follow-up (p=0.02). The second and third troponins were significant for need for cardiology consult (p<0.01, p=0.01). An increase from the first to second troponin was not associated with any of outcomes of interest.

To further evaluate if troponin T levels were associated with need for further cardiac workup or adverse outcomes, multiple logistic regression modeling was done. Given troponin is renally excreted, presence of chronic kidney disease was controlled for in the models. Other variables included initial troponin, abnormal ECG, age, chest pain and cardiac history. When controlling for these other factors, increasing initial troponin T was only significantly associated with cardiology consult (p=0.02). The remainder of the results are shown in table 3.

To determine if there was a troponin T threshold that could have more utility in clinical outcomes, analysis was done for a variety of thresholds including: 19 ng/L, 30 ng/L, 50 ng/L, 70 ng/L, and 90 ng/L. Multiple logistic regression modeling was performed to compare the odds of the event happening with varying thresholds. The model also included abnormal ECG, age, chronic kidney disease, chest pain and cardiac history. Results with OR and p values are in table 4. A troponin T threshold of 19 ng/L was significant for cardiology consult (p=0.01) and cardiology follow-up (p=0.04). When the threshold was increased to 50 ng/L, it was also significant for admission for cardiac issue (p<0.01). When the cut-off was 90 ng/L, it was significant for the same three outcomes and in-hospital mortality (p=0.04). None of the cut-offs were significant for need of TTE or cardiac intervention. However, cardiac history was significant for TTE (p=0.01) at all troponin cut-offs. Abnormal ECG (p<0.01), cardiac history (p=0.03), and age (p=0.01) were significant for cardiac intervention at all troponin levels.

DISCUSSION

In this study, we found that in patients with suspicion of syncopal fall or unknown etiology of the fall (such as those unwitnessed), increasing initial troponin level was associated with the need for further cardiac workup, cardiology consultation, admission for a cardiac workup, in-hospital mortality, and cardiology follow-up after discharge. Further, serial troponin testing appears to offer little incremental diagnostic benefit as there was no association between the second or third troponin and the outcome measures. Finally, we found that a troponin T cut-off of 50 ng/L (compared with our current approach of 19 ng/L) was more closely associated with clinically meaningful outcomes and a cut-off of 90 ng/L was associated with in-hospital mortality.

Table 3 Multivariate analysis of initial troponin and clinical presentation with outcomes

	TTE OR (95% CI)	Cardiology consult OR (95% CI)	Admission for cardiac issue OR (95% CI)	Cardiac intervention OR (95% CI)	Cardiology follow-up OR (95% CI)	In-hospital mortality OR (95% CI)
Initial troponin	1 (0.9 to 1) p=0.5	1 (1 to 1) **p=0.02**	1 (1 to 1) p=0.08	1 (0.9 to 1) p=0.97	1 (0.9 to 1) p=0.3	1 (0.9 to 1) p=0.97
Chest pain	1.1 (0.6 to 2) p=0.8	4.2 (2 to 8.9) **p<0.01**	4 (1.7 to 9.3) **p<0.01**	1 (0.3 to 3.8) p=0.9	2.2 (0.9 to 4.8) p=0.053	1.2 (0.1 to 10) p=0.9
Cardiac history	1.7 (1.1 to 2.4) **p=0.01**	3.6 (1.9 to 6.7) **p<0.01**	4 (1.8 to 8.7) **p<0.01**	2.6 (1.1 to 6.1) **p=0.03**	4.6 (2.5 to 8.7) **p<0.01**	7.3 (0.9 to 60.2) p=0.07
Abnormal ECG	1.2 (0.8 to 1.8) p=0.5	2.8 (1.6 to 4.9) **p<0.01**	3.6 (1.9 to 6.8) **p<0.01**	4.3 (2.1 to 9) **p<0.01**	3.4 (2 to 5.8) **p<0.01**	0.3 (0.03 to 2.2) p=0.2
Age	1 (0.9 to 1) p=0.2	1 (0.99 to 1) p=0.8	0.9 (0.95 to 0.99) **p=0.04**	0.9 (0.94 to 0.99) **p=0.01**	0.9 (0.9 to 1) p=0.3	1 (0.9 to 1) p=0.2
CKD	1.4 (0.9 to 2.3) p=0.2	1.1 (0.6 to 2.1) p=0.7	1.7 (0.8 to 3.4) p=0.17	0.7 (0.3 to 2.1) p=0.5	1.7 (0.9 to 3.2) p=0.06	2.1 (0.5 to 8.2) p=0.3

Bolded p-values are statistically significant.
CKD, chronic kidney disease; TTE, transthoracic echocardiography.

Table 4 Troponin T cut-off multivariate regression

	TTE OR (95% CI)	Cardiology consult OR (95% CI)	Admission for cardiac issue OR (95% CI)	Cardiac intervention OR (95% CI)	Cardiology follow-up OR (95% CI)	In-hospital mortality OR (95% CI)
Troponin T >19 ng/L	1.1 (0.8 to 1.6) p=0.6	2.2 (1.2 to 4) **p=0.01**	1.7 (0.8 to 3.4) p=0.2	1 (0.5 to 2.2) p=0.9	1.8 (1 to 3.3) **p=0.04**	3.6 (0.4 to 30.7) p=0.2
Troponin T >30 ng/L	1.2 (0.8 to 1.8) p=0.4	2.4 (1.4 to 4.1) **p<0.01**	1.8 (0.9 to 3.5) p=0.08	1.2 (0.5 to 2.6) p=0.7	1.8 (1.1 to 3.2) **p=0.03**	2.6 (0.6 to 11) p=0.2
Troponin T >50 ng/L	1.5 (0.9 to 2.6) p=0.1	2.8 (1.5 to 5.3) **p<0.01**	3 (1.4 to 6.4) **p<0.01**	1.7 (0.6 to 4.4) p=0.3	2 (1 to 3.7) **p=0.04**	1.2 (0.3 to 5.5) p=0.8
Troponin T >70 ng/L	1.4 (0.7 to 2.6) p=0.3	3.3 (1.6 to 6.9) **p<0.01**	5.2 (2.3 to 11.8) **p<0.01**	1.7 (0.5 to 5.5) p=0.4	2.4 (1.1 to 5) **p=0.02**	2.8 (0.6 to 12.6) p=0.2
Troponin T >90 ng/L	1.6 (0.8 to 3.5) p=0.2	5.3 (2.4 to 12) **p<0.01**	5 (2.1 to 12.2) **p<0.01**	0.9 (0.2 to 4.4) p=0.9	3.3 (1.5 to 7.6) **p<0.01**	4.9 (1.1 to 22.8) **p=0.04**

Model includes worrisome ECG, age, chest pain, cardiac history and CKD history.
TTE significant: cardiac history; Cardiac intervention significant: worrisome ECG, cardiac history and age.
Bolded p-values are statistically significant
CKD, chronic kidney disease; TTE, transthoracic echocardiography.

In the last decade, many hospital systems have changed the cardiac markers they obtain to high-sensitivity troponin I and T. Data on the use of high-sensitivity troponin in patients who are not having a myocardial infarction are limited, particularly in the identification of cardiac causes of syncopal ground-level falls. One study found that an elevated troponin I level was associated with 1.9 times the odds of a 30-day serious event occurring in older patients after syncope.[8] However, in a study of elderly patients admitted after a syncopal episode, 95% had cardiac enzymes measured, but it only impacted diagnosis in 2% and management in only 1% of the cases.[9] Ultimately, both the American College of Cardiology/American Heart Association/Heart Rhythm Society,[10 11] and European Society of Cardiology guidelines[12] recommend against routine comprehensive laboratory testing and could not make a recommendation on the utility of high-sensitivity troponin given uncertain clinical utility after a suspected syncopal episode.

Our data suggest that the utility of a troponin T level drawn after a suspected syncopal episode varies depending on the test value threshold used to prompt further evaluation. Our findings support increasing the threshold of the initial troponin value for pursuing additional cardiac testing and consultations for patients undergoing trauma evaluations after ground-level falls. Specifically, the increase from a cut-off of 19 ng/L to 50 ng/L would result in no significant adverse outcomes and eliminate unnecessary, costly additional investigations. In contrast, a mildly elevated initial test introduces spurious data into the diagnostic process, potentially leading to additional testing, specialist consultation, prolonged emergency department stays, and unnecessary admissions. The current generation of troponin tests appears too sensitive to use a standard laboratory threshold for abnormal values (19 ng/L), but that a higher threshold (50 ng/L) should be considered for trauma patient populations undergoing syncope evaluations.

Given the size of our patient cohort, the findings are likely generalizable across hospital systems using a similar high-sensitive troponin test. However, this work represents a single-center experience. All clinical laboratory testing in chemiluminescence immunoassay-certified laboratories is required to be locally validated. As such, before implementing local practice change at individual hospital systems, best practice in clinical laboratory medicine would recommend establishing local validation in individual centers based on the specific assay used.

Regarding repeated testing, our data suggest that the most value resides in the initial test and subsequent repeat tests are of little added clinical utility for determining care pathways. Specifically, we found that if the second troponin increased from the first, there was not association with any of the outcomes. The cost of a single high-sensitivity troponin test is modest in US healthcare terms (approximately $250). When one considers the number of patients evaluated for ground-level falls across the USA annually, the cost savings to the healthcare system would be substantial. Thus, we would recommend against repeating troponin tests as a routine for otherwise asymptomatic trauma patients with mildly elevated initial troponins that do not meet the threshold of 50 ng/L.

This study has several strengths. To the best of our knowledge, this is the first study to address the utility of serial troponin T testing in patients with concern for syncope post-fall and the first to examine the potential to define a more clinically useful threshold for concern. Historical cut-off values predate the current high-sensitivity troponin assays and thus, may inadvertently be introducing unnecessary, costly workups. Developing a more relevant cut-off is possible given the large sample size of this study. This cohort of elderly, hemodynamically stable patients on presentation for initial evaluation is important to interpreting the study implications. The focus on those who seemingly appear well is a strength as these are often the most difficult patients to determine how much investigation is prudent. Surprisingly, we still found a 2% inpatient mortality associated with these initially well-appearing patients and a reasonable rate of worrisome cardiac disease. The large size of the cohort makes generalizability to other centers more applicable than would be typical for single-center studies.

There are notable limitations to this study. First, this study focused on a group of patients who were hemodynamically stable with a GCS score of 15, limiting the generalizability of the results to other patient populations. The retrospective nature of the study limits the understanding of every clinical factor that influenced decision-making. Importantly, two of the outcomes that we describe, TTE and cardiology consultation, are ordered at the discretion of the evaluating trauma team and may be influenced by the results of the troponin tests. Thus, our conclusions rest on the remaining outcomes (admission for cardiac issue, need for cardiac intervention, cardiology follow-up, and in-hospital mortality) that are likely distinct from the troponin level and the trauma team's discretion. Also, this is a retrospective review and this new troponin cut-off will need to be validated in a separate database. In addition, the calibration of troponin testing likely varies slightly between assays used at each institution. Thus, we advocate that institutions re-evaluate their own cut-offs to determine if this absolute threshold is relevant for their specific troponin assay.

CONCLUSIONS

We found that the initial serum troponin does have clinical value in identifying and underlying cardiac issue in patients who

present after ground-level fall; however, serial troponin testing is likely of little value. Further, we demonstrated that using a cut-off of >50 ng/L as a marker of clinical concern would improve the utility of the test and likely reduce unnecessary delays in the care of otherwise healthy patients.

Contributors ARB, JTR, AJR and RAC conceived of the study. ARB, JTR, ML and SP performed the chart review. ARB, JTR, AJR and RAC performed the analysis and interpreted the results. All authors contributed to article writing and critical reviews of the article. RAC is the guarantor of this article and accepts full responsibility for the work and/or the conduct of the study, had access to the data, and controlled the decision to publish.

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Competing interests None declared.

Patient consent for publication Not applicable.

Ethics approval This study was exempted by the University of California Davis Institutional Review Board (IRB# 2016588-1).

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Data availability statement Data are available upon reasonable request. Deidentified data are available on reasonable request.

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