The Vulnerable Elders Survey-13 Predicts Hospital Complications and Mortality in Older Adults with Traumatic Injury: A Pilot Study

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OBJECTIVES: To determine whether the Vulnerable Elders Survey (VES)-13, a survey based on functional status that has been validated in uninjured older populations, will predict complications and mortality in injured older adults.

DESIGN: Prospective observational pilot study.

SETTING: Level 1 trauma center.

PARTICIPANTS: Sixty-three older adults (≥65) with a traumatic injury who survived and required inpatient care for at least 24 hours.

MEASUREMENTS: Predictor: preinjury VES-13 score (0–10 points, higher = greater risk) obtained by interviewing participants or proxies. Outcomes: composite outcome of one or more medical complications (e.g., aspiration pneumonia, respiratory failure) or death, discharge destination (home, nursing home, death), length of stay, hospital charges. Covariates: Charlson Comorbidity Index (CCI), Injury Severity Score (ISS), and sex.

RESULTS: Of the 63 participants, 30 (48%) were discharged to home and 28 (44%) to a nursing facility, 21 (33%) developed one or more complications, and four (6%) died. In a model that also controlled for ISS and comorbidity, each additional VES-13 point was associated with greater risk of complication or death (odds ratio = 1.53 per point, 95% confidence interval = 1.12–2.07).

CONCLUSION: The VES-13, in combination with injury severity, may be useful early in the hospital course to predict complications and death in older adults with traumatic injury, potentially identifying candidates who may benefit from additional inpatient geriatric services. **J Am Geriatr Soc 59:1471–1476, 2011.**

Key words: trauma; acute surgical care; functional status

With continued aging of the population, traumatic injuries sustained by older adults are increasingly common.[1] Death due to traumatic injury is twice as likely at age 75 (20%) as at age 45 (10%),[2] and mortality in older adults (aged 65 and older) is more than twice that of younger adults (<65) for motor vehicle accidents, falls, pedestrian accidents, and penetrating injuries.[2] Older adults also use disproportionate levels of hospital care and have greater morbidity and mortality than younger adults with similar injury severity.[3–5]

The geriatric population is heterogeneous in its vulnerability to deterioration in health[6] and ability to recover from injury.[7] Better identification of older adults at the highest risk for death, hospital complications, and resource utilization would allow for better targeting of inpatient interventions, for example, a focused geriatric program to reduce postoperative complications and facilitate discharge planning to posthospital settings. Of demographic and clinical characteristics (e.g., age, sex, comorbidity, injury severity, vital signs) tested in older adults, age and injury severity are the strongest predictors of survival.[3,5,7–13] The Injury Severity Score (ISS),[11] a measure of overall injury severity that includes injuries in multiple anatomic regions, is used universally and predicts survival even in older adults,[5,8,12,13] but the Eastern Association for the Surgery of Trauma has recommended against using the ISS in the clinical care of individuals because it is not available until after hospital discharge.[14]

Preinjury functional status of older adults, or a person's ability to perform daily activities, has predicted survival and healthcare utilization in acute[15,16] and outpatient settings.[17–19] Older individuals with higher functional status

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may be more resilient to physiological insult independent of their chronological age, for example, after hip fracture.[20] The Vulnerable Elders Survey (VES)-13, a simple function-based screening tool, was developed to predict the risk of death and functional decline in older adults.[17] Nonclinical personnel can administer it at bedside or over the telephone, and participants or proxy respondents can answer it within 5 minutes. The survey has been validated in ambulatory[17,18,21] and acute medical care settings.[22] It does not require knowledge of preexisting conditions. Because it can be obtained from participants or caregivers, it has the added advantage of being available at the time of admission. Whether preinjury functional status is predictive of hospital outcomes in an inpatient setting after serious traumatic injury has not been reported in the literature. It was hypothesized that the VES-13, a simple survey based on functional status and age, would predict hospital survival, discharge destination, and hospital complications in older adults with traumatic injury independent of traditional risk factors.

METHODS

This analysis was part of a larger study to implement a routine geriatric consultation for older adults with traumatic injury at an academic Level 1 trauma center (determined by state requirements for availability of trauma, neurosurgical, and orthopedic surgeons). The hospital has an annual trauma admission volume of approximately 1,000 patients, of whom 10% are aged 65 and older, three-quarters of whom are admitted for inpatient care. The local institutional review board approved this study.

All individuals aged 65 and older who met criteria for trauma team activation (blunt or penetrating mode of injury with suspicion of traumatic injury) and were hospitalized for 24 hours or longer were approached. If an eligible individual was unable to provide consent, possible proxy respondents who knew the individual well enough to answer questions about preinjury functional status were approached. The protocol included enrollment and interview within 48 hours of admission.

Individuals were interviewed using the VES-13,[17] which assigns points in four categories: activities of daily living (ADLs), common physical tasks, self-rated health, and age. For ADLs, presence of disability in any of five activities (shopping, managing money, light housework, bathing, or walking) is assigned 4 points (0 points for no disabilities). Disability is defined as requiring help or inability to perform the activity because of health reasons. For common physical tasks (stooping, crouching, or kneeling; walking one-quarter of a mile; lifting 10 pounds; heavy housework; reaching above shoulder level; writing or grasping small objects), 1 point is assigned for each task that a individual had a lot of difficulty or was unable to do, up to two tasks maximum. The individual's self-rated health is compared with that of others of the same age, with a response of fair or poor conferring 1 point. For the current study, the initial stem of these questions was modified to inquire about preinjury, rather than current, functional status.[16,22] Last, VES-13 confers points according to age category (75–84 = 1 point, $\geq$85 = 3 points). Total VES-13 score ranges from 0 (best prognosis) to 10 (worst prognosis). For older ambulatory care adults, scores of 3 or more represent a 4.2 greater 2-year risk of further functional decline and death than in those with scores of 2 or less.[17] This survey has been prospectively validated in outpatient populations over 1-year[18] and 5-year[21] intervals, with higher scores conferring a greater risk of declining or dying.

Covariates

The ISS was collected from the hospital trauma registry. The ISS[11] consists of a sum of squared severity ratings for the three most injured body regions, ranging from 0 to 75, with a scores of 16 and 25 considered moderate and severe overall injury, respectively. The Charlson Comorbidity Index (CCI) was collected using medical record abstraction for preexisting diabetes mellitus, respiratory disease, coronary artery disease (history of myocardial infarction, coronary artery bypass graft, percutaneous transluminal angioplasty, or angina pectoris), congestive heart failure, chronic kidney disease (moderate to severe), hypertension, cancer (local or disseminated), chronic liver disease, dementia, alcoholism, cerebrovascular accident, and current smoking.[23,24]

Outcome Variables

Death versus survival to discharge was collected from the hospital trauma registry as the primary outcome measure for all individuals aged 65 and older. Death or development of medical complication (vs survival with no complication), discharge to home (vs discharge to nursing or rehabilitation facility), hospital charges (dollars), and length of stay (LOS, in days) were considered as secondary measures. Posttrauma complications collected in the registry were acute renal failure, coma, cardiopulmonary resuscitation, decubitus ulcer, deep venous thrombosis, aspiration pneumonia, pneumonia, pulmonary embolism, respiratory failure, and hyponatremia.

Sensitivity Analyses Variables

In addition to the ISS, a physiological measure of injury severity, the Revised Trauma Score (RTS), calculated from hospital trauma registry data (blood pressure, respiratory rate, and Glasgow coma score) was also calculated.[25] Age (in years, rather according to age category as in the VES-13) was also considered separately from the VES-13; to do so, an alternative VES-13 score was recalculated without points awarded for age. Last, whether an individual received a major surgical procedure, which was also obtained from the trauma registry, was considered.

Analysis

Ordinary least squares regression was used to model continuous outcomes (log-transformed LOS and charges), logistic regression for dichotomous outcomes (death vs survival, development of each specific complication vs no complication, and complication or death vs no complications), and ordered logistic regression to evaluate hospital disposition (0 = survival to home discharge, the best outcome; 1 = survival to nursing facility or rehabilitation hospital discharge; 2 = death, the worst outcome).

All analyses were first performed using the VES-13 without adjustment, then multivariable analyses adjusting for ISS, CCI, and sex were performed. The first sensitivity

analysis compared RTS with VES-13 in predicting outcomes. Second, because age alone might be predictive of outcomes, the modified VES-13 score that did not account for age was tested, and age was added as a separate variable to the models. Third, the final analysis was stratified according to whether the individual received surgery. Last, the VES-13 was considered as a series of dummy variables to consider nonlinear effects.

Area under the receiver operating curve (AUC) was calculated for logistic regression models with and without VES-13 ($P < .05$). All analyses were performed using STATA 10 (StataCorp, College Station, TX).

RESULTS

From December 1, 2007, to July 31, 2009, 63 of 87 (72.4%) eligible participants were enrolled for participation. Mean age was 78, two-thirds were male, and nearly all were Caucasian and had blunt injuries. Mean VES-13 score was 2.8 ± 2.8, and mean ISS was 14.0 ± 9.2. One-third of the interviews were done with a proxy respondent. Individuals who were not enrolled (unable to identify appropriate proxy for 6, enrollment refused by 18) did not differ from the enrolled group with respect to age ($P = .40$), sex ($P = .40$), or ISS ($P = .90$), but nonwhite individuals were less likely to enroll than white individuals (40.0% vs 78.2%, $P = .002$) because of inability to locate an appropriate proxy (20.0% vs 4.2%, $P = .03$) and refusal to participate (40.0% vs 16.7%, $P = .04$).

Of the 63 participants, four died (6.4%), and 21 had complications (33.3%). All four participants who died also had at least one complication. Complications (Table 1) included pneumonia (19.0%); respiratory failure (9.5%); aspiration pneumonia (6.3%); pressure ulcer (3.2%); acute renal failure (3.2%); coma (3.2%); and pulmonary embolism, deep venous thrombosis, cardiopulmonary resuscitation, hyponatremia, and urinary tract infection (1.3% each).

The relationship between VES-13 and clinical outcomes is described in Table 1. Small sample size limited analysis of the individual specific complications, with higher VES-13 scores predicting development only of aspiration pneumonia (unadjusted odds ratio (OR) = 1.39, 95% confidence interval (CI) = 1.00–1.93), although the VES-13 predicted the composite outcome (any complication or death) in adjusted and unadjusted models. Each VES-13 point increased odds of complication by 1.53 (95% CI = 1.12–2.07). In the same model, ISS also predicted complication or death (OR = 1.2 per point). To put these odds into clinical perspective, a severely injured man with an ISS of 25 would be expected to have a 32% risk of complication or death if he had a preinjury VES-13 score of 0, 63% risk with a VES-13 score of 3, and 97% with a VES-13 score of 10 (Figure 1).

The AUC for the composite outcome model was excellent: 88.0% for the model with and 82.7% without the VES-13, a substantial improvement in outcome discrimination of 5.3 percentage points. The Hosmer-Lemeshow goodness-of-fit test did not suggest lack of fit (chi-square = 0.6). The results were robust to exclusion of the four individuals with the highest leverage (beta $< .05$, OR = 1.8, $P = .01$) and residuals (OR = 2.1, $P = .004$).

In this sample, there was a trend toward poorer discharge condition (Table 1) and longer length of hospitalization (Table 2) with higher VES-13 scores, but CIs were broad, and none were statistically significant at $P < .05$ but

Table 1. Relationship Between the Vulnerable Elders Survey (VES)-13 and Categorical Outcomes: Death, Complications, and Discharge Destination

Outcome	%	Mean VES-13 in Participants: With Outcome	Mean VES-13 in Participants: Without Outcome	Effect of Each Additional VES-13 Point: OR (95% Confidence Interval) Unadjusted	Effect of Each Additional VES-13 Point: OR (95% Confidence Interval) Adjusted*
Specific complications					
Coma	3.2%	5.5	2.8	1.33 (0.86–2.05)	
Acute renal failure	3.2%	3.5	2.8	1.09 (0.69–1.72)	
Pressure ulcer	3.2%	2.0	2.8	0.88 (0.48–1.63)	
Aspiration pneumonia	6.3%	5.8	2.6	1.39 (1.00–1.93)	1.97 (1.03–3.78)
Respiratory failure	9.5%	4.2	2.6	1.19 (0.90–1.55)	1.36 (0.95–1.94)
Pneumonia	19.0%	2.6	2.8	0.97 (0.84–1.28)	1.18 (0.88–1.59)
Death	6.3%	2.8	2.8	1.0 (0.69–1.43)	1.07 (0.66–1.73)
Any complication, including death†	33.3%	3.7	2.3	1.19 (1.01–1.48)	1.53 (1.12–2.07)
Discharge destination‡					
Home	47.6%	2.4			
Nursing or rehabilitation facility	44.4%	3.0		1.09 (0.92–1.29)‡	1.21 (0.99–1.48)‡
Death or hospice	7.9%	3.4			

* Adjusted for Injury Severity Score, sex, and Charlson Comorbidity Index. Results of the adjusted models for specific complications should be interpreted with caution because there were fewer than 5 events per predictor variable.

† Patients could have more than one specific complication.

‡ Discharge destination was an ordinal categorical outcome, with home considered as the best outcome, nursing or rehabilitation facility as the next worse outcome, and death or hospice as the worst outcome. The odds ratio (OR) reported for this ordinal logistic regression represents the greater odds of a poorer outcome (versus one better level of outcome) associated with each additional VES-13 point.

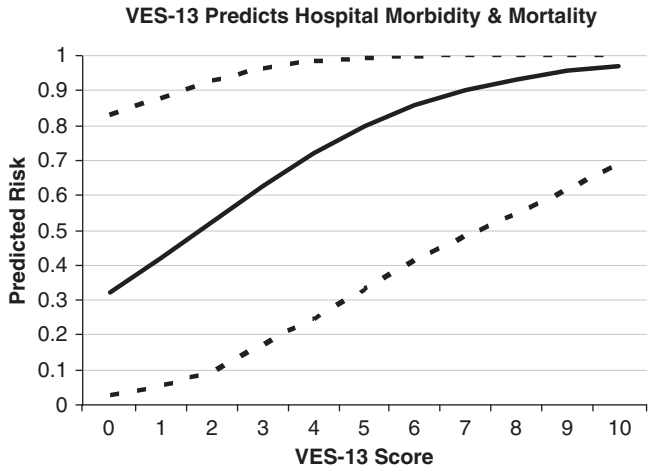

Figure 1. Relationship between the Vulnerable Elders Survey (VES)-13 and hospital morbidity and mortality. The VES-13 predicts hospital morbidity and mortality. The predicted risks of the composite outcome (development of a hospital complication or death) are plotted against the VES-13 score (solid line). Higher VES-13 scores represent greater risk. The dotted lines represent 95% confidence intervals (obtained by bootstrapping 1,000 times, percentile method). The model was adjusted for Injury Severity Score (ISS), Charlson Comorbidity Index, and sex. The displayed predicted risks are for a man with an ISS of 25 (severe injury) and no comorbidities.

the ISS predicted nearly all other outcomes of interest. Each ISS point was also related ($P < .05$) to greater odds of death (OR = 3.3), poorer discharge condition (OR = 1.2), increase in charges (8.1%), and longer LOS (4.8%). The RTS predicted death but not any of the other outcomes.

Sensitivity Analysis Results

Adding RTS or age in years to the model did not change the effect of the VES-13 on complications, and RTS and age variables were not significant predictors in the sensitivity analyses ($P = .3$, $P = .7$). When VES-13 was rescored without age category, similar results were seen. When the effect of VES-13 on complications could be nonlinear was considered, no increase in risk between scores of 0 and 1 was found (44% risk for both), but the risk increased linearly between 2 and 10 (70% risk for score of 2; 95% risk for score of 10). Using the originally published VES-13 cutoff score for vulnerability of 3 and an ISS cutoff score of 16, the predicted risks of complication ranged from 4% for a nonvulnerable woman with a nonsevere injury to 75% for a vulnerable woman with severe injury (Table 3).

Table 3. Predicted Risk of Hospital Complication or Death According to Sex, Vulnerability, and Injury Severity Score (ISS)

	% (95% CI)	
VES-13 Score[17]	ISS ≤15	ISS ≥16
Men		
≤2 (not vulnerable)	8.6 (0.2–18.8)	40.7 (10.4–70.0)
≥3 (vulnerable)	29.0 (3.6–59.3)	74.9 (44.3–97.8)
Women		
≤2 (not vulnerable)	3.8 (0–13.5)	22.7 (0.4–66.0)
≥3 (vulnerable)	14.8 (0.4–41.0)	56.0 (10.5–93.7)

Predicted risks are based on logistic regression model using dichotomous Vulnerable Elders Survey (VES)-13 score, dichotomous ISS score, sex, and comorbidity. Actual number of nonvulnerable subjects with low ISS, vulnerable with low ISS, nonvulnerable with high ISS, and vulnerable with high ISS were 12, 15, 13, and 13, respectively. Predicted risks were obtained by setting the sample to male and female for sex-specific estimates; 95% confidence intervals (CIs) were obtained using bootstrapping with replacement.

Of the 21 participants (33.3%) who had surgery, 10 (47.6%) developed one or more complications. Despite the smaller sample size, the VES-13 predicted complications (adjusted for ISS, CCI, and sex) in the 21 surgery participants (OR = 3.3, 95% CI = 1.1–10.2).

DISCUSSION

This pilot study showed that the VES-13, originally developed for outpatient use, can potentially be used in conjunction with injury severity to predict inpatient complications in hospitalized older adults with traumatic injuries. Small sample size limited analysis of specific complications, but the VES-13 predicted composite hospital complications independently of age, sex, comorbidity, and injury severity. With validation on a larger sample, the VES-13 may be useful as an important and practical tool shortly after hospital admission to help differentiate risk and target hospital services toward older adults with traumatic injury at greatest risk of specific posttrauma complications.

These results extend prior research on hospital outcomes of older adults with traumatic injury. The effect of

Table 2. Relationship Between the Vulnerable Elders Survey (VES)-13 and Continuous Outcomes: Charges and Length of Stay (LOS)

		Effect of Each Additional VES-13 Point: â (95% Confidence Interval)	
Charges and LOS	Mean ± Standard Deviation	Unadjusted	Adjusted*
Charges over hospitalization, $1,000	134 ± 146	1.8% (−8.2% to +12.0%)	3.9% (−2.8% to +10.6%)
LOS, days	9.8 ± 8.5	4.8% (−3.0% to +12.6%)	6.5% (−0.05% to +13.0%)

LOS and charges were log-transformed for these linear regressions, so results displayed are the percentage increase (i.e., multiplicative rather than additive) in dollars or days associated with each additional VES-13 point.

* Adjusted for Injury Severity Score, sex, and Charlson Comorbidity Index.

age is well understood in observational data; mortality due to injury increases with age,[3] and age-related risk accelerates in the fourth decade.[7] Certain preexisting conditions have been found to predict mortality.[8] Comorbidity scales have been used to predict outcomes in mildly injured older adults with traumatic injury[9] but added little value in other samples.[10] Injury severity can be measured as degree of physiological compromise (e.g., respiratory rate, blood pressure, and level of consciousness as measured by the RTS[25]) or degree of trauma involvement by anatomical body regions (e.g., ISS[11]), but the ISS is used most universally to predict survival in older adults.[5,8,12] To the knowledge of the authors, this is the first study to prospectively collect an ADL-based measure upon admission to study hospital outcomes in older adults with traumatic injury. These findings are in agreement with a study of older inpatients on a medical ward, in whom VES-13 was predictive of postdischarge survival.[22]

Self-reported functional status is attractive as a predictor in older adults because it has predicted outcomes in other clinical settings[17–19] and is consistent with the concept that physical and functional reserve may protect older individuals during traumatic injury.[20,26] One widely used measure of function, the Functional Independence Measure (FIM)[27] is typically measured by trained personnel during the hospital stay (postinjury function) and has been found to predict nursing home admission after trauma.[5] The benefit of the VES-13 over the FIM is its brevity, decreasing burden on participants and their families during the trauma admission. Any member of the care team, including clerical personnel, can also complete it.

The VES-13 was associated with but was not statistically significant in predicting discharge destination. One explanation might be that discharge destination is not a good surrogate for health status at discharge.[28] It was assumed that discharge to home represented a better outcome than discharge to a facility, but factors external to the participant's health (e.g., availability of facilities[28] or family caregivers, participant preference) influence discharge location. Some individuals with poor functional outcome may have been sent home because they were deemed poor rehabilitation candidates, but given the borderline significance of this finding, the most likely explanation is inadequate sample size.

It was found that the ISS was consistently the strongest predictor of all hospital outcomes tested in the sample. This is consistent with other literature regarding the ISS in older adults.[5,8,12] The results of the current study suggest that the VES-13 is more useful at differentiating risk in conjunction with the ISS, although ISS is typically collected after hospital discharge. Therefore, future work to validate the VES-13 as an early predictor of hospital complications should use an alternative, simpler estimate of injury severity (rather than ISS) that can be collected upon admission.

Complications of injury and surgery are highly relevant to this population. The authors believe that the VES-13 can be used in an inpatient protocol to target inpatient services to prevent complications and mortality, for example, geriatric consultation, geriatric case management, multidisciplinary team care, and quality improvement efforts. The current results may also be useful for identifying which older adults are likely to suffer specific complications, for example, aspiration pneumonia, a recognized complication in older inpatients that has been studied for possible preventive interventions.[29] Despite the small size of the subsample of individuals requiring surgery, the VES-13 was predictive of development of postsurgery complications. Although a larger study in surgical patients is necessary, this pilot study suggests that the VES-13 can be helpful with targeting post- and perioperative hospital services to prevent postoperative complications.

An important strength of this study is that data were prospectively collected before hospital outcomes and complications were known. Thus, it was possible to minimize potential recall bias regarding functional status. The results should also be interpreted in the context of a few limitations. First, the VES-13 was developed to predict death and functional decline over a longer 1- to 5-year time frame,[17,18,21] but this study was underpowered to detect the previously validated death outcome, and information on discharge functional status was not collected. It has been hypothesized that hospital complications are precursors of the worst hospital outcome: death.[30] The current data suggest that over a shorter and more-acute time frame, the VES-13 score may be related to this continuum of postinjury complications to death. Second, it was not possible to test specific complications adequately because of low event rates. Third, eligible participants at the trauma center were predominantly white. Refusals may have been due to language barriers or historical reluctance of minorities to participate in research, which further compounded the lack of diversity in the sample.

There are several future directions for this study. A larger study is needed to validate risk of specific complications that were pooled in the current study. Because ISSs are not readily available upon admission, a larger study of the VES-13 stratified according to broad categories of injury severity (e.g., head vs nonhead injury, with high-, mid-, and low-severity classifications on admission) would be helpful as part of a clinically feasible algorithm that combines VES-13 with injury severity. Natural cutoff values of the VES-13 predict risk in large samples of older outpatients,[17] so a future direction would be to explore various cutoff scores in a larger population of older adults with traumatic injury. Last, the VES-13 should be tested in a population with higher minority group representation.

In conclusion, the VES-13 predicted inpatient outcomes in this pilot study of older adults with traumatic injury independent of traditional trauma risk indices. The VES-13 should be explored as part of an early risk assessment to target geriatric-specific hospital services aimed at preventing complications and death.

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Author Contributions: Lillian Min: study concept and design, acquisition of subjects and data, analysis and interpretation of data, and preparation of manuscript. Nitin Ubhayakar and Areti Tillou: study concept and design, acquisition of data, analysis and interpretation of data, and preparation of manuscript. Debra Saliba: study concept and design, analysis and interpretation of data and preparation of manuscript. Lorraine Kelley-Quon: acquisition of subjects and data, preparation of manuscript. Eric Morley: acquisition of subjects and/or data and preparation of manuscript. Jonathan Hiatt and Henry Cryer: study concept and design and preparation of manuscript.

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