The impact of frailty on failure-to-rescue in geriatric trauma patients: A prospective study

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INTRODUCTION: Failure-to-rescue (FTR) (defined as death from a major complication) is considered as an index of hospital quality in trauma patients. However, the role of frailty in FTR events remains unclear. We hypothesized that FTR rate is higher in elderly frail trauma patients.

METHODS: We performed a prospective cohort study of all elderly (age ≥ 65 years) trauma patients presenting at our level one trauma center. Patient's frailty status was calculated utilizing the Trauma Specific Frailty Index (TSFI) within 24 hours of admission. Patients were stratified into non-frail, pre-frail, and frail. FTR was defined as death from a major complication (respiratory, infectious, cardiac, and renal). Binary logistic regression analysis was performed after adjusting for age, gender, injury severity (ISS), and vital parameters to assess the relationship between frailty status and FTR.

RESULTS: A total of 368 elderly trauma patients were evaluated of which 25% (n = 93) were non-frail, 38% (n = 139) pre-frail, and 37% (n = 136) frail. Overall, 30% of the patients developed in-hospital complications; of them, mortality occurred in 26% of the patients (FTR group). In the FTR group, 69% of the patients were frail compared to 17% pre-frail and 14% non-frail ($p = 0.002$). On multivariate regression analysis for predictors of FTR, frail status was an independent predictor of FTR (OR [95% CI] = 2.67 [1.37–5.20]; $p = 0.004$). On sensitivity analysis, positive predictive value of TSFI for FTR was 69% and negative predictive value for FTR was 67%.

CONCLUSION: In elderly trauma patients, the presence of frailty increased the odds of FTR almost threefold as compared to non-frail. Although FTR has been considered as an indicator of health care quality, the findings of this study suggest that frailty status independently contributes to FTR. This needs to be considered in the future development of quality metrics, particularly in the case of geriatric trauma patients. (*J Trauma Acute Care Surg.* 2016;81: 1150–1155. Copyright © 2016 Wolters Kluwer Health, Inc. All rights reserved.)

LEVEL OF EVIDENCE: Prognostic study, level II.

KEY WORDS: Frailty; geriatric; Trauma Specific Frailty Index (TSFI); failure to rescue (FTR).

The recent demographic trends indicate an increase in the elderly population. This upward trend in elderly population is also reflected in changing demographics of patient population. The elderly patients now account for more than 20% of all hospital admissions.[1,2] With more active lifestyle choices in recent years, this already at-risk population is at an increased risk of morbidity and mortality after trauma compared to their younger counterparts.[3] Because of the presence of multiple comorbidities and overall decreased physiological reserve, in elderly patients clinical decision-making often becomes challenging. The phenotype of frailty has emerged in the published literature as an important estimate of physiological reserve of a geriatric individual.[4–6] Frailty is defined as a biologic syndrome of decreased reserve and resistance to stressors, which has been linked to adverse outcomes such as developing in-hospital complications and mortality.[7]

Failure to rescue (FTR), defined as death after a major complication, is an important benchmark of patient safety and health care quality. It is a common index of quality of healthcare delivery and shows how well hospitals perform once a complication occurs. Several previous studies have found that in-hospital mortality rate is significantly affected with variation in the management of complications. Complications after injury are relatively common among trauma patients, and emerging literature indicated that majority of these complications may be independent of a hospital's quality of care. Recent evidence suggests that reducing failure to rescue events might be the most appropriate target for quality improvement in geriatric population.

Successful rescue of patients with complications requires both timely identification of patients experiencing physical decline and also providing appropriate clinical interventions.[8] Several authors have reported the association of frailty syndrome with indirect measures of FTR; however, there is limited surgical literature that has reported the usefulness of frailty index in predicting FTR in geriatric patients, and the correlation between frailty and FTR in geriatric trauma patients is growing and still there is a room to assess the impact of frailty status on FTR in geriatric trauma patients.[9,10]

We conducted a study to investigate the impact of frailty on failure to rescue in geriatric trauma patients. We hypothesized that frailty as measured by Trauma Specific Frailty Index (TSFI) is a significant and reliable predictor of failure to rescue in geriatric trauma patients.

METHODS

Study Settings and Patients

After approval from the University of Arizona institutional review board, we performed a 2-year (2013–2014) prospective cohort analysis of consecutive elderly trauma patients aged ≥65 years presenting at our Level 1 trauma center. Patients transferred from other institutions, including rehabilitation centers or skilled nursing facilities, were excluded from the study. Patients who were dead on arrival, discharged from the ED, or admitted less than 24 hours were excluded. Patients who did not consent or in whom frailty index could not be calculated secondary to altered mental status and unavailability of family historians were also excluded. The prospective design and exclusion criteria eliminated the possibility of missing variables.

Data Points and Definitions

After enrollment, data was collected prospectively by trained researchers for each subject including patient demographics (age, gender, race, and ethnicity), injury characteristics (type and mechanism), vital signs on presentation (Glasgow Coma Scale (GCS) score, systolic blood pressure (SBP), heart rate (HR), and body temperature), need for operative intervention, in-hospital complications, hospital and intensive care unit length of stay, and discharge disposition (home, skilled nursing facility (SNiF), and rehabilitation center). The trauma registry was queried for Injury Severity Score (ISS) and Abbreviated Injury Scale (AIS) score. AIS divides the body into six regions (head and neck, face, chest, abdomen, pelvis, and extremities and general) and classifies the severity of injuries in each region based on clinical experience (1 = minor; 2 = moderate; 3 = severe, not life-threatening; 4 = severe, life threatening, survival probable; 5 = critical, survival uncertain; 6 = fatal). Electronic health records and personal interviews were used to acquire data.

Our primary outcome measure was failure to rescue (FTR) rate. Our secondary outcomes were in-hospital complications, mortality, discharge disposition (home, rehabilitation center, and skilled nursing facility), hospital and intensive care unit (ICU) length of stay, and ventilator days. We defined overall in-hospital complications as pneumonia, deep venous thrombosis (DVT), heart failure (HF), acute kidney injury (AKI), urinary tract infection (UTI), and anemia. FTR was defined as death after developing a complication.

Study Protocol

Patients fulfilling the enrollment criteria were identified every morning in trauma sign out rounds. All eligible patients were approached by one of the investigators, and after written informed consent, the TSFI questionnaire was administered (see Table, Supplemental Digital Content 1, http://links.lww.com/TA/A817). Every patient received an explanation of the variables with the emphasis that these are related to pre-injury conditions. Patient responses were recorded on allocated frailty index form. For patients who were intubated or unresponsive, the closest family member was approached to complete the questionnaire.

In our previous study to develop TSFI, we enrolled consecutive geriatric trauma patients using the 50-variable frailty index for development of the TSFI. Univariate analysis was performed to identify associations among variables in the 50-variable frailty index for development of unfavorable discharge disposition. Fifteen variables with the strongest association for development of unfavorable discharge disposition were selected to develop the TSFI. We then enrolled more consecutive trauma patients aged older than 65 years to validate our Frailty Index.

A TSFI score was calculated using the TSFI questionnaire, which includes the following domains: patient demographics (age, comorbidities, and medication history), social activity, activities of daily living, nutritional status, and general attitude. The presence of a deficit was given a point. Most of the variables in the TSFI are dichotomized, whereas others have multiple categories. The TSFI was calculated as the total score of deficits in a patient divided by the total number of possible responses (n = 15) in the TSFI questionnaire. The TSFI scores ranged from 0 to 1 with higher scores indicating frail status. Patients were then stratified into three groups based on their TSFI: non-frail (TSFI ≤ 0.12), pre-frail (TSFI = 0.13–0.25), and frail (TSFI > 0.25).

Statistical Analysis

Data are presented as mean ± SD for continuous variables, as medians [range] for ordinal variables, and as proportions for categorical variables. We used Student *t* test to assess the difference between parametric variables and Mann–Whitney *U* test to assess the difference between nonparametric variables. The chi-square test was used to assess the difference between proportions for categorical variables. The cutoff point of frailty score was derived from our previous studies.[4,6] One-way analysis of variance (ANOVA) was performed to compare the three groups of non-frail, pre-frail, and frail patients. Univariate analysis was performed for association between variables and outcomes. Variables with a significant ($p \leq 0.20$) association on the univariate analysis were used in the multivariate logistic regression model. On multivariate logistic regression analysis, a *p* value ≤0.05 was considered significant.[11,12] All statistical analyses were performed using Software for Social Sciences (SPSS, version 21; IBM, Inc., Armonk, NY).

RESULTS

During the study period, 388 consecutive eligible patients were approached for enrollment in the study. Twenty patients were not enrolled in the study. Seven of those patients refused to participate in the study (1.8%), and 13 (3.35%) had an altered mental status and no surrogate family member can be reached. Of the excluded patients, eight were transferred from a SNiF. All the patients who were transferred from SNiF were fall-related traumas and were later discharged to SNiF at the end of their hospital stay. The frailty index was successfully obtained in 368 patients; of them, 37% (136) were frail, 38% (139) were pre-frail, and 25% (93) were non-frail. Figure 1 shows the distribution of the study population.

The mean age of the population was 74.79 ± 10.76 years, 61.4% were male, and 77.8% were white. The median [IQR] injury severity scale score (ISS) was 11 [9–17], the median [IQR] Head Abbreviated Injury Scale (AIS) score was 2 [2–3], median [IQR] GCS was 15 [15–15], and mean ± SD TSFI was 0.23 ± 0.16. The most common mechanisms of injury were ground-level fall (49.2%) followed by motor vehicle collision (39.4%). Frail patients were significantly older than the other groups (frail: 78.83 ± 10.63, pre-frail: 74.71 ± 9.74, non-frail: 68.52 ± 9.55, $p < 0.001$). Mean TSFI was significantly higher in frail patients (frail: 0.40 ± 0.14, pre-frail: 0.17 ± 0.03, non-frail: 0.063 ± 0.035, $p < 0.001$). Ground-level falls were most common in the frail patients (frail: 79%, pre-frail: 57%, non-frail: 28%, $p < 0.001$). Frail patients also had a higher median [IQR] ISS (frail: 13 [9–19], pre-frail: 11 [9–14], non-frail: 9 [9–14], $p = 0.004$). There were no differences in gender ($p = 0.39$), ethnicity ($p = 0.06$), SBP ($p = 0.48$), HR ($p = 0.49$), body temperature ($p = 0.26$), GCS ($p = 0.21$), and head-AIS ($p = 0.13$) between the groups. Table 1 shows the comparison of demographics between the groups.

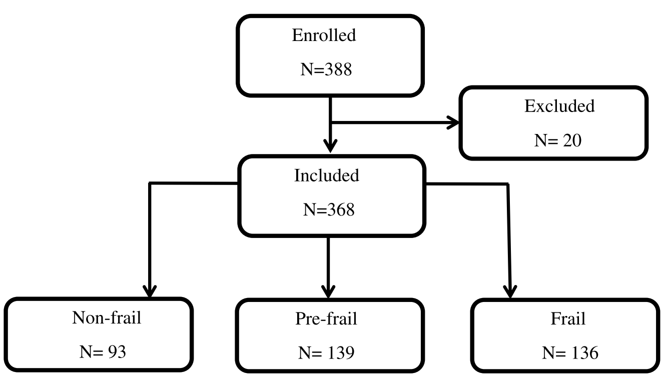

Figure 1. Patient selection.

TABLE 1. Demographics of the Study Population

Variables	Non-frail N = 93	Pre-frail N = 139	Frail N = 136	p
Age, mean ± SD	68.52 ± 9.55	74.71 ± 9.74	78.83 ± 10.63	**<0.001**
Male gender, % (n)	63% (58)	65% (90)	57% (77)	0.39
White race, % (n)	85% (79)	83% (115)	69% (94)	0.06
TSFI, mean ± SD	0.063 ± 0.035	0.17 ± 0.03	0.40 ± 0.14	**<0.001**
Presentation vitals:				
SBP, mean ± SD	141 ± 26	142 ± 30	146 ± 26	0.48
Heart rate, mean ± SD	82 ± 15	84 ± 16	85 ± 16	0.49
Body temperature, mean ± SD	36.6 ± 0.67	36.5 ± 0.7	36.5 ± 0.4	0.26
GCS, median [IQR]	15 [15–15]	15 [15–15]	15 [14–15]	0.21
Injury parameters:				
Mechanism of injury				
Fall, % (n)	28% (26)	57% (79)	79% (107)	**<0.001**
MVC, % (n)	58% (53)	39% (54)	27% (36)	**<0.001**
ISS, median [IQR]	9 [9–14]	11 [9–14]	13 [9–19]	**0.004**
Head-AIS, median [IQR]	3 [2–3]	3 [2–3]	3 [2–4]	0.13

The overall in-hospital complication rate was 30% (111). Frail patients were more likely to develop in-hospital complications than non- and pre-frail patients (frail: 42%, pre-frail: 24%, non-frail: 23%, $p = 0.002$). Pneumonia (4.4%) followed by AKI (3%) were the most common complications among the patients. Frail patients were more likely to develop AKI (frail: 5.8%, pre-frail: 2.1%, non-frail: 0%, $p = 0.03$) and anemia (frail: 5%, pre-frail: 3.6%, frail: 0, $p = 0.04$) in comparison with non- and pre-frail patients. There were no differences in UTI ($p = 0.09$), pneumonia ($p = 0.28$), DVT ($p = 0.92$), and HF ($p = 0.18$) among the groups.

TABLE 2. In-hospital and Discharge Outcomes

Variables	Non-frail N = 93	Pre-frail N = 139	Frail N = 136	p
In-hospital complications:	23% (21)	24% (33)	42% (57)	**0.002**
UTI, % (n)	1.1% (1)	1.4% (2)	5.1% (7)	0.09
Pneumonia, % (n)	3.5% (3)	2.8% (4)	6.5% (9)	0.28
AKI, % (n)	0	2.1% (3)	5.8% (8)	**0.03**
DVT, % (n)	1.1% (1)	0.7% (1)	0.7% (1)	0.92
HF, % (n)	0	0	1.4% (2)	0.18
Anemia, % (n)	0	3.6% (5)	5% (7)	**0.04**
Other complications, % (n)	8% (7)	5% (7)	2% (3)	0.12
Discharge disposition:				
Home, % (n)	72% (67)	59% (82)	29% (39)	**<0.001**
Rehab, % (n)	8% (7)	14% (19)	38% (51)	**<0.001**
SNiF, % (n)	13% (12)	22% (30)	16% (22)	0.13
Length of stay (LOS):				
Hospital, median [IQR]	4 [2–7]	4 [2–7]	5 [3–8]	0.48
ICU, median [IQR]	0 [0–1]	1 [0–3]	1 [0–4]	0.23
Ventilator days, median [IQR]	2 [0–3]	1 [0–6]	0 [0–5]	0.46
In-hospital mortality, % (n)	7% (6)	5% (7)	17% (23)	**0.001**
FTR, % (n)	4.6% (4)	3.5% (5)	14.5% (20)	**0.001**

UTI, urinary tract infection; AKI, acute kidney injury; DVT, deep venous thrombosis; HF, heart failure; SNiF, skilled nursing facility; ICU, intensive care unit; FTR, failure to rescue.

TABLE 3. Regression Analysis for Failure to Rescue

Variables	Univariate* OR [95% CI]	p
Frail status	2.39 [1.32–4.33]	**0.004**
Age	1.01 [0.97–1.05]	0.50
Gender	0.98 [0.45–2.15]	0.97
Fall as mechanism	1.94 [0.83–4.52]	**0.12**
ED SBP	1.00 [0.98–1.01]	0.92
ED HR	1.01 [0.98–1.03]	0.35
ISS	1.02 [0.96–1.08]	0.44
Head-AIS	1.76 [1.08–2.89]	**0.02**

*Controlling for frail status, age, gender, mechanism of injury, SBP, HR, ISS, and head-AIS. p values ≤0.2 will be included in multivariate regression model.
SBP, systolic blood pressure; HR, heart rate; ISS, Injury Severity Score; AIS, Abbreviated Injury Score.

Overall median [IQR] of hospital length of stay (LOS) was 4 [2–7], median [IQR] ICU LOS was 1 [0–3], and median [IQR] ventilator days were 1 [0–5]. There was no difference in hospital LOS ($p = 0.48$), ICU LOS ($p = 0.23$), and ventilator days ($p = 0.46$) between the groups. Overall mortality rate was 10% (36), and 80% (29) of those patients died after developing a complication (FTR). Overall mortality rate (non-frail: 7%, pre-frail: 5%, frail: 17%, $p < 0.001$) and FTR rate (non-frail: 4.6%, pre-frail: 3.5%, frail: 14.5%, $p < 0.001$) was significantly higher in frail patients compared to the other groups.

Of the 331 patients who survived to discharge, 187 (50.8%) patients were discharged home, 79 (21.5%) were discharged to a rehabilitation center, and 65 (17.7%) were discharged to a SNF. Frail patients were statistically less likely to be discharged home (non-frail: 72%, pre-frail: 59%, frail: 22%, $p < 0.001$) and more likely to be discharged to a rehabilitation center (non-frail: 8%, pre-frail: 14%, frail: 38%, $p < 0.001$) compared to the other groups. Table 2 depicts the outcomes among the groups.

On univariate regression analysis of the predictors of FTR, frail status ($p = 0.004$), fall as mechanism ($p = 0.12$), and head-AIS ($p = 0.02$) were significant predictors of FTR ($p < 0.2$) after controlling for frailty status, age, gender, mechanism of injury, SBP, HR, ISS, and head-AIS (Table 3). On subsequent multivariate regression analysis for the predictors of FTR, frail status was the only significant predictor of developing FTR (OR [95% CI]: 5.07 [1.65–13.11]; $p = 0.01$). Table 4 demonstrates the results of the multivariate regression analysis for the predictors of the FTR.

On sensitivity analysis, positive predictive value of TSFI for FTR was 69% and NPV for FTR was 67%. On ROC analysis for correlation between TSFI and FTR, TSFI had a linear correlation with FTR (AUC: 0.75 [95% CI: 0.6–0.79]; $p = 0.001$).

TABLE 4. Regression Analysis for Failure to Rescue

Variables	Multivariate* OR [95% CI]	p
Frail status	5.07 [1.65–13.11]	**0.01**
Fall as mechanism	0.86 [0.19–3.84]	0.84
Head-AIS	1.48 [0.90–2.44]	0.12

*Controlling for frail status, mechanism of injury, and head-AIS. p value ≤0.05 is significant.
AIS, Abbreviated Injury Score.

DISCUSSION

Failure to rescue, defined as death after developing an in-hospital complication, seems to be a very sensitive benchmark of quality of care compared to other hospital quality indices.[13,14] In this study, we assessed the impact of frailty measured by TSFI on FTR in geriatric trauma patients. We demonstrated that the failure to rescue rate is significantly higher in frail patients compared to non-frail patients.

To our knowledge, there are more than 32 frailty measurement indices, which can predict mortality, morbidity, and discharge disposition; however, majority of these tools have been designed for patients undergoing elective surgery and cannot be applied in trauma patients as they failed to meet the criteria for objectivity and feasibility in the trauma setting. Majority of these measurement indices commonly use some tools (e.g., gait speed and grip strength) or techniques (e.g., lengthy questionnaires), which cannot reasonably and reliably be accomplished among injured patients arriving to a busy trauma bay with an altered state of consciousness. The Trauma-Specific Frailty Index (TSFI) is the only tool that was developed specifically to assess frailty in trauma patients.[15]

Primary focus of regulators and payers is on reducing in-hospital complications, which they believe may be the leading cause of higher rate of mortality in patients. Although programs like Trauma Quality Improvement Program aims to identify best practices to improve hospital care, we believe that patient-level factors such as physiological reserve can be another predictor of higher rate of mortality and FTR in geriatric trauma patients. As demographics of trauma population varies geographically, hospital quality measures should adjust for frailty status of their population.[14]

The impact of hospital care on FTR has been well established within the surgical literature.[13] There is an increased interest in understanding what factors influence quality and safety and are associated with FTR. Previous work studying failure to rescue in patients undergoing a surgical procedure identified the importance of hospital characteristics, such as bed size, ICU availability, and teaching status. However, the impact of patient's factors such as frailty status on FTR is not well studied, and in geriatric trauma literature, there is a void on the impact of frailty on FTR in geriatric trauma patients.[16]

The results of this study provide new insights into this void in trauma literature and look at a very important patient-related factor that is going to play an increasingly important role in the face of changing population demographics. Although rates of mortality and FTR were higher in geriatric frail patients compared to non-frail patients, these differences could not be explained only with differences in the rate of in-hospital complications. Our study adds to a growing body of evidence that highlight the frailty status of a geriatric trauma patient as a predictor of patient outcomes.[17]

The main focus of this study was to assess the impact of frailty status measured by TSFI on FTR in geriatric trauma patients. Our findings defended our hypothesis that frailty is associated with the higher rate of FTR in geriatric trauma patients. It has been always reported in the literature that the likelihood a patient is rescued after developing a complication reflects the ability of hospital resources such as number of physicians and nursing staff to reduce the impact of a potentially life-threatening complication.[13,14,16] Majority of the literature focused on assessment of the variation in mortality rates across the institutions to show that discrepancy in mortality rates is related to the quality of hospital care. However, in our study, we assessed the geriatric trauma patients in a single trauma center and found that frailty status as a patient factor has a significant effect on the rates of in-hospital mortality, complications, and FTR. This finding also implies that hospitals that cater higher number of frail patients should be compensated for their higher FTR rates. Similarly, models to assess FTR should also include markers of frailty as their integral component and adjust individual hospital FTR rates relative to number of frail patients.

The ability to effectively rescue a patient from a complication relies on several factors. Intensivist recognizing frailty status of a geriatric patient is a key point in management of this at-risk population. Moreover, a multidisciplinary collaborative approach by physicians and nurses is required, which can lead to more effective interventions, diagnosis, and management of geriatric trauma patients who experience complications.[17] By identifying potential contributing factors including frailty in developing adverse outcomes, we can significantly modify the adverse outcomes of these patients. This approach should occur early within the trauma patient's hospital stay and set a trail that would impact FTR rates.

Overall in-hospital complications were significantly higher in geriatric frail patients than in the non-frail patients. In our previous study comparing the impact of frailty and age on adverse outcomes in geriatric trauma patients, we demonstrated that frail trauma patients were 2.5 times more likely to develop in-hospital complications.[1] Similarly, Saxton and Velanovich highlighted the role of frailty as an effective tool in the identification of geriatric patients who are at higher risk of developing in-hospital complications.[18] However, their study was retrospective and included a heterogeneous patient population undergoing elective general surgical procedures. In our prospective study, we demonstrated that the FI can be implemented in the acute setting of trauma and can be used to identify patients at higher risk of developing in-hospital complications after injury.

Discharge disposition is a critical component in management of trauma patients. Studies have shown that age and Injury Severity Score were significant predictors of adverse discharge disposition among trauma patients.[19,20]

In our study, frailty had a significant impact on adverse discharge disposition. Frail patients were less likely to be discharged home, and a vast majority of them required some forms of institutional disposition. This finding is of great importance, as identifying patients who are more likely to require discharge to an institutional facility can expedite this tedious process and ultimately shorten unnecessarily prolonged hospital stays. Our study is in coherence with Robinson et al., who found that patients with frailty were likely to require institutional care after a major surgical procedure.[21] Similarly, Lee et al. demonstrated that frail patients were more likely to have adverse discharge disposition after cardiac surgery.[22] However, these studies were retrospective and there was a variability in their frailty scores. In our study, we demonstrated that the results of the implementation of TSFI in trauma patients could give a reliable prediction of patients who require discharge to an institutional facility.

Limitations

Our study is one of the first to report the impact of in-hospital TSFI on FTR in geriatric trauma patients. However, our findings should be interpreted in context of the limitations. First, we did not evaluate the impact of frailty on long-term outcomes. Second, our findings are representative of data from a single institution and may not be generalizable beyond similar patients. Third, we did not evaluate the predictive value of frailty index in individual complications and mortality. Nevertheless, our study demonstrates the significant effect of frailty measured by TSFI to predict failure to rescue in geriatric trauma patients.

Conclusion

Frailty measured by TSFI is a significant predictor of developing in-hospital complications, mortality, and failure to rescue. It might explain some of the variabilities in FTR rate among the institutions. Identification of frailty status of a geriatric trauma patient and early prevention and management of complications should be targeted as a focused area in which improvements could significantly impact the overall quality of trauma care. Hospital quality metrics should consider frailty as an integral component in their assessment of failure to rescue.

AUTHORSHIP

B.J., T.O.J., H.P., P.R., and A.H. contributed to study conception and design. B.J., H.P., A.A., R.L., T.O.J., and N.K. acquired the data. B.J., T.O., P.R., H.P., and A.A. performed data analysis and interpretation. B.J., N.K., A.H., R.L., and A.A. drafted the manuscript. B.J., L.G., T.O., T.O.J., A. H., and P.R. contributed to critical revision.

DISCLOSURE

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