BMC Geriatrics

RESEARCH

Open Access

Frailty and 6-month trajectory of elderly trauma patients over the age of 65 years admitted to intensive care unit for severe trauma: experience of a level 1 trauma center

Vincent Legros[1,2,3,7*], Pierre-Antoine Seube-Remy[2,4], Thierry Floch[1], Cindy Chauchard[2], Marion Leclercq-Rouget[1], Pierre-Alexandre Prevot-Minella[2], Alice Duvivier[5], Lucas Flamant[4,6] and Lukshe Kanagaratnam[3,5]

Abstract

Background The aging global population forecasts a significant rise in severe trauma cases among individuals aged 65 and above. Frailty emerges as a paramount predictor of post-traumatic outcomes, surpassing age and trauma severity indices. Despite this, scant attention is given to the trajectory of elderly patients post-intensive care unit (ICU) stay following severe trauma, justifying this study. The objective of this study was to analyze trajectories (frailty, place of residence) following a major trauma requiring an ICU stay.

Materials and methods An observational cohort study was conducted, leveraging data from a level 1 trauma center spanning 2018 to 2023. Inclusion criteria included elderly patients aged 65 and above admitted to the ICU for severe trauma. Data encompassed demographic profiles, trauma severity scores, clinical parameters, and frailty assessments sourced from the Traumabase database.

Results Among 293 patients included 190 were non-frail, frailty was correlated with elevated mortality rates (114 (38.9%) at 6 months), heightened incidence of traumatic brain injuries, and notable declines in post-traumatic autonomy. Only 39.2% of patients had resumed residence at home six months post-injury, with a conspicuous trend towards institutionalization, particularly among frail individuals.

Conclusion This study highlights the role of frailty in determining the outcomes of elderly patients following severe trauma. Frailty is associated with higher mortality, increased rates of institutionalization, and a decline in functional status. These results highlight the importance of assessing frailty in the trajectory of severely injured patients over the age of 65 years-old.

Keywords Trauma, Mortality, Trajectory frailty, Elderly patients, Clinical frailty scale

*Correspondence:
Vincent Legros
vlegros@chu-reims.fr
[1]Surgical and Trauma Intensive Care Unit, Reims University Hospital, Reims F-51100, France
[2]Anesthesiology, Critical Care and Perioperative Medicine, Reims University Hospital, Reims F-51100, France
[3]Université de Reims Champagne-Ardenne, VieFra, Reims F-51100, France
[4]Faculty of Medicine, Université de Reims Champagne-Ardenne, Reims F-51100, France
[5]Department of Research and Public Health, Reims University Hospital, Reims F-51100, France
[6]Emergency Department, Reims University Hospital, Reims F-51100, France
[7]Anesthesiology, Critical Care and Perioperative Medicine Hopital Maison Blanche, CHU de Reims, 45 Rue Cognacq Jay, Reims, Cedex 51092, France

Introduction

With the aging of global population, the incidence of severe trauma in patients over the age of 65 is expected to increase significantly in the coming years [1]. This aging population, combined with improvements in resuscitation techniques, should lead to increasing survival rates for elderly patients admitted to intensive care for severe trauma [2, 3].

Different criteria currently allow us to predict outcomes of this population with varying degrees of accuracy. Among these, frailty appears to be more strongly correlated with the outcomes of these patients than age or trauma severity scores [4].

Various frailty scores have been developed over years, such as the Modified Frailty Index (mFI), the Clinical Frailty Scale (CFS), and even more specifically, the Trauma-Specific Frailty Index in the context of severe trauma [5–9].

Different studies focusing on frailty in the context of trauma primarily examine hospital mortality or failure to rescue (FTR), which is defined as death following a major complication. FTR is an indicator of the quality of trauma care management [10, 11].

Although this data is extremely relevant, particularly frailty which, according to the Kojima and al study, increases the risk of FTR after trauma by 1.32 times between frail and no-frail [10], The trajectory of severely injured patients who have had a stay in intensive care is not well studied [12].

By trajectory we obviously mean hospital survival, but also 1-year survival, as well as the onset or worsening of a state of frail or pre-frail.

Admission to nursing home is also a relevant factor to analyze following severe trauma. Unfortunately, little is known about these patient's trajectories in the context of trauma requiring a move to intensive care, although few data exist for intensive care patients [8, 12].

The aim of this study was to analyze patient trajectories (i.e. mortality, institutionalization, frailty 6 month after the trauma) in a cohort of severe trauma patients over 65 years of age.

Methods

Study design

We conducted an observational retrospective cohort study using data from Reims Level-1 Trauma Center between January 1st, 2018, and December, 31st, 2023. This study included all consecutive severely injured elderly patients (≥65 years-old) admitted in Trauma center with ICU stay and also included in the traumabase© registry. This study adheres to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines and a checklist is provided in Supplementary Material 1.

Participants

The study cohort included all consecutive trauma patients aged ≥ 65 years admitted in Reims level-1 trauma center and also included in the national major trauma registry Traumabase© (https://Traumabase.eu) during the specified study period.

Reims level-1 trauma center participating in this study accept all patients with suspected severe trauma according to the Vittel criteria [13] and is responsible for the management of all trauma patients in their respective geographical areas.

The Vittel criteria include 5 sub-items that take into account physiological variables, kinetic elements, the type of anatomical lesions, the care provided at the scene of the accident, and the victim's condition [14].

Detailed descriptions of the French Emergency Medical Services and trauma system are available in other publications [15].

Data source and collection

The Traumabase registry is a prospective database that systematically collects sociodemographic, clinical, biological, therapeutic, and in-hospital evolution Data. All trauma patients with severely injury suspected and admitted to Reims University hospital are included. This comprehensive data collection spans from the prehospital scene to hospital discharge. The participating center ensures the admission of all consecutive severe traumas occurring within its respective geographical area, enabling the creation of a cohort-based overview of severe trauma care in the region. Severe trauma is defined as a situation suggesting life-threatening or life-changing injuries.

Collected data

For the specified periods, the number of patients admitted was reported, and comprehensive data were collected for each patient, including demographic information such as age and gender, American Society of Anesthesiologists score (ASA), details on the injury mechanism, and assessment of injury severity using the Injury Severity Score (ISS), regional Abbreviated Injury Score (AIS), Sequential Organ Failure Assessment (SOFA) Score and new Simplified Acute Physiology Score (SAPS 2). Additionally, key medical factors, including occurrence of hemorrhagic shock (defined as the transfusion of more than four red cells concentrates within 6 h) and traumatic brain injury (TBI) (intracranial bleeding on CT scan or Coma Glasgow Scale < 13) were documented. Trauma management details, both pre-hospital and intra-hospital time, were extensively recorded, covering aspects such as time intervals, surgical interventions within the first 24 h, duration of mechanical ventilation, length of hospital stay, and decisions regarding withdrawal of care.

Mortality outcomes were tracked in the ICU, and the patient's status 30 days post-trauma was also reported.

Autonomy data for each patient were collected through medical record for assessment of Activities of Daily Living. (ADL), and Instrumental Activities of Daily Living (IADL).

Frailty was evaluated by the Clinical Frailty Scale (CFS), before trauma and 6-month after trauma. Survival and location were also reported before the trauma and up to 6-month after it.

Frailty was assessed using the CFS, a tool that categorizes patients into three groups: the non-frail group with a CFS between 1 and 3, the pre-frail group with a CFS between 4 and 5, and the frail group with a CFS greater than 5, as described by Guidet and al. [7].

Patient follow-up ranged from 6 months to 3 years, depending on the year of injury.

For any information on patient autonomy and frailty were carried out by analyzing medical records. For patients who did not have a frailty assessment with the CFS, an analysis using the method described by Curtis et al. [16] was performed.

Statistical analysis

The results were expressed as mean (standard deviation) or median (1st −3rd quartile) according to the distribution, for quantitative variables and in numbers (percentages) for qualitative variables.

Univariate analyses were performed to compare frailty status and the socio-demographic. Physiological, prehospital and hospital clinical variables using Chi2 tests, Fisher's exact tests, ANOVA or Kruskall-Wallis tests, as appropriate.

Survival curves based on Clinical Frailty Scale (CFS) values were plotted using the Kaplan-Meier method, at 1 year after trauma.The log-rank test was used to compare these curves.

Alluvial diagrams were created to visualize the transitions between pre- and post-trauma CFS, as well as between living areas before and one year after the trauma. These diagrams illustrate the flow of patients between different categories, offering a clear visualization of changes in status.

All statistical analyses were performed using SAS software, version 9.4 (SAS Institute Inc., Cary, NC, USA).

Ethical approval

This study complied with the Declaration of Helsinki. This is a retrospective study using data already collected. It complies with French law, corresponding to MR004, for which authorization (MR004060520241) was obtained from the University hospital of Reims. The Traumabase registry is approved by the Advisory Committee for Information Processing in Health Research (CCTIRS; 11.305bis) and the National Commission for Data Protection agency (CNIL 911461 and 2211878). The Traumabase registery adheres to national institutional review board requirements (Comité de Protection des Personnes Paris VI. Paris. France) in accordance with the ethical standards of the French legislation (Committees for the protection of Human Subjects). Informed consent was waived for this retrospective study, as it exclusively used preexisting data.

Results

Between January 2018 and December 2023, 1432 severely injured trauma patients were admitted to ICU of Reims University level-1 trauma center, included 299 aged over 65 (20.9%).

Of these 299 patients, 6 were excluded due to too many missing data. In fact a total of 293 patients were included in the analysis.

Baseline characteristic

Of the 293 patients included, the median age was 73 [68–78] years-old. One hundred and ninety (64.9%) were non-frail, 69 (23.5%) were pre-frail and 34 (11.6%) were frail.

Frail patients had higher ASA scores than non-frail patients and were more frequently on anticoagulant (12 (35.3%) vs. 31 (16.3%) $p=0.04$) and antiaggregant therapies (9 (26.4%) vs. 20 (10.5%), $p=0.04$).

The predominant mechanism of injury was fall in 154 (52.5%) of the cohort, and reached 70.6% in frail patients ($p=0.01$), ground-level fall is predominant in frail patients.

The second mechanism was a road traffic accident for 105 (35.8%) of the patients.

Traumatic brain injury was more frequent in frail and pre-frail patients ($p=0.001$).

Severity scores were also higher in pre-frail and frail patients (SAPS II $p<0.001$, SOFA, $p<0.001$), while trauma severity measured by the ISS had a median of 20 [13–28], and did not differ between groups ($p=0.57$).

Withholding or withdrawal of life support therapies were observed in 32 (10.9%) patients, with a significantly higher rate in 9 (26.4%) frail patients ($p=0.03$).

Mortality in the ICU, at 30 days, 6 months and during follow-up was significantly higher in frail patients, reaching 64.7% at 6 months (Table 1).

Autonomy and place of residence

Concerning autonomy data, for ADL, IADL, and these 2 scores are significantly higher in non-frail patients. (<0.001).

At 6 months after the accident, only 113 (39.2%) of patients had returned home, and this rate fell to 4 (11.7%) in frail patients ($p<0.001$).

Table 1 Epidemiology and socio-demographic characteristics

	All	Non-Fail (CFS1-3)	Pre-Frail (CFS4,5)	Frail (CFS 6–8)	*p*
	(*n* = 293)	(*n* = 190)	(*n* = 69)	(*n* = 34)	
Age	73 [69–80]	72 [68–78]	75 [72–81]	78 [71–84]	0,01
Sex (men)	214 (73)	145 (76,3)	43 (62,3)	26 (76,4)	0,07
ASA	2 [2–3]	2 [2–3]	2 [2–3]	3 [2–3]	< 0,001
Antiplatelet agent's n (%)	63 (21,5)	31 (16,3)	20 (28,9)	12 (35,3)	0,04
Anticoagulants n (%)	44 (15)	20 (10,5)	15 (21,7)	9 (26,4)	0,04
Mechanisms n (%)					
Fall	154 (52,5)	86 (45,2)	44 (63,7)	24 (70,6)	0,01
falls from its height	68 (33,8)	26 (30,9)	24 (48,9)	18 (64,3)	< 0,0001
Road traffic accident	105 (35,8)	79 (41,6)	18 (26,1)	8 (23,5)	0,02
pedestrian	25 (8,5)	17 (8,9)	4 (5,8)	4 (11,7)	0,5
accidental	266 (90,8)	176 (92,6)	60 (87)	20 (88)	0,2
self-inflicted	20 (6,8)	8 (4,2)	8 (11,6)	4 (11,7)	0,2
Traumatic brain injury	126 (43)	66 (34,8)	44 (63,7)	16 (47)	0,001
Hemorrhagic shock	36 (12,3)	22 (11,6)	6 (8,7)	8 (23,5)	0,08
Severity score					
SAPS II	44 [31–62]	36 [29,56]	57 [40–72]	53 [35–75]	< 0,001
SOFA	6 [2–9]	4 [1–9]	6 [5–10]	5 [4–9]	< 0,001
ISS	20 [13–28]	19 [13–25]	25 [16–25]	21 [13–25]	0,56
Dead					
ICU	91 (31)	45 (23,7)	31 (44,9)	15 (44,1)	0,01
at Day 30	99 (33,8)	50 (26,3)	32 (46,3)	17 (50)	0,001
at 6 Month	114 (38,9)	55 (28,9)	37 (53,6)	22 (64,7)	< 0,001
During follow-up	122 (41,6)	56 (29,4)	42 (60,8)	24 (70,6)	< 0,001
WLST in ICU	32 (10,9)	16 (8,4)	7 (10,1)	9 (26,4)	0,03

Data are expressed in median [interquartile], number (percentage)

ASA American Society of Anesthesiologists; *SAPSII* Simplified Acute Physiology Score II ; *SOFA* Sepsis-related Organ Failure Assessment; *ICU* Intensive Care Unit ; *ISS* Injury Severity Score *WLST* Withhold or Withdrawal Life-Sustaining Therapies

Before the accident, the majority of patients (287 (97.9%)) lived at home and around a third 99 (33.8%) lived alone.

During follow-up (from 6 months to 3 years) the rate of return home increased to 142 (48.4%), mainly in non-fragile patients 117 (61.4%) ($p<0.001$) where 17 patients (5.8) were admitted to a nursing home, including 6 (17.6%) frail patients (Table 2).

Survival analysis

Mortality in ICU is higher in patients with frailty (45 (23.7%) vs. 15 (44.1%) $p=0.01$), at 30 days (50 (26.3%) vs. 17 (50%) $p=0.001$), at 6 months (55 (28.9%) vs. 22 (64.7%) $p<0.001$) (Table 1) and during follow-up ranging from 6 months to 1 year was statistically higher in pre-frail and frail patients compared to non-frail patients (Log-rank < 0.001) (Fig. 1).

6-month trajectory

During follow-up, 142 patients (48.4%) had returned home, 13 were still hospitalized (4.4%) and 17 (5.8%) were in a nursing home (Fig. 2).

The trajectory of frailty is summarized in Fig. 3, which shows that only 55 (28.9%) of non-frail patients remain so 6 months after the accident (Fig. 3).

Discussion

The primary aim of this study was to analyze the trajectories of severely injured elderly patients, particularly focusing on frailty and its impact on outcomes such as mortality, institutionalization, and changes in frailty status. The findings underscore the significant influence of frailty on these outcomes, demonstrating that frail patients face markedly worse prognoses compared to their non-frail counterparts.

Frailty and mortality

The data clearly indicate that frail patients have significantly higher mortality rates at various time points—ICU, 30 days, 6 months, and during follow-up—compared to non-frail and pre-frail patients. This is consistent with previous studies that have highlighted frailty as a critical determinant of survival following severe trauma [4, 17]. The higher ASA scores and increased use of anticoagulant and antiaggregant therapies among frail patients

Table 2 Autonomy and location before and after trauma

	All	non-Fail (CFS1-3)	Pre-Frail (CFS4,5)	Frail (CFS 6–8)	*p*
	(*n* = 293)	(*n* = 190)	(*n* = 69)	(*n* = 34)	
Pré accident condition					
ADL	5 [5–6]	5,5 [5–6]	4,5 [4–5]	3 [1,5 – 4]	< 0,001
IADL	7 [6–8]	7 [7–8]	6 [6–7]	4 [3–5]	< 0,001
CFS	3 [2–4]	2 [2–3]	4 [4–4]	6 [6–6]	< 0,001
Living at Home	287 (97,9)	190 (100)	69 (100)	28 (82,3)	< 0,001
Patient living alone	99 (33,8)	57 (30)	26 (37,7)	16 (47)	0,3
Post-accident condition at 6 month					< 0,001
Return at home	113 (39,2)	94 (49,5)	14 (20,3)	4 (11,7)	
Still hospitalized	59 (20,2)	39 (20,5)	16 (23,2)	4 (11,7)	
Institutionalized	8 (2,7)	2 (1,05)	2 (2,9)	4 (11,7)	
Post-accident during follow-up*					< 0,001
Return at home	142 (48,4)	117 (61,6)	21 (30,4)	4 (11,7)	
Still hospitalized	13 (4,4)	12 (6,3)	1 (1,4)	0 (0)	
Institutionalized	17 (5,8)	5 (2,6)	6 (8,7)	6 (17,6)	

Data are expressed in median [interquartile], number (percentage)

ADL Activity of Daily Living; *IADL* Instrumental Activity of Daily Living, *CFS* Clinical Frailty Score

*Follow-up ranged from 6 months to 3 years, depending on the year of injury

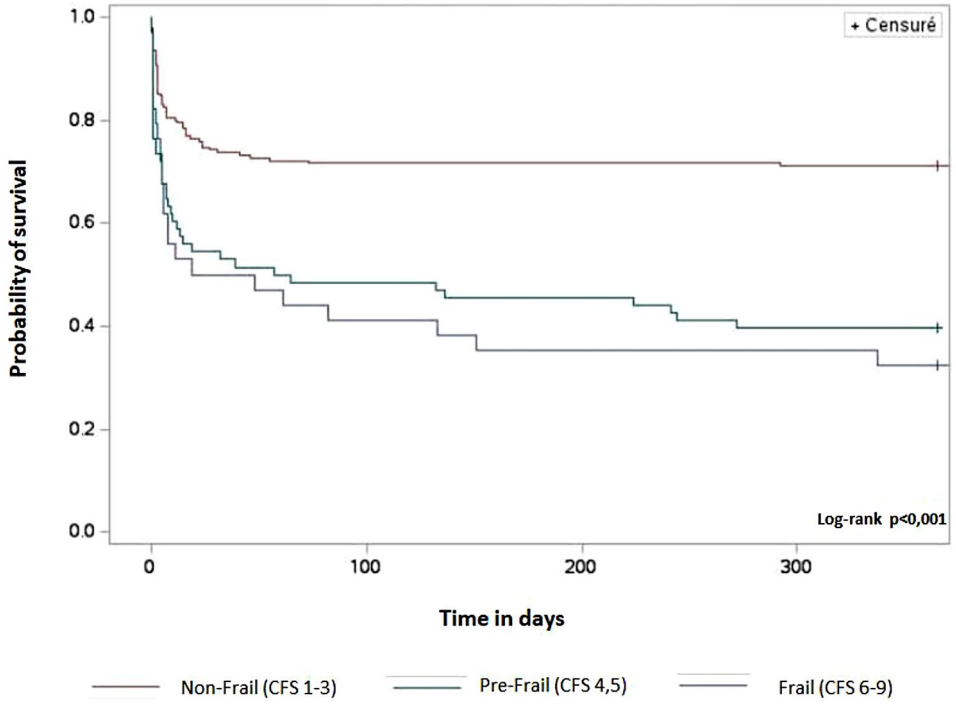

Fig. 1 Kaplan-Meier survival curve at 1 year. Kaplan-Meier survival curve, showing 1-year mortality respectively at 29.4% (56 patients) for non-frail patients, 60.8% (42 patients) for pre-frail patients and 70.6% (24 patients) for frail patients

suggest a more complex medical profile, contributing to poorer outcomes [6].

Mechanisms of injury

Falls were identified as the predominant mechanism of injury, particularly among frail patients. This aligns with existing literature which suggests that falls from standing height are a common cause of trauma in the elderly due to age-related declines in balance and muscle strength [5, 18, 19]. The increased incidence of traumatic brain injury (TBI) in frail and pre-frail patients further highlights the vulnerability of this group to severe outcomes from relatively minor mechanisms of injury [20].

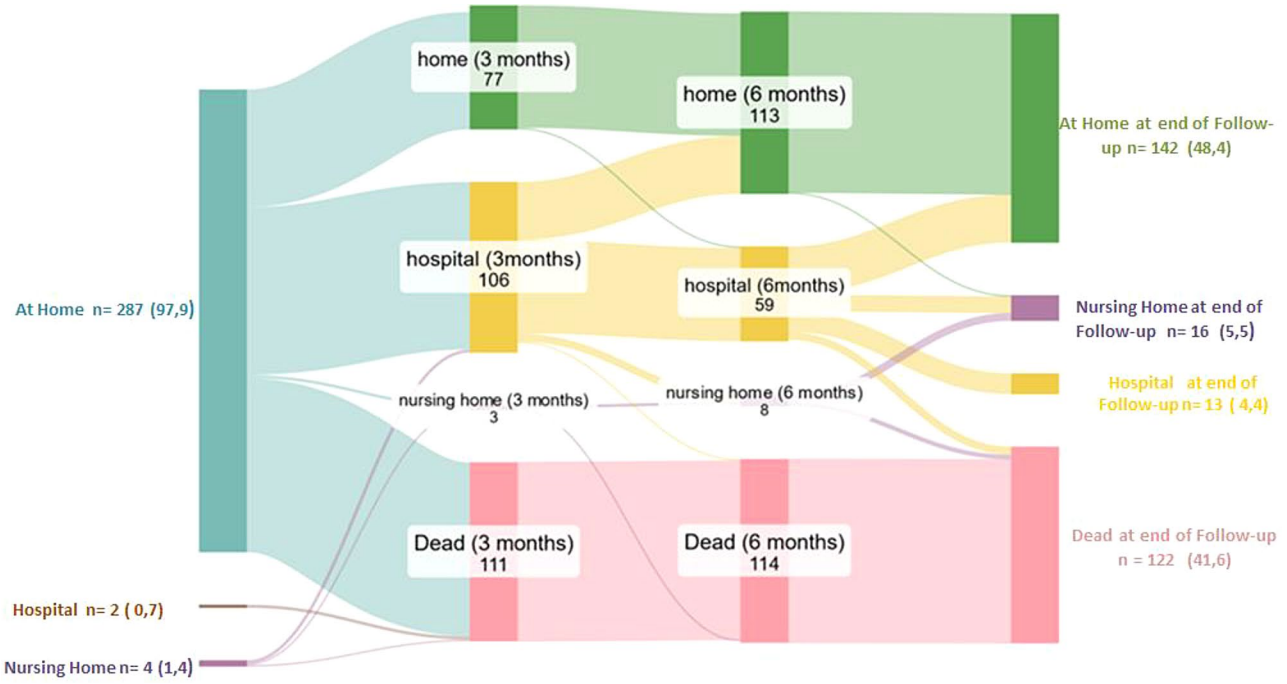

Fig. 2 Alluvial diagram of patients' place of residence before and 6 months and 1 year after the accident. Alluvial diagram showing patients' trajectories according to where they live, with milestones at 3, 6 months and during follow-up.At the end of follow-up, only 48.4% (142 patients) were living at home at least 1 year after the trauma, compared with 97.9% (287 patients) before the trauma. Data are expressed in number (percentage), End of Follow-up ranged from 6 months to 3 years, depending on the year of injury

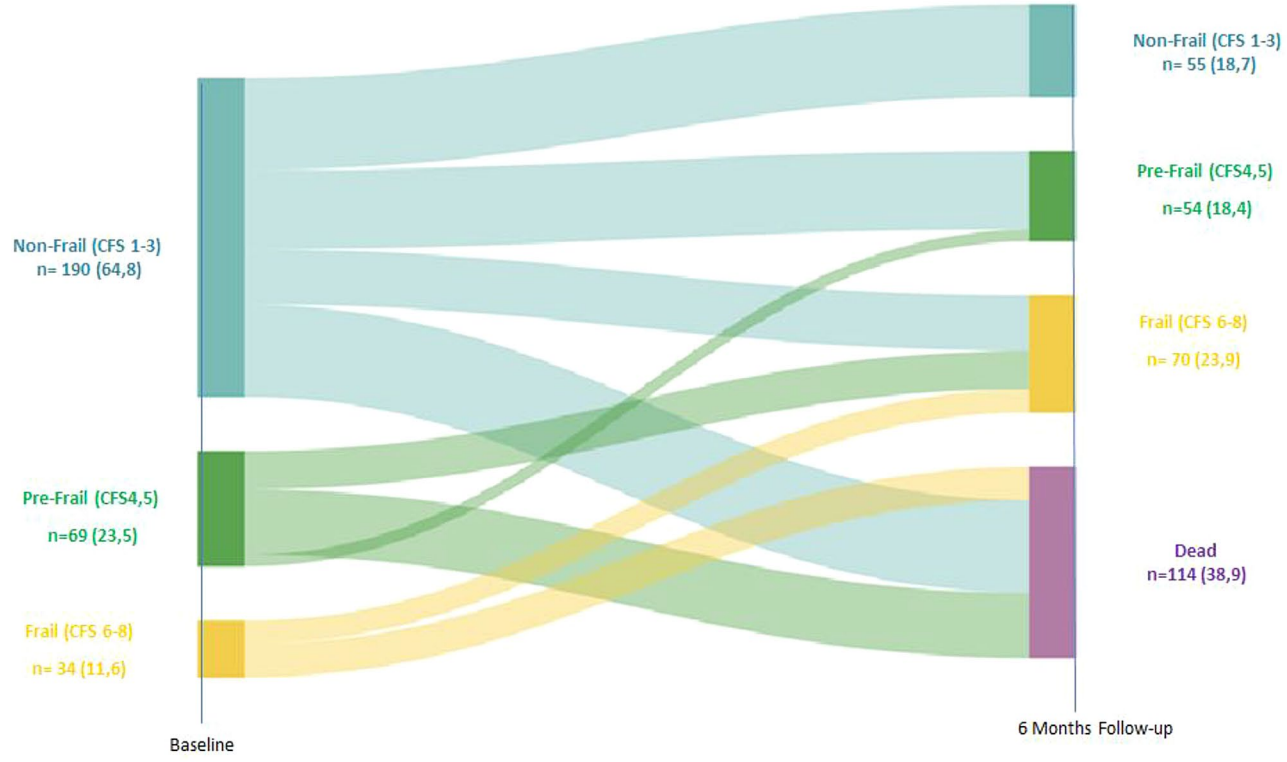

Fig. 3 Alluvial diagram of frailty before and 6 months after the accident. An alluvial diagram shows the trajectory of patients based on their frailty status, before and one year after the trauma. Of the 114 patients (38.9%) who died within one year, among the 190 patients (64.8%) who were non-frail, only 55 (18.7%) remained one year after the trauma. Data are expressed in number (percentage)

Impact on autonomy and living situation

The study also revealed a substantial impact of severe trauma on patient's autonomy and living situations. Before the trauma, the majority of patients lived at home, with a significant portion living alone. However, six months post-trauma, only a minority of frail patients had returned home, highlighting a drastic decline in independence. This finding is critical as it reflects the broader implications of severe trauma on the quality of life and long-term care needs of elderly patients. The increased rates of institutionalization among frail patients underscore the need for targeted interventions to support this vulnerable population [8].

Trajectories of frailty

The trajectory analysis demonstrated a significant shift in frailty status post-trauma. Notably, a substantial number of non-frail patients transitioned to a frail state six months post-trauma, indicating the profound impact of severe trauma on functional status. This transition emphasizes the importance of early identification and management of frailty in trauma patients to potentially mitigate this decline [7, 8, 21].

Clinical implications and future directions

The findings of this study have important clinical implications. The high mortality and morbidity associated with frailty suggest that frailty assessment should be integrated into trauma care protocols. Early identification of frailty could guide decision-making regarding the intensity of interventions and resource allocation. Additionally, tailored rehabilitation programs aimed at improving physical function and reducing frailty could enhance recovery and reduce long-term dependence.

Futures researches should focus on developing and validating frailty-specific intervention strategies in the context of trauma care. Moreover, studies exploring the mechanisms underlying the progression from non-frail to frail status post-trauma could provide insights into potential preventive measures. Finally, the development of predictive models incorporating frailty assessments could improve the accuracy of outcome predictions and inform clinical practice.

Limitations of the study

While this study provides valuable insights into the trajectories of elderly patients after intensive care unit (ICU) admission following severe trauma, several limitations should be considered.

Firstly, this study relies on retrospective data collected from a prospective database. While this approach allows for comprehensive analysis of admitted patients, it is subject to potential biases such as coding errors or missing data. Despite efforts to minimize these biases by excluding patients with a significant amount of missing data, there remains a possibility that unrecorded data may influence our results.

Secondly, this study was conducted in a single level 1 trauma center, which may limit the generalizability of our findings to other healthcare facilities. Trauma management practices and patient characteristics may vary across centers, which could impact the post-traumatic trajectories of elderly patients.

Thirdly, although we assessed retrospectively patient's frailty using the Clinical Frailty Scale (CFS), there are other tools and methods to assess frailty that could provide complementary insights. Our exclusive use of the CFS may limit the overall understanding of frailty among our population.

Lastly, the duration of patient follow-up ranged from 6 months to 3 years, depending on the year of the injury. While this allowed us to capture short- and medium-term outcomes, longer-term surveillance could have provided additional insights into the evolution of post-traumatic trajectories among elderly patients.

Despite these limitations, this study contributes to our understanding of long-term outcomes among elderly patients following severe trauma and provides valuable insights to guide future research and clinical practices in this field.

Conclusion

This study highlights the role of frailty in determining the outcomes of elderly patients following severe trauma. Frailty is associated with higher mortality, increased rates of institutionalization, and a decline in functional status. These results highlight the importance of assessing frailty in the trajectory of severely injured patients over the age of 65. Adding frailty assessments to trauma care could help tailor treatments and support for elderly patients.

The retrospective nature of this study is a limitation ; a large prospective trial could address this question.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12877-024-05350-1.

Supplementary Material 1

Acknowledgements

Not applicable.

Author contributions

VL, LK contributed to the conception and study design. Analysis and interpretation of data, drafting and revising the manuscript. LK, AD VL contributed to analysis and interpretation of data. VL, LK supervision of the study. VL, PASR, MLR, TF, LF, PAPM, CC included patient. All authors read and approved the final manuscript.

Funding

None.

Data availability
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This is a retrospective study using data already collected from the Traumabase Registery (The TraumaBase registry is approved by the Advisory Committee for Information Processing in Health Research (11.305bis) and the National Commission for Data Protection agency (CNIL 911461 and 2211878) The TraumaBase meets the requirements of the national institutional review board (Comité de Protection des Personnes Paris VI, Paris, France). It complies with French law (loi Jardé), corresponding to MR004, for which authorization of The General Data Protection Regulation (GDPR) number MR004060520241 was obtained from the University hospital of Reims. In accordance with the ethical standards of the French legislation (Committees for the protection of Human Subjects), informed consent was waived for this retrospective study, as it exclusively used preexisting data.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Received: 31 May 2024 / Accepted: 3 September 2024
Published online: 14 September 2024

References

1. Angus DC, Kelley MA, Schmitz RJ, White A, Popovich J, Committee on Manpower for Pulmonary and Critical Care Societies (COMPACCS). Caring for the critically ill patient. Current and projected workforce requirements for care of the critically ill and patients with pulmonary disease: can we meet the requirements of an aging population? JAMA. 2000;284(21):2762–70.
2. Schoeneberg C, Probst T, Schilling M, Wegner A, Hussmann B, Lendemans S. Mortality in severely injured elderly patients: a retrospective analysis of a German level 1 trauma center (2002–2011). Scand J Trauma Resusc Emerg Med. 2014;22:45.
3. Schönenberger A, Billeter AT, Seifert B, Neuhaus V, Trentz O, Turina M. Opportunities for improved trauma care of the elderly - a single center analysis of 2090 severely injured patients. Arch Gerontol Geriatr. 2012;55(3):660–6.
4. Joseph B, Pandit V, Zangbar B, Kulvatunyou N, Hashmi A, Green DJ, et al. Superiority of frailty over age in predicting outcomes among geriatric trauma patients: a prospective analysis. JAMA Surg. 2014;149(8):766–72.
5. Joseph B, Pandit V, Zangbar B, Kulvatunyou N, Tang A, O'Keeffe T, et al. Validating trauma-specific frailty index for geriatric trauma patients: a prospective analysis. J Am Coll Surg. 2014;219(1):10–e171.
6. Maxwell CA, Patel MB, Suarez-Rodriguez LC, Miller RS. Frailty and Prognostication in geriatric surgery and trauma. Clin Geriatr Med. 2019;35(1):13–26.
7. Guidet B, Vallet H, Flaatten H, Joynt G, Bagshaw SM, Leaver SK et al. The trajectory of very old critically ill patients. Intensive Care Med. 2024.
8. Ferrante LE, Pisani MA, Murphy TE, Gahbauer EA, Leo-Summers LS, Gill TM. The Association of Frailty with Post-ICU disability, nursing home admission, and mortality: a longitudinal study. Chest. 2018;153(6):1378–86.
9. Rockwood K, Song X, MacKnight C, Bergman H, Hogan DB, McDowell I, et al. A global clinical measure of fitness and frailty in elderly people. CMAJ. 2005;173(5):489–95.
10. Kojima M, Morishita K, Shoko T, Zakhary B, Costantini T, Haines L, et al. Does frailty impact failure-to-rescue in geriatric trauma patients? J Trauma Acute Care Surg. 2024;96(5):708–14.
11. Sammy I, Lecky F, Sutton A, Leaviss J, O'Cathain A. Factors affecting mortality in older trauma patients-A systematic review and meta-analysis. Injury. 2016;47(6):1170–83.
12. Rainer TH, Hung KKC, Yeung JHH, Cheung SKC, Leung YK, Leung LY, et al. Trajectory of functional outcome and health status after moderate-to-major trauma in Hong Kong: a prospective 5 year cohort study. Injury. 2019;50(5):1111–7.
13. Vivien B, Raux M, Riou B. Évaluation préhospitalière de la gravité des traumatisés. Ann Fr Med Urgence. 2011;1(1):33–42.
14. Cassignol A, Marmin J, Cotte J, Cardinale M, Bordes J, Pauly V, et al. Correlation between field triage criteria and the injury severity score of trauma patients in a French inclusive regional trauma system. Scand J Trauma Resusc Emerg Med. 2019;27(1):71.
15. Bouzat P, Ageron FX, Brun J, Levrat A, Berthet M, Rancurel E, et al. A regional trauma system to optimize the pre-hospital triage of trauma patients. Crit Care. 2015;19(1):111.
16. Curtis E, Romanowski K, Sen S, Hill A, Cocanour C. Frailty score on admission predicts mortality and discharge disposition in elderly trauma patients over the age of 65 y. J Surg Res. 2018;230:13–9.
17. Joseph B, Phelan H, Hassan A, Orouji Jokar T, O'Keeffe T, Azim A, et al. The impact of frailty on failure-to-rescue in geriatric trauma patients: a prospective study. J Trauma Acute Care Surg. 2016;81(6):1150–5.
18. Clement ND, Tennant C, Muwanga C. Polytrauma in the elderly: predictors of the cause and time of death. Scand J Trauma Resusc Emerg Med. 2010;18(1):26.
19. Pecheva M, Phillips M, Hull P, Carrothers AOR, Queally JM. The impact of frailty in major trauma in older patients. Injury. 2020;51(7):1536–42.
20. van der Vlegel M, Mikolić A, Lee Hee Q, Kaplan ZLR, Retel Helmrich IRA, van Veen E, et al. Health care utilization and outcomes in older adults after traumatic Brain Injury: A CENTER-TBI study. Injury. 2022;53(8):2774–82.
21. Mudge AM, Hubbard RE. Management of frail older people with acute illness. Intern Med J. 2019;49(1):28–33.

Publisher's note