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Prevalence and impact of frailty on mortality in elderly ICU patients: A prospective, multicenter, observational study

Running title: Frailty and critically ill patients

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Abstract

Purpose: Frailty is a recent concept used for evaluating elderly individuals. Our study determined the prevalence of frailty in intensive care unit (ICU) patients and its impact on the rate of mortality.

Methods: A multicenter, prospective, observational study performed in four ICUs in France included 196 patients aged ≥ 65 years hospitalized for >24 hours during a 6-month study period. Frailty was determined using the frailty phenotype (FP) and the clinical frailty score (CFS). The patients were separated as follows: FP score <3 or ≥ 3 and CFS < 5 or ≥ 5 .

Results: Frailty was observed in 41% and 23% of patients based on a FP score ≥ 3 and a CFS ≥ 5 , respectively. At admission to the ICU, the Simplified Acute Physiology Score II (SAPS II) and Sequential Organ Failure Assessment (SOFA) scores did not differ between the frail and nonfrail patients. In the multivariate analysis, the risk factors for ICU mortality were FP score ≥ 3 (hazard ratio [HR], 3.3; 95% confidence interval [CI], 1.6-6.6; $p < 0.001$), male gender (HR, 2.4; 95% CI, 1.1-5.3; $p = 0.026$), cardiac arrest before admission (HR, 2.8; 95% CI, 1.1-7.4; $p = 0.036$), SAPS II score ≥ 46 (HR, 2.6; 95% CI, 1.2-5.3; $p = 0.011$), and brain injury before admission (HR, 3.5; 95% CI, 1.6-7.7; $p = 0.002$). The risk factors for 6-month mortality were a CFS ≥ 5 (HR, 2.4; 95% CI, 1.49-3.87; $p < 0.001$) and a SOFA score ≥ 7 (HR, 2.2; 95% CI, 1.35-3.64; $p = 0.002$). An increased CFS was associated with significant incremental hospital and 6-month mortalities.

Conclusions: Frailty is a frequent occurrence and is independently associated with increased ICU and 6-month mortalities. Notably, the CFS predicts outcomes more effectively than the commonly used ICU illness scores.

Keywords: aging, critical care, frail elderly, decision-making, mortality

Introduction

With increased life expectancy and improved medico-surgical procedures, the number of elderly patients admitted to intensive care units (ICUs) has been increasing and is expected to increase dramatically in the next decade [1-3]. However, controversies exist regarding aging as a risk factor for mortality in ICUs. Currently, identifying elderly patients who may or may not benefit from intensive treatment remains challenging, and the final decisions may be subjective [4-10]. The scoring systems currently used do not precisely assess co-morbidity and prehospital functional status or disability. Moreover, the mechanisms underlying the aging process are heterogeneous. Therefore, clinicians need a method for quantifying the interindividual variability in aging rate [11].

To achieve this objective, frailty has been recently established as a concept that is primarily investigated in the elderly population and is distinct from disability or co-morbidity [12, 13]. Frailty is characterized by a loss of physiological reserves and, consequently, an inability to maintain homeostasis to combat a disease or injury [12, 13]. The common signs and symptoms of frailty include fatigue, weight loss, weakness, low activity level, slow motor performance, and cognitive loss [12, 14]. Frailty has been associated with increased morbidity and mortality in emergency and geriatric medicine and surgery [15, 16], but it has been poorly investigated in critically ill patients [17, 18]. Therefore, understanding the relationship between frailty and ICU outcomes is becoming increasingly important.

The aim of our study was to determine the prevalence of frailty and the impact of frailty on mortality in a prospective cohort of patients older than 65 years who were admitted to ICUs.

Materials and methods

This prospective, observational study was conducted in four university-affiliated hospitals in France (Rennes, Nantes, Angers, and Poitiers). Recruitment was conducted from November 1, 2011, to May 1, 2012. As a non-interventional study, the local ethics committee waived the need for informed consent according to French legislation (Comité d’Ethique du CHU de Rennes, France, n° 11.39).

All of the patients aged ≥ 65 years and hospitalized for >24 hours in the ICU were considered to be eligible for inclusion in the study. Patients were excluded if they had no proxies or could not be interviewed. For patients readmitted to the ICU,

only the first ICU hospitalization was considered. All of the patients included in the study were followed for 6 months or until death.

Data collection

Age, gender, and body mass index were recorded for each patient at the time of ICU admission. The reasons for ICU admission (medical, scheduled and unscheduled surgery, and trauma) and, more specifically, data regarding brain injury, cardiac arrest, and the presence of an infection at the time of ICU admission were collected. The severity of illness was assessed according to the Simplified Acute Physiology Score II (SAPS II) [19], the modified SAPS II (SAPS II without age) score, the Sequential Organ Failure Assessment (SOFA) score [20], and the Glasgow Coma Scale. Life expectancy was estimated using the McCabe classification [21].

During the patients' hospitalization, the following data were collected: the occurrence of severe sepsis, septic shock, acute renal failure, and acute respiratory distress syndrome; the number of acquired infections per patient; the need for dialysis; the duration of mechanical ventilation; and the need for surgery [22, 23]. The use of corticosteroids, neuromuscular blocking agents, and vasopressors was recorded. The rates of limitation and discontinued treatment were also documented.

The multi-dimensional syndrome of frailty in elderly, critically ill patients was assessed using two scales [12, 17]. There is no clear consensus regarding the definition of frailty, and, schematically, two operational approaches have been proposed [13]. Fried et al. validated the first operational definition, i.e., the frailty phenotype (FP), which views frailty as a biological syndrome resulting from cumulative decline across multiple physiological systems and contains 5 criteria (shrinking, weakness, slowness, low-level physical activity, and self-reported exhaustion) [12, 24]. All five components were considered from the previously reported definition and adapted to the ICU environment (Table 1, electronic supplementary material [ESM]) [12, 24]. The patients were considered to be frail if they had 3 or more frailty components among the 5 criteria [12]. The second scale, the clinical frailty score (CFS), which has been adapted from the clinical frailty scale developed by Rockwood et al., views frailty as a multidimensional risk state that can be better measured by the quantity rather than by the nature of the health problems (cumulative deficit model) [17, 25]. The CFS ranges from 1 (very fit) to 9 (terminally ill), with frailty ranging from scores of 5 to 8 (mildly, moderately, severely, and very severely frail). The patients were considered to be frail when the CFS was ≥ 5 (Table 2, ESM) [17]. Moreover, the FP score and the CFS were

each separated into 4 categories (from nonfrail to the most severely frail/terminally ill; FP score 0, 1-2, 3, and >3 and CFS 1-3, 4, 5, and >5), and the hospital and 6-month mortalities were studied for each category.

Furthermore, disability was quantified using the Katz Index of Independence in activities of daily living (ADL), which assesses the ability of patients to perform the daily activities of bathing, dressing, toileting, transferring, continence, and feeding. This index correlates with physical dependence. Patient dependence was described in 1 of 2 manners for each function: independent (1 point) or dependent (0 point). The ADL score ranges from 0 (complete dependence) to 6 (complete independence) [26]. The burden of co-morbidity was quantified using the Charlson Co-morbidity Index, which is based on the assignment of co-morbidities observed in patients in one of several categories [27]. A weighted score is assigned to each co-morbidity based on the relative risk of 1-year mortality. The sum of the index scores is an indicator of disease burden and a predictor of death [27]. Memory status was assessed by asking relatives if they had noticed whether the patient had exhibited memory problems in the last 6 months. It was quantified as present if the patient had trouble remembering the names of people he/she had recently met, had trouble remembering the flow of a conversation, and had an increased tendency to misplace items.

The FP, CFS, Katz Index of Independence in ADL, and presence or absence of a memory disorder were obtained as soon as possible from the patient, when possible, or his/her relatives. The Charlson Co-morbidity Index was obtained from the patient, when possible, or his/her relatives (spouse, children, and sibling(s)); the referring physician; and the patient's medical charts. Moreover, based on the possible interference between these scores and the acute illness requiring ICU admission, the patient or his/her relatives were asked to extrapolate the patient's status one month before hospital admission.

The ICU and hospital lengths of stay and the ICU, hospital, and 6-month mortalities were recorded. Finally, for all of the patients who survived the ICU, their final location (home, hospital, or other institution) after 6 months was recorded.

Statistical analysis

All of the statistical analyses were performed using SAS 9.1 Statistical Software (SAS Institute, Cary, NC, USA). The quantitative variables are expressed as the mean \pm standard deviation, and the qualitative variables are expressed as numbers (percentages). The patients were divided into 2 independent groups, namely, frail and nonfrail patients, based on a FP score <3 or ≥ 3 and a CFS <5 or ≥ 5 , respectively. For descriptive statistics, the categorical variables were compared

using the χ^2 test or Fisher's exact test, as required. The continuous variables were compared using Student's *t* test. The survival variables were compared using the log rank test, and Kaplan-Meier survival curves were constructed.

To build the model for multivariate analysis, we selected among the variables with a $p \leq 0.20$ according to the univariate analysis. Subsequently, survival regression (Cox proportional hazard model) was performed to identify the independent factors associated with ICU and 6-month mortalities. The hazard ratios (HRs) and 95% confidence intervals (95% CIs) were calculated. The model fit and calibration were assessed using the c-index. A $p < 0.05$ was considered to be statistically significant for all of the comparisons.

Results

During the 6-month study period, 961 patients were admitted to the ICUs. A total of 309 elderly patients ≥ 65 years old, hospitalized >24 hours, and consecutively admitted to the ICUs were assessed for eligibility, and 196 were analyzed (Rennes, $n=107$; Nantes, $n=49$; Angers, $n=22$; and Poitiers, $n=18$) (Figure 1, ESM). Details regarding the ICUs and institutions from which the patients were recruited are presented in Table 3 of the ESM. The frailty data were collected at the time of admission by querying the patients (31%), their relatives (61%), or both (8%).

Frailty was observed in 80 patients (41%) and 46 patients (23%) of the 196 patients based on a FP score ≥ 3 and a CFS ≥ 5 , respectively (Table 1). The CFS was significantly correlated with the FP score ($R^2=0.66$, $p < 0.001$). At baseline, frail patients had significantly higher numbers of severe underlying diseases, co-morbidities, disabilities, and memory disorders (Table 1). During ICU hospitalization, the limitation or discontinuation of treatment was significantly more frequent in patients who had a CFS ≥ 5 (Table 2). There were no differences in ICU and hospital lengths of stay between the frail and nonfrail patients, regardless of the measurement modalities used to assess frailty (Table 2). Figure 1 depicts survival probability according to the FP score and CFS status. Only ICU mortality was higher among frail-FP patients, whereas frail-CFS patients had significantly higher ICU, hospital, and 6-month mortality rates (Figure 2). According to the CFS, nonfrail patients were more likely to live at home (Figure 2).

Table 3 provides hospital and 6-month mortality rates according to the increasing levels of the FP scores and CFSs. An increase in the CFS was associated with significant incremental hospital and 6-month mortalities.

The univariate analysis of ICU and 6-month mortalities is provided in Tables 4 and 5 in the ESM. In the multivariate analysis, the risk factors for ICU mortality were a FP score ≥ 3 (HR, 3.3; 95% CI, 1.6-6.6; $p < 0.001$), male gender (HR, 2.4; 95% CI, 1.1-5.3; $p = 0.026$), cardiac arrest before admission (HR, 2.8; 95% CI, 1.1-7.4; $p = 0.036$), a SAPS II ≥ 46 (HR, 2.6; 95% CI, 1.2-5.3; $p = 0.011$), and brain injury before admission (HR, 3.5; 95% CI, 1.6-7.7; $p = 0.002$) (c-index=0.76 [0.45; 0.99]). The risk factors for 6-month mortality were a CFS ≥ 5 (HR, 2.4; 95% CI, 1.5-3.9; $p < 0.001$) and a SOFA ≥ 7 (HR, 2.2; 95% CI, 1.3-3.6; $p = 0.002$) (c-index=0.75 [0.53; 0.93]).

Discussion

In this prospective study involving ICU patients ≥ 65 years old, 41% and 23% were considered to be frail at the time of admission according to the FP score and CFS, respectively. Frailty constitutes an independent risk factor for ICU and 6-month mortalities. These results are consistent with a recent study performed in a younger population of ICU patients aged ≥ 50 years, which showed that frailty evaluated by the CFS was associated with an increased risk of adverse events, morbidity, and mortality [18].

In our study, age did not appear to be a predictive factor of death; however, this result is a controversial issue. Recently, a large retrospective study in patients ≥ 75 years of age reported a linear increase in the adjusted mortality probability at 28 days from ICU admission and at 1 year among the 28-day ICU survivors [9]. Similarly, aging was independently associated with a higher mortality rate in patients suffering from circulatory failure [28]. Nevertheless, evidence suggests that factors other than age itself, notably, previous health status, play a pivotal role in outcome [4, 10]. In a medical ICU, in patients ≥ 80 years old, long-term mortality was shown to be independently associated with the presence of an underlying fatal disease and severe functional limitations [4]. Similarly, although focused on the long-term quality of life after ICU admission, a reduction in health-related quality of life was observed up to 36 months after ICU admission and was related to the effects of pre-existing diseases [10].

To better define long-term outcomes in elderly individuals, it is important to include other parameters, such as disability and co-morbidity, rather than chronologic age and the common illness severity scores [29]. Frailty is a state of increased vulnerability in elderly adults, which is distinct from disability and co-morbidity; however, an overlap exists between these entities [14]. The prevalence of frailty is approximately 7% in the general population ≥ 65 years old [12, 14], although a higher prevalence ($>40\%$) has been reported, particularly in patients who are hospitalized for various reasons [14, 25, 30,

31]; these prevalence differences could be a result of the different frailty models used [32]. Geriatric frail patients are predisposed to hospitalization, institutionalization, and decreased survival [14, 25, 31]. Frailty was identified to be a major predictor of postoperative complications and death after scheduled or unscheduled surgery [16, 30].

It is not surprising that several components of a preexisting frailty syndrome may compromise rehabilitation and outcome. An ICU hospitalization is an exhausting experience; after discharge from the ICU, the majority of patients have early substantial functional disabilities in ADL [33]. We studied long-term mortality but did not evaluate health-related quality of life (HRQOL), which has been controversially reported to be impaired in the elderly after ICU discharge [34, 35]. Nevertheless, frail ICU patients reportedly had a lower HRQOL at 6 and 12 months, regardless of their physical and mental status, which reinforces the importance of the “frail” versus “nonfrail” status at the time of admission [18]. Moreover, in the ICU, severe weakness is recognized to be a complication that, in turn, significantly impacts the recovery and return to former functional status of patients who survive organ failures [36]. Although valid for all patients, these points are more important for elderly individuals. The early recognition of frailty may help to identify targets for interventions to reduce the functional decline related to critical illness and ICU stay [36, 37].

Our results are consistent with those in previous reports, performed in areas other than ICUs [25, 38]. Frailty, independent of age, is a risk factor for ICU and 6-month mortalities. Notably, the FP score is associated with ICU mortality, whereas the CFS is associated with 6-month mortality. The assessment of functional measures provided by the FP score may be subjective, particularly when ascertained from surrogate decision-makers or family, and may explain the differences between the two scores. However, two operational definitions of frailty, namely, the FP score and CFS, were proposed because they responded to two different approaches regarding the concept of frailty, and they capture related but distinct groups of patients. In a recent study performed in a geriatric population, the prevalence of frailty ranged from 6% to 45% when 8 commonly used scales were compared [32]. The FP score is known to more precisely evaluate sarcopenia and decreased functional reserves with the loss of resilience to stressors and is likely to be more relevant for the ICU environment. The CFS, which explores the physical aspects and the environmental spectrum, appears to be more relevant for delayed mortality [13].

Upon first admission to the ICU, frail patients were more dependent and had more memory problems and co-morbidities than nonfrail patients; however, the common markers of illness severity at the time of admission and during hospitalization were not different between frail and nonfrail patients. The severity of illness scoring systems used in the ICU (i.e.,

APACHE II, SAPS II, and SOFA) are largely dominated by the assessment of acute physiological derangements that are present at the time of admission, although several researchers incorporate a limited assessment of confirmed advanced comorbid illnesses [17, 39]. This point underscores the importance of determining the frailty status in ICU patients to assess the need for increasing the duration of hospitalization and institutionalization and to predict mortality.

Our study has several limitations. For example, the threshold of 65 years of age used for patient inclusion in this study may be criticized. Nevertheless, it is generally accepted that elderly individuals are at least 65 years old. The threshold of ≥ 65 years old has been frequently used to characterize frailty in ICU patients, although frailty may also exist in younger individuals [12, 18, 24, 25]. Several components of the FP score, notably those that evaluate performance, were difficult to explore in ICU patients, which could explain the differences between the FP scores and CFS [12, 24]. In accordance with a geriatrician's advice, we chose to interpret slowness as difficulty walking while aided and the occurrence of a fall. Other components of frailty were easier to translate because clear substitutes were available [24]. The majority of the questionnaires, notably those for the FP score, were completed by the next-of-kin and may be over- or underscored as a consequence. However, in the ICU, this approach is routine and can be considered to be the "real life" and pragmatic approach, although the next-of-kin tend to underestimate the patient's abilities and the degree of family ties may modify the relevance of the responses [40, 41]. Finally, during ICU hospitalization, the limitation or discontinuation of treatment was more frequent in frail patients and may have contributed to the increased mortality rates in these patients. This potential bias is difficult to avoid because the weight of the frailty status in the decisions to withhold/withdraw therapy has not been studied; other factors are usually considered in these types of decisions. Similarly, 20% of our patients suffered a brain injury and 8% suffered cardiac arrest; thus, it could be argued that in these patients, the decision of whether to withdraw support may be different for frail and nonfrail patients. Nevertheless, we did not find any difference in the support withdrawal practice between these patient subgroups (Tables 6 and 7, ESM) or between the 4 ICUs studied (Tables 8 and 9, ESM).

Conclusions

As the number of elderly patient admissions to the ICU continues to increase, physicians must identify the predictive factors of mortality. At the time of admission, the common markers of illness severity (SAPS II and SOFA), as assessed by ICU physicians, did not differ between the frail and nonfrail patients. The frailty status is frequently assessed and allows for

a better definition of the risk of death in elderly patients, particularly using the CFS, although the use of the frailty score in decision-making regarding the withdrawal of support must be approached with caution.

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Figure Legends

Fig. 1 Kaplan-Meier survival curves for 6-month mortality according to the frailty phenotype and clinical frailty score status

Fig. 2 Living situation at 6 months and ICU, hospital, and 6-month mortalities versus frailty status

Table 1: Baseline characteristics, Frailty, disability and co-morbidity scores and memory status.

| | Total (n = 196) | Not frail FP < 3 (n = 116) | Frails FP ≥ 3 (n = 80) | <i>p</i> | Not frail CFS < 5 (n = 150) | Frails CFS ≥ 5 (n = 46) | <i>p</i> |
|-------------------------------|----------------------------------|--|---|----------|---|--|----------|
| Age, years | 75 ± 6 | 74 ± 6 | 75 ± 6 | 0.96 | 75 ± 6 | 76 ± 7 | 0.34 |
| Sex, male | 128 (65) | 72 (62) | 56 (70) | 0.25 | 100 (67) | 28 (61) | 0.47 |
| BMI, kg.m⁻² | 28 ± 6 | 28 ± 5 | 28 ± 8 | 0.45 | 28 ± 5 | 30 ± 10 | 0.12 |
| Type of admission | | | | | | | |
| Medical | 50 (26) | 31 (27) | 19 (24) | | 34 (23) | 16 (35) | |
| Scheduled surgery | 52 (26) | 24 (21) | 28 (35) | 0.09 | 42 (28) | 10 (22) | 0.25 |
| Unscheduled surgery | 76 (39) | 47 (40) | 29 (36) | | 58 (39) | 18 (39) | |
| Trauma | 18 (9) | 14 (12) | 4 (5) | | 16 (11) | 2 (4) | |
| At admission | | | | | | | |
| Brain injury | 40 (20) | 28 (24) | 12 (15) | 0.12 | 32 (21) | 8 (17) | 0.56 |
| Cardiac arrest | 15 (8) | 8 (7) | 7 (9) | 0.60 | 8 (5) | 7 (15) | 0.05 |
| Infection | 85 (43) | 46 (40) | 39 (49) | 0.21 | 64 (43) | 21 (46) | 0.72 |
| SAPS II | 48 ± 17 | 49 ± 17 | 47 ± 16 | 0.52 | 48 ± 17 | 49 ± 16 | 0.51 |
| Modified SAPS II* | 33 ± 16 | 32 ± 16 | 33 ± 17 | 0.52 | 32 ± 17 | 34 ± 16 | 0.57 |
| SOFA | 7 ± 4 | 7 ± 4 | 7 ± 3 | 0.65 | 7 ± 4 | 7 ± 3 | 0.93 |
| Glasgow coma scale | 11 ± 5 | 11 ± 5 | 11 ± 5 | 0.51 | 11 ± 5 | 11 ± 5 | 0.98 |
| McCabe score | | | | | | | |
| A | 88 (45) | 64 (55) | 24 (30) | 0.0014 | 75 (50) | 13 (28) | 0.02 |
| B | 85 (43) | 43 (37) | 42 (52) | | 61 (41) | 24 (52) | |
| C | 23 (12) | 9 (8) | 14 (18) | | 14 (9) | 9 (20) | |
| CFS | 3.7 ± 1.6 | 2.9 ± 1.3 | 4.8 ± 1.3 | < 0.0001 | - | - | - |
| FP | - | - | - | - | 1.7 ± 1.4 | 3.3 ± 1.1 | < 0.0001 |
| Charlson Score | 2.1 ± 2.0 | 1.8 ± 1.8 | 2.5 ± 2.1 | 0.006 | 1.9 ± 2.0 | 2.6 ± 1.9 | 0.05 |
| Katz Score | 5.3 ± 1.5 | 5.8 ± 0.8 | 4.6 ± 2.0 | < 0.0001 | 5.8 ± 0.9 | 3.7 ± 2.1 | < 0.0001 |
| Memory disorders | 43 (22) | 18 (16) | 25 (31) | 0.01 | 27 (18) | 16 (35) | 0.02 |

Quantitative and qualitative values are expressed as the mean±SD and n (%). BMI: Body mass index. SAPS II: Simplified acute physiologic score II. SOFA: Sequential organ failure assessment. *The modified SAPS II score was SAPS II not including age. FP: Frailty phenotype. CFS: Clinical frailty score

Table 2: Clinical data during ICU hospitalization and ICU and hospital length of stay.

| | Total (n = 196) | Not frail FP < 3 (n = 116) | Frails FP ≥ 3 (n = 80) | <i>p</i> | Not frail CFS < 5 (n = 150) | Frails CFS ≥ 5 (n = 46) | <i>p</i> |
|--|----------------------------------|--|---|----------|---|--|----------|
| Severe sepsis | 73 (37) | 44 (38) | 29 (36) | 0.81 | 58 (39) | 15 (33) | 0.46 |
| Septic shock | 68 (35) | 39 (34) | 29 (36) | 0.70 | 54 (36) | 14 (30) | 0.49 |
| Number of acquired infections | 0.8 ± 0.8 | 0.9 ± 0.9 | 0.8 ± 0.7 | 0.31 | 0.9 ± 0.9 | 0.7 ± 0.6 | 0.13 |
| Acute renal failure | 83 (42) | 43 (37) | 40 (50) | 0.07 | 64 (43) | 19 (41) | 0.87 |
| Dialysis | 41 (21) | 25 (22) | 16 (20) | 0.79 | 33 (22) | 8 (17) | 0.50 |
| Mechanical ventilation, days | 11 ± 15 | 12 ± 15 | 10 ± 15 | 0.35 | 10 ± 14 | 12 ± 20 | 0.54 |
| ARDS | 14 (7) | 8 (7) | 6 (8) | 0.87 | 12 (8) | 2 (4) | 0.53 |
| Surgery | 98 (50) | 61 (53) | 37 (46) | 0.38 | 74 (49) | 24 (52) | 0.74 |
| Corticosteroid treatment | 43 (22) | 22 (19) | 21 (26) | 0.23 | 31 (21) | 12 (26) | 0.44 |
| Use of neuromuscular blocking | 24 (12) | 14 (12) | 10 (13) | 0.93 | 20 (13) | 4 (9) | 0.40 |
| Vasopressor use | 113 (58) | 68 (59) | 45 (56) | 0.74 | 91 (61) | 22 (48) | 0.12 |
| Limitation or discontinuance of treatment | 38 (19) | 18 (16) | 20 (25) | 0.10 | 18 (12) | 20 (43) | < 0.0001 |
| Length of stay, days | | | | | | | |
| ICU | 8 [5-17] | 10 [5-18] | 7 [4-14] | 0.21 | 9 [5-18] | 8 [4-14] | 0.96 |
| Hospital | 23 [13-47] | 24 [13-50] | 21 [13-42] | 0.15 | 24 [13-49] | 22 [13-42] | 0.26 |

Quantitative and qualitative values are expressed as the mean ± SD or median [Interquartile range] and *n* (%). ARDS: Acute respiratory distress syndrome. FP: Frailty phenotype. CFS: Clinical frailty score.

Table 3. ICU, hospital and 6-month mortalities according to the level of frailty.

| | ICU mortality (n = 41) | <i>p</i> † | Hospital mortality (n = 65) | <i>p</i> † | 6-month mortality (n = 72) | <i>p</i> † |
|-------------------------------|----------------------------------|------------|---------------------------------------|------------|--------------------------------------|------------|
| Frailty phénotype | | | | | | |
| 0 (n = 36) | 10 (28) | 0.02 | 11 (31) | 0.11 | 11 (31) | 0.09 |
| 1 - 2 (n = 80) | 9 (11) | | 25 (31) | | 28 (35) | |
| 3 (n = 36) | 7 (19) | | 9 (25) | | 10 (28) | |
| 4 - 5 (n = 44) | 15 (34) | | 20 (45) | | 23 (52) | |
| Clinical frailty score | | | | | | |
| 1-3 (n = 88) | 16 (18) | 0.21 | 26 (30) | 0.003 | 28 (32) | < 0.001 |
| 4 (n = 62) | 8 (13) | | 16 (26) | | 17 (27) | |
| 5 (n = 19) | 7 (37) | | 7 (37) | | 7 (37) | |
| 6 - 8* (n = 27) | 10 (37) | | 16 (59) | | 20 (74) | |

*For CFS = 9, n = 0. † Log rank test.

Figure 1.

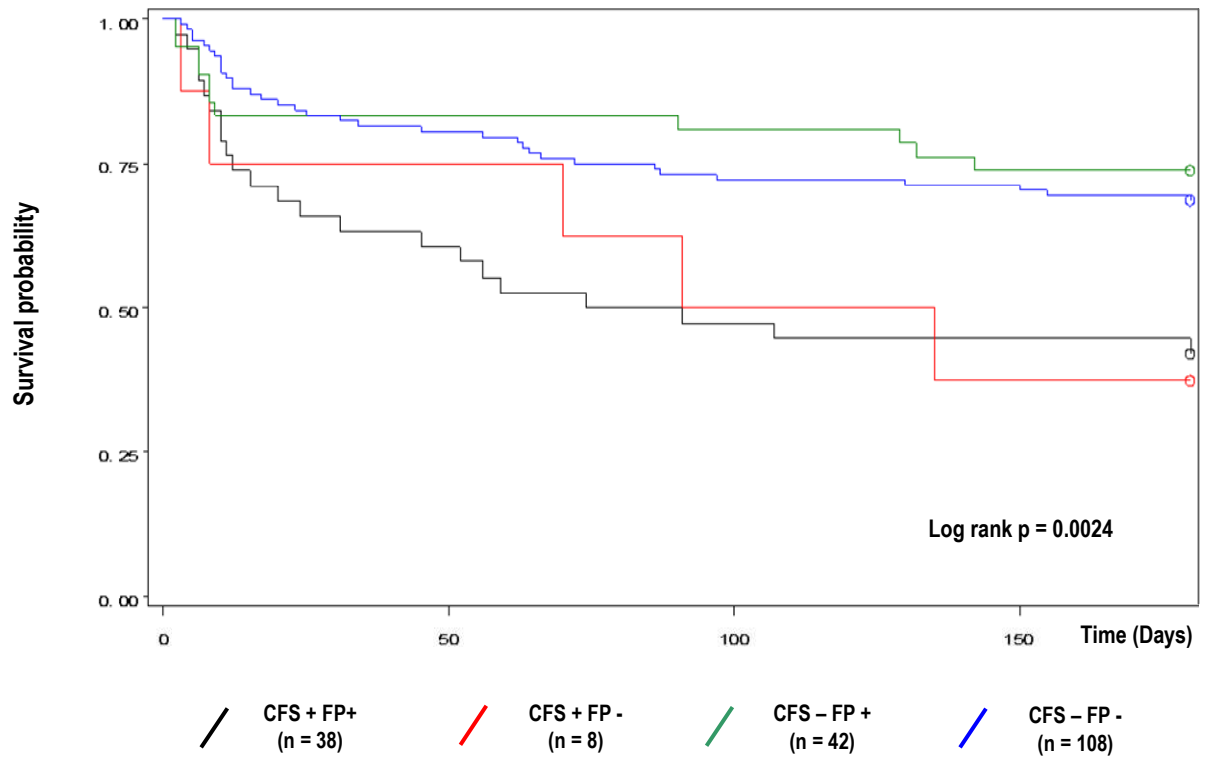
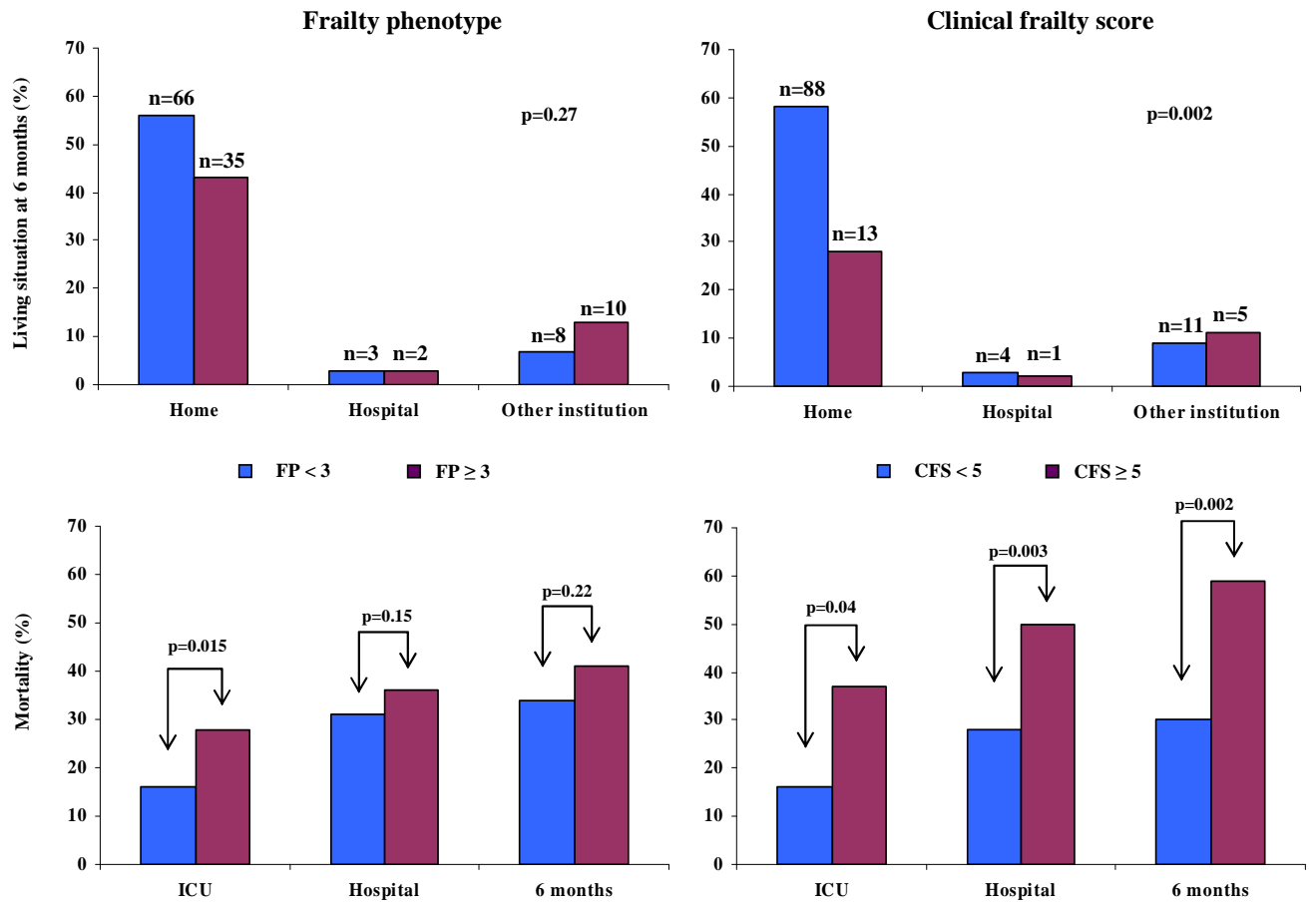


Figure 2.



**Prevalence and impact of frailty on mortality in elderly ICU patients: a
prospective, multicenter observational study.**

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Electronic supplementary material

Online resource 1: Table 1 Frailty phenotype score

Online resource 2: Table 2 Clinical frailty score

Online resource 3: General characteristics of the 4 centers.

Online resource 4: Table 3 Univariate analysis for ICU mortality

Online resource 5: Table 4 Univariate analysis for 6-month mortality

Online resource 6: Table 5 Severity, support and outcome for brain injury patients according to the frailty status

Online resource 7: Table 6 Severity, support and outcome for cardiac arrest patients according to frailty

Online resource 8: Table 7 Severity, support and outcome for brain injury patients according to centers

Online resource 9: Table 8 Severity, support and outcome for cardiac arrest patients according to centers

Online resource 10: Fig 1 Flow chart

Online resource 11: references

Online resource 1.

Table 1: Operationalizing a phenotype of frailty.

| Characteristics of frailty | Original scale [1] | Tools used in our study (adapted from [2]) | |
|----------------------------|--|--|---|
| Shrinking | Unintentionally (not due to dieting or exercise) weight loss ≥ 4.5 kg or more than 5% of body weight in the prior year | Unintentionally (not due to dieting or exercise) weight loss ≥ 4.5 kg or more than 5% of body weight in the prior year | Yes = 1 No = 0 |
| Weakness | Handgrip strength measured by dynamometer (adjusted for gender and body mass index) | Difficulty rising from a chair | Yes = 1 No = 0 |
| Slowness | Time to walk 15 feet, (adjusted for gender and standard height) | Slowed walking speed (during the last 6 months, with difficulties walking and with aid) and/or the occurrence of fall(s). | Yes = 1 No = 0 |
| Low physical activity | Kilocalories expended per week. | Discontinued daily leisure activities such as walking or gardening and/or discontinued some sport activity per week. | Yes = 1 No = 0 |
| Exhaustion | Feeling that everything the patient does is an effort and/or the feeling that he could not get going, as well as how often in the last 3 months he/she felt this way: rarely or not at all=0, occasionally=1, often=2, usually=3 | Feeling that everything the patient does is an effort and/or the feeling that he could not get going, as well as how often in the last 3 months he/she felt this way: rarely or not at all=0, occasionally=1, often=2, usually=3 | Answering 2 or 3 to either of these questions were considered frail (1 point) by exhaustion |

Nonfrail: FP < 3. Frail: FP ≥ 3 .

Online resource 2.

Table 2: Clinical frailty score.

| Score | Frailty grade | Description |
|-------|---------------------|--|
| 1 | Very Fit | People who are robust, active, energetic and motivated. These people commonly exercise regularly. They are among the fittest for their age. |
| 2 | Well | People who have no active disease symptoms but are less fit than category 1. Often, they exercise or are very active occasionally, e.g. seasonally. |
| 3 | Managing well | People whose medical problems are well controlled, but are not regularly active beyond routine walking. |
| 4 | Vulnerable | While not dependent on others for daily help, often symptoms limit activities. A common complaint is being “slowed up”, and/or being tired during the day. |
| 5 | Mildly frail | These people often have more evident slowing, and need help in high order independence in activities of daily living (finances, transportation, heavy housework, medications). Typically, mild frailty progressively impairs shopping and walking outside alone, meal preparation and housework. |
| 6 | Moderately frail | People need help with all outside activities and with keeping house. Inside, they often have problems with stairs and need help with bathing and might need minimal assistance (cuing, standby) with dressing. |
| 7 | Severely frail | Completely dependent for personal care, from whatever cause (physical or cognitive). Even so, they seem stable and not at high risk of dying (within ~ 6 months). |
| 8 | Very severely frail | Completely dependent, approaching the end of life. Typically, they could not recover even from a minor illness. |
| 9 | Terminally Ill | Approaching the end of life. This category applies to people with a life expectancy <6 months, who are not otherwise evidently frail. |

Nonfrail: CFS < 5. Frail: CFS ≥ 5.

Online resource 3.

Table 3: General characteristics of the 4 centers. (A=Rennes, B=Nantes, C=Angers, D=Poitiers)

| | Centers | Total |
|---|--|-------|
| ICU beds (n) | A = 21 B = 17 C = 12 D = 15 | 65 |
| Senior physicians (n FTE) | A = 8 B = 8 C = 3.5 D = 6 | 25.5 |
| Fellows (n FTE) | A = 6 B = 2 C = 3 D = 5 | 16 |
| Nurses (n FTE) | A = 49 B = 34 C = 31 D = 28 | 142 |
| Auxiliary nurses (n FTE) | A = 30 B = 21 C = 20 D = 23 | 94 |
| Admissions to intensive care unit per year (n) | A = 1044 B = 1232 C = 470 D = 576 | 3322 |
| Beds in University Hospital (n) | A = 1323 B = 1650 C = 1185 D = 1247 | 5405 |

FTE: Full time equivalent

ICU: Intensive care unit

Online resource 4.

Table 4: Univariate analysis for ICU mortality.

| | Total (n = 196) | Dead (n = 41) | Alive (n = 155) | <i>p</i> [†] |
|--------------------------------------|---------------------------|-------------------------|---------------------------|-----------------------|
| Age, years | 75 [69 - 79] | 75 ± 6 | 75 ± 6 | 0.70 |
| Sex, male | 128 (65) | 31 (76) | 97 (63) | 0.03* |
| BMI, kg.m⁻² | 27.4 [24.0-30.9] | 27.9 ± 5.7 | 28.1 ± 6.5 | 0.29 |
| Type of admission | | | | |
| Medical | 50 (26) | 13 (32) | 36 (23) | 0.30 |
| Scheduled surgery | 52 (26) | 8 (19) | 44 (28) | |
| Unscheduled surgery | 76 (39) | 14 (34) | 63 (41) | |
| Trauma | 18 (9) | 6 (15) | 12 (8) | |
| At admission | | | | |
| Brain injury | 40 (20) | 11 (27) | 29 (19) | 0.19* |
| Cardiac arrest | 15 (8) | 6 (15) | 9 (6) | 0.08* |
| Infection | 85 (43) | 17 (41) | 68 (44) | 0.55 |
| SAPS II | 46 [35 - 57] | 53 ± 17 | 46 ± 17 | 0.04* |
| SOFA | 7 [4 - 9] | 9 ± 3 | 6 ± 4 | 0.55 |
| Glasgow coma scale | 15 [6 - 15] | 9 ± 5 | 12 ± 5 | 0.18* |
| McCabe score | | | | |
| A | 88 (45) | 19 (46) | 69 (44) | 0.92 |
| B | 85 (43) | 19 (46) | 66 (43) | |
| C | 23 (12) | 3 (8) | 20 (13) | |
| CFS | 4 [3 - 4] | 4.1 ± 2.0 | 3.6 ± 1.4 | 0.04* |
| FP | 2 [1 - 3] | 2.3 ± 1.7 | 2.0 ± 1.4 | 0.02* |
| Charlson Score | 2 [0 - 3] | 2.0 ± 2.0 | 2.1 ± 2.0 | 0.68 |
| Katz Score | 6 [6 - 6] | 5.0 ± 1.9 | 5.3 ± 1.4 | 0.79 |
| Memory disorders | 43 (22) | 13 (32) | 30 (19) | 0.09* |
| Severe sepsis | 73 (37) | 15 (37) | 58 (37) | 0.09* |
| Septic shock | 68 (35) | 16 (39) | 52 (34) | <0.01* |
| Acute renal failure | 83 (42) | 22 (54) | 61 (39) | 0.85 |
| Dialysis | 41 (21) | 11 (27) | 30 (19) | 0.08* |
| ARDS | 14 (7) | 4 (10) | 10 (6) | 0.18 |
| Surgery | 98 (50) | 23 (56) | 75 (48) | 0.32 |
| Corticosteroid treatment | 43 (22) | 12 (29) | 31 (20) | 0.16* |
| Use of neuromuscular blocking | 24 (12) | 9 (22) | 15 (10) | 0.54 |
| Vasopressor use | 113 (58) | 32 (78) | 81 (52) | 0.91 |

Quantitative and qualitative values are expressed as the median [IQR] or mean ± SD and n (%).

[†]Log Rank tests

* Variables selected for Cox model

BMI: Body mass index. SAPS II: Simplified acute physiologic score II. SOFA: Sequential organ failure assessment. FP: Frailty phenotype. CFS: Clinical frailty score. ARDS: Acute respiratory distress syndrome

Online resource 5.

Table 5: Univariate analysis for 6-month mortality.

| | Total (n = 196) | Dead (n = 72) | Alive (n = 124) | <i>p</i>† |
|--------------------------------------|----------------------------|--------------------------|----------------------------|------------------|
| Age, years | 75 [69 - 79] | 75 ± 7 | 75 ± 6 | 0.88 |
| Sex, male | 128 (65) | 50 (69) | 78 (63) | 0.33 |
| BMI, kg.m⁻² | 27.4 [24.0 - 30.9] | 28.0 ± 7.3 | 28.1 ± 5.7 | 0.19* |
| Type of admission | | | | |
| Medical | 50 (26) | 23 (32) | 27 (22) | 0.44 |
| Scheduled surgery | 52 (26) | 16 (22) | 36 (29) | |
| Unscheduled surgery | 76 (39) | 27 (38) | 49 (39) | |
| Trauma | 18 (9) | 6 (8) | 12 (10) | |
| At admission | | | | |
| Brain injury | 40 (20) | 17 (24) | 23 (19) | 0.25 |
| Cardiac arrest | 15 (8) | 8 (11) | 7 (6) | 0.10* |
| Infection | 85 (43) | 33 (46) | 52 (42) | 0.73 |
| SAPS II | 46 [35 - 57] | 52 ± 18 | 46 ± 16 | 0.01* |
| SOFA | 7 [4 - 9] | 8 ± 3 | 6 ± 4 | <0.01* |
| Glasgow coma scale | 15 [6 - 15] | 10 ± 5 | 12 ± 5 | 0.18* |
| McCabe score | | | | |
| A | 88 (45) | 31 (43) | 57 (46) | 0.90 |
| B | 85 (43) | 32 (44) | 53 (43) | |
| C | 23 (12) | 9 (13) | 14 (11) | |
| CFS | 4 [3 - 4] | 4.2 ± 1.9 | 3.4 ± 1.3 | <0.01* |
| FP | 2 [1 - 3] | 2.3 ± 1.6 | 1.9 ± 1.4 | 0.21 |
| Charlson Score | 2 [0 - 3] | 2.3 ± 2.1 | 2.0 ± 1.9 | 0.95 |
| Katz Score | 6 [6 - 6] | 4.8 ± 1.8 | 5.5 ± 1.3 | <0.01* |
| Memory disorders | 43 (22) | 17 (24) | 26 (21) | 0.64 |
| Severe sepsis | 73 (37) | 27 (37) | 46 (37) | 0.79 |
| Septic shock | 68 (35) | 29 (40) | 39 (31) | 0.41 |
| Acute renal failure | 83 (42) | 35 (49) | 48 (39) | 0.18* |
| Dialysis | 41 (21) | 19 (26) | 22 (18) | 0.21 |
| ARDS | 14 (7) | 5 (7) | 9 (7) | 0.95 |
| Surgery | 98 (50) | 39 (54) | 59 (48) | 0.58 |
| Corticosteroid treatment | 43 (22) | 19 (26) | 24 (19) | 0.26 |
| Use of neuromuscular blocking | 24 (12) | 11 (15) | 13 (10) | 0.33 |
| Vasopressor use | 113 (58) | 50 (69) | 63 (51) | <0.01* |

Quantitative and qualitative values are expressed as the median [IQR] or mean ± SD and n (%).

†Log Rank tests

* Variables selected for Cox model

BMI: Body mass index. SAPS II: Simplified acute physiologic score II. SOFA: Sequential organ failure assessment. FP: Frailty phenotype. CFS: Clinical frailty score. ARDS: Acute respiratory distress syndrome

Online resource 6 .

Table 6: Support and outcome for brain injury patients according to frailty.

| | Total (n=40) | FP ≥ 3 (n = 12) | FP < 3 (n = 28) | <i>p</i> † | CFS ≥ 5 (n= 7) | CFS < 5 (n= 33) | <i>p</i> † |
|--|------------------------|---------------------------|------------------------------|------------|--------------------------|------------------------------|------------|
| Type of brain injury | | | | | | | |
| Trauma | 16 (40) | 5 (42) | 11 (39) | 0.90 | 4 (57) | 12 (36) | 0.51 |
| aneurismal subarachnoid hemorrhage | 12 (30) | 4 (33) | 8 (29) | | | | |
| Other acute stroke | 12 (30) | 3 (25) | 9 (32) | | | | |
| Dialysis | 3 (7) | 2 (17) | 1 (4) | 0.21† | 1 (14) | 2 (6) | 0.45 |
| Surgery, n | 23 (57) | 6 (50) | 17 (61) | 0.73† | 4 (57) | 19 (58) | 1.0 |
| SAPS II | 48 ± 13 | 50 ± 17 | 47 ± 12 | 0.62 | 53 ± 12 | 47 ± 14 | 0.32 |
| SOFA | 6 ± 3 | 6 ± 2 | 6 ± 3 | 0.65 | 6 ± 2 | 6 ± 3 | 0.98 |
| CFS | 3.1 ± 1.6 | 4.6 ± 1.2 | 2.5 ± 1.2 | < 0.01 | 5.7 ± 0.8 | 2.5 ± 1.0 | < 0.01 |
| FP | 1.8 ± 1.5 | 3.7 ± 0.8 | 1.0 ± 0.8 | < 0.01 | 3.4 ± 1.1 | 1.5 ± 1.3 | < 0.01 |
| Mechanical ventilation duration, days | 10 ± 9 | 8 ± 9 | 11 ± 10 | 0.31 | 10 ± 9 | 10 ± 10 | 0.93 |
| Limitation or discontinuance of treatment | 10 (25) | 3 (25) | 7 (25) | 1.0† | 3 (43) | 7 (21) | 0.34 |
| Length of stay, days | | | | | | | |
| ICU | 14 ± 12 | 12 ± 11 | 15 ± 13 | 0.41 | 13 ± 8 | 15 ± 13 | 0.78 |
| Hospital | 33 ± 30 | 28 ± 24 | 34 ± 32 | 0.55 | 25 ± 19 | 34 ± 32 | 0.45 |
| Mortality | | | | | | | |
| ICU | 11 (27) | 4 (33) | 7 (25) | 0.70 | 3 (43) | 8 (24) | 0.37 |
| Hospital | 16 (40) | 5 (42) | 11 (39) | 1.0† | 4 (57) | 12 (36) | 0.41 |
| 6-month | 16 (40) | 5 (42) | 11 (39) | 1.0† | 4 (57) | 12 (36) | 0.41 |

† Fisher exact tests and Wilcoxon tests.

SAPS II: Simplified acute physiologic score II. SOFA: Sequential organ failure assessment. FP: Frailty phenotype. CFS: Clinical frailty score

Online resource 7.

Table 7: Severity, support and outcome for cardiac arrest patients according to the frailty status.

| | Total (n=15) | FP ≥ 3 (n = 7) | FP < 3 (n = 8) | <i>p</i> † | CFS ≥ 5 (n= 7) | CFS < 5 (n= 8) | <i>p</i> † |
|--|-------------------------------|---------------------------------|------------------------------------|------------|---------------------------------|------------------------------------|------------|
| SAPS II | 57 ± 27 | 58 ± 27 | 57 ± 28 | 0.94 | 56 ± 29 | 58 ± 27 | 0.14 |
| SOFA | 10 ± 5 | 9 ± 4 | 11 ± 5 | 0.44 | 8 ± 4 | 11 ± 5 | 0.27 |
| Surgery, n | 6 (40) | 3 (43) | 3 (37) | 1.0 | 4 (57) | 2 (25) | 0.31 |
| CFS | 4.3 ± 2.1 | 5.9 ± 1.5 | 2.9 ± 1.5 | < 0.01 | 6.0 ± 1.3 | 2.8 ± 1.3 | < 0.01 |
| FP | 2.2 ± 1.8 | 4.0 ± 0.6 | 0.6 ± 0.5 | < 0.01 | 3.6 ± 1.3 | 1.0 ± 1.3 | < 0.01 |
| Dialysis | 6 (40) | 3 (43) | 3 (37) | 1.0 | 3 (43) | 3 (37) | 1.0 |
| Mechanical ventilation duration, days | 14 ± 15 | 7 ± 4 | 19 ± 19 | 0.12 | 7 ± 5 | 20 ± 18 | 0.10 |
| Limitation or discontinuance of treatment | 5 (33) | 3 (43) | 2 (25) | 0.61 | 3 (43) | 2 (25) | 0.61 |
| Length of stay, days | | | | | | | |
| ICU | 16 ± 17 | 8 ± 5 | 23 ± 20 | 0.07 | 8 ± 5 | 22 ± 21 | 0.10 |
| Hospital | 27 ± 22 | 15 ± 5 | 38 ± 26 | 0.04 | 17 ± 5 | 36 ± 28 | 0.10 |
| Mortality | | | | | | | |
| ICU | 6 (40) | 3 (43) | 3 (37) | 1.0 | 3 (43) | 3 (37) | 1.0 |
| Hospital | 7 (47) | 3 (43) | 4 (50) | 1.0 | 3 (43) | 4 (50) | 1.0 |
| 6-month | 8 (53) | 4 (57) | 4 (50) | 1.0 | 4 (57) | 4 (50) | 1.0 |

† Fisher exact tests and Wilcoxon tests.

SAPS II: Simplified acute physiologic score II. SOFA: Sequential organ failure assessment. FP: Frailty phenotype. CFS: Clinical frailty score

Online resource 8.

Table 8: Severity, support and outcome for brain injury patients according to centers (A=Rennes, B=Nantes, C=Angers, D=Poitiers).

| Center | Total (n=40) | A (n = 23) | B (n = 12) | C (n= 4) | D (n= 1) | p[†] |
|--|-------------------------|-----------------------|-----------------------|---------------------|---------------------|----------------------|
| SAPS II | 48 ± 13 | 48 ± 13 | 50 ± 14 | 50 ± 3 | 16.0±0 | 0,11 |
| SOFA | 6 ± 3 | 5 ± 3 | 8 ± 2 | 7 ± 3 | 5.0±0 | 0.06 |
| Surgery, n | 23 (57) | 13 (56) | 9 (75) | 1 (25) | 0 (0) | 0.20 |
| Dialysis, n | 3 (7) | 3 (13) | 0 (0) | 0 (0) | 0 (0) | 0.50 |
| Mechanical ventilation duration, days | 10 ± 9 | 6 ± 7 | 19 ± 9 | 9 ± 5 | 8.0±0 | < 0.01 |
| Limitation or discontinuance of treatment | 10 (25) | 3 (13) | 5 (42) | 2 (50) | 0 (0) | 0.16 |
| Length of stay, days | | | | | | |
| ICU | 14 ±12 | 9 ± 9 | 25 ± 14 | 11 ± 4 | 22 ± 0 | < 0.01 |
| Hospital | 33 ± 30 | 27 ± 30 | 47 ± 29 | 24 ± 24 | 32 ± 0 | 0.27 |
| Mortality | | | | | | |
| ICU | 11 (27) | 6 (26) | 3 (25) | 2 (50) | 0 (0) | 0.69 |
| Hospital | 16 (40) | 9 (39) | 5 (42) | 2 (50) | 0 (0) | 0.84 |
| 6-month | 16 (40) | 9 (39) | 5 (42) | 2 (50) | 0 (0) | 0.84 |

† ANOVA analysis

SAPS II: Simplified acute physiologic score II. SOFA: Sequential organ failure assessment. FP: Frailty phenotype. CFS: Clinical frailty score

Online resource 9.

Table 9: Severity, support and outcome for cardiac arrest patients according to centers

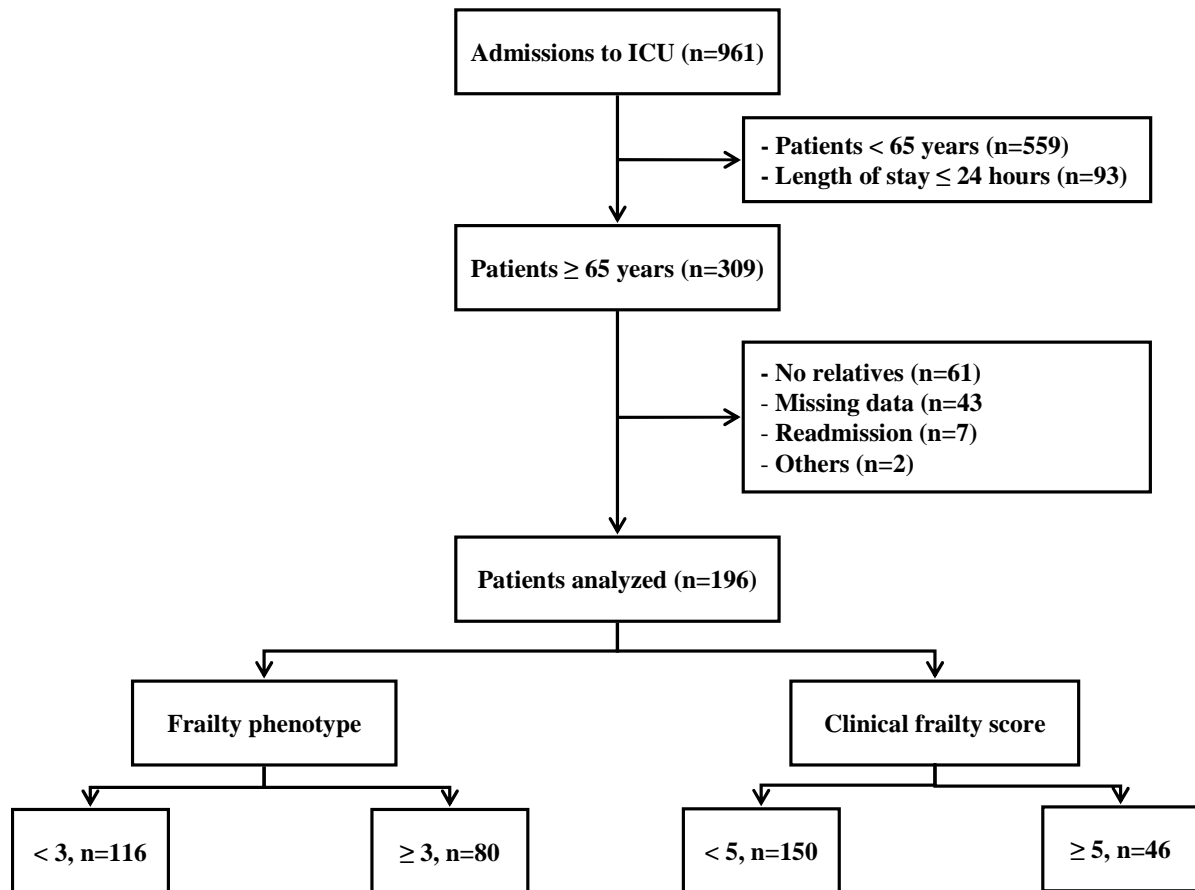
| Center | Total (n=15) | A (n = 6) | B (n = 5) | C (n= 2) | D (n= 2) | p[†] |
|--|-------------------------|----------------------|----------------------|---------------------|---------------------|----------------------|
| SAPS II | 57 ± 27 | 56 ± 22 | 64 ± 34 | 74 ± 27 | 29 ± 5 | 0.39 |
| SOFA | 10 ± 5 | 9 ± 6 | 10 ± 4 | 11 ± 3 | 9 ± 1 | 0.97 |
| Surgery, n | 6 (40) | 3 (50) | 3 (60) | 0 (0) | 0(0) | 0.29 |
| Dialysis, n | 6 (40) | 3 (50) | 2 (40) | 1 (50) | 0 (0) | 0.64 |
| Mechanical ventilation duration, days | 14 ± 15 | 11 ± 11 | 14 ± 22 | 25 ± 13 | 7 ± 1 | 0.67 |
| Limitation or discontinuance of treatment | 5 (33) | 2 (13) | 1 (7) | 0 (0) | 2 (13) | 0.15 |
| Length of stay, days | | | | | | |
| ICU | 16 ± 17 | 12 ± 12 | 19 ± 25 | 26 ± 12 | 8 ± 0 | 0.69 |
| Hospital | 27 ± 22 | 23 ± 11 | 32 ± 35 | 42 ± 11 | 12 ± 6 | 0.58 |
| Mortality | | | | | | |
| ICU | 6 (40) | 2 (33) | 1 (20) | 1 (50) | 2 (100) | 0.26 |
| Hospital | 7 (47) | 3 (50) | 1 (20) | 1 (50) | 2 (100) | 0.29 |
| 6-month | 8 (53) | 3 (50) | 2 (40) | 1 (50) | 2 (100) | 0.54 |

† ANOVA tests

SAPS II: Simplified acute physiologic score II. SOFA: Sequential organ failure assessment. FP: Frailty phenotype. CFS: Clinical frailty score (A=Rennes, B=Nantes, C=Angers, D=Poitiers)

Online resource 10.

Figure 1. Flow chart.



Online resource 11.

References.

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