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1-year survival in critically ill elderly medical patients treated with a conservative or an invasive approach (OCTO-REVERSE study): a nationwide observational study

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ABSTRACT

Objective To determine whether an invasive approach is associated with favourable long-term outcomes among elderly medical patients in the intensive care unit (ICU), compared with a conservative approach.

Design Nationwide observational study (OCTO-REVERSE study) using data prospectively collected in the National French Healthcare Database (covering 99% of the population, 66 million people).

Setting Comprehensive multicentre study through the linkage of large-scale national registries (including all public or private facilities) from 2013 to 2018 to avoid ambiguities related to the COVID-19 pandemic.

Participants All non-surgical patients aged 80 years or older admitted to an ICU in France during the period (n=107 014 patients at 822 hospitals).

Outcome measures The main outcome was the 1-year survival rate. The association of the two approaches with 1-year survival was estimated using a time-dependent Cox model and a propensity score (PS) adapted to time-to-event analysis, yielding the average treatment effect in the treated and extended weighted Kaplan–Meier curves.

Results 107 014 patients were categorised into two groups based on the type of care received: invasive (n=51 680 (48%) received invasive ventilation and/or vasopressor support) or conservative (n=55 334 (52%) received neither). 1-year survival rate was significantly lower in the invasive group than in the conservative group (27% vs 59% estimated with extended time-dependent Kaplan–Meier method). The risk of death in the invasive group remained significantly higher after time-dependent PS weighting (HR 1.64; 95% CI 1.60 to 1.69; p<0.001). The loss in restricted mean survival time was 67.7 days (95% CI 65.7 to 69.8) in this group and 31% of deaths occurred the day of initiation of the procedure, or the following day.

Conclusion Among the whole population of critically ill elderly medical patients in France, the invasive approach was unknowingly associated with end-of-life care in nearly three quarters of cases. Further research is needed to align intensive care with compassionate goals.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This study uses the National French Healthcare Database, which records all medical procedures coded for reimbursement, ensuring exhaustiveness and real-world representativeness.
⇒ This study employs a robust time-dependent analysis using the extended Kaplan–Meier method, which accounts for variations in treatment exposure over time and improves survival estimates.
⇒ The simplified acute physiology score II, used in the propensity score model as the main severity adjustment factor, proved to be the primary determinant in balancing patient characteristics between groups.
⇒ The main limitation is the presence of potential unmeasured confounding factors, including key clinical parameters that could influence both treatment decisions and patient outcomes.
⇒ Information on whether care was withheld or withdrawn is not available, making it difficult to assess the impact of end-of-life decisions on mortality differences.

INTRODUCTION

The proportion of older patients in the intensive care unit (ICU) has been steadily increasing over the past two decades, although the overall benefit to patient outcomes remains unclear.[1] Many studies have explored this topic, but variations in patient selection (age 65–90, surgical vs medical and invasive vs conservative care) and outcome measures (mortality vs functional status and early vs delayed assessment) have led to uncertain conclusions.[2] Additional research is needed to address the care consequences of this growing population. However, a randomised trial has been deemed infeasible on ethical grounds.[3] The ensuing uncertainty may have led to a decision-making process based solely on clinical judgement, while triage systems based on even limited evidence would have been preferable.[4] In addition, overoptimistic expectations[5] of outcomes could have favoured the expansion of time-limited trials,[6] some of which turned out to be disproportionate. Previous studies on this issue[7–9] have identified older age (≥80 years),[10] non-operative condition[11] and exposure to invasive procedures (primarily invasive mechanical ventilation and vasopressor therapy)[12–14] as prognostic factors that should be considered especially as to long-term outcomes. By conducting a nationwide study that combines these three factors, we aimed to assess the characteristics, management and 1-year survival of the entire target population of elderly patients admitted to the ICU for medical reasons in France.

METHODS

Study design and data sources

We performed a nationwide retrospective analysis (OCTO-REVERSE study) using data prospectively collected in the Système National des Données de Santé (SNDS), the national French healthcare database that covers 99% of the population regardless of socioeconomic status (66 million). The SNDS was created for hospital payment and government purposes, and regular audits are conducted to ensure reliability and completeness. The SNDS also facilitates epidemiological research, with a specific interest in ageing by an extended follow-up. Formal methods have been developed to assess the strengths and limitations of databases, and population-level data have enhanced our understanding of the use and outcomes of mechanical ventilation,[12] particularly for elderly patients hospitalised in ICUs in France.[15–17] The SNDS links the national hospital discharge database of diagnosis-related groups (DRGs) 'PMSI (Programme de Médicalisation des Systèmes d'Information (French national hospital discharge database))' with the national death registry 'CépiDC', enabling the tracking of individual patient trajectories from any hospital stay through to death. This allows for the identification of the date and place of death, whether it occurs in hospital or in the community. It contains comprehensive medical and administrative data for all patients in the country. This linkage of large-scale French national registry populations contributes to guiding public decisions. Each patient is assigned a unique identification number with pseudonymised information, allowing individuals to be followed over time by linking inpatient and outpatient data from each hospitalisation in all public or private facilities in France. Procedures, including surgery or life-sustaining treatments, are time stamped and coded using a national classification system called CCAM (Classification Commune des Actes Médicaux (Common Classification of Medical Procedures)) (online supplemental appendix 1).

The study was submitted to and approved by the independent national data protection authority (CNIL (Commission Nationale de l'Informatique et des Libertés (French Data Protection Authority)) Registration: 920181). All data were deidentified for research purposes, and French law waives the need for informed consent. An independent institutional review board approved the study protocol (Institutional Review Board (IRB) Registration: #00011928).

Study population

All patients aged 80 years or older with complete data, admitted to hospitals in France from January 2013 to December 2018 (to avoid any ambiguities related to COVID-19), were eligible. We then selected ICU stays where the simplified acute physiology score (SAPS) II is comprehensively collected. To select the non-operative condition, we excluded stays that involved a surgery or whose DRG was surgical (or severe burn injury), either during the ICU stay or within 30 days prior to the ICU admission. To avoid counting multiple hospital outcomes for a single patient, only the first hospital stay, including a medical admission to an ICU during the study period, was considered for each patient, and readmission stays were excluded. Finally, we considered the invasive condition for patients who underwent invasive mechanical ventilation (CCAM codes GLLD004, GLLD008 and GLLD015) or vasopressor support (CCAM codes EQLF001 and EQLF003) (online supplemental table 2, appendix 1).

Variables and exposure

The exposure variable was defined as the first occurrence of one of the following invasive procedures during the ICU stay: vasopressor support or invasive mechanical ventilation. We focused on these two main modifiable factors of interest because clinicians often question their benefit for the oldest patients. This choice was also driven by their coding reliability, as there is a clear-cut bedside decision without delay, marking a turning point in the patient's trajectory. We did not include non-invasive ventilation (NIV) because its use as a palliative treatment for dyspnoea has become increasingly common. We also did not include renal replacement therapy (RRT) due to the large grey area in coding between acute and chronic situations, and because its initiation can often be delayed without threatening the prognosis.[18] We addressed potential confounding resulting from variation in the case mix by controlling for age, severity of illness, pre-existing medical conditions expressed by the Charlson comorbidity index, primary diagnosis at admission, preadmission location and academic status of the ICU. These confounders were specified a priori to develop a risk adjustment model for mortality. Patients were followed until death or the end of the year 2019, whichever occurred sooner. The invasive and non-invasive cohorts were mutually exclusive.

Outcomes

The primary objective of our analysis was to describe the 1-year mortality of two populations of elderly medical ICU patients based on the treatment intensity (invasive vs conservative care). Additionally, we analysed intermediate mortality rates and lengths of stay, both in ICU and in hospital.

Statistical analysis

Characteristics of patients according to the use of invasive procedures were described using mean and SD for age and median and IQR for other continuous variables. Categorical variables were presented as counts and percentages. Comparisons between the two groups were performed using the Wilcoxon test for continuous variables and the χ^2 test for categorical variables. Crude mortality rates were calculated at ICU and hospital discharge, along with 1-year readmission rates and the duration of procedures and hospital stays, for both groups and for each invasive procedure (online supplemental appendix 2, pp. 11–12).

Survival was measured from the date of ICU admission to the date of death or censored at the last follow-up. To limit immortal time bias, the occurrence of any invasive procedure was considered as a time-dependent covariate. Time precision was day, and the time of death was shifted by 0.1 day to avoid ties with the time of the procedure. Multivariate analysis of survival was performed by a Cox proportional hazards (PHs) model producing HRs. The handling of ties used the Efron approximation. The PH assumption was verified by scaled Schoenfeld residuals. The time-varying effect of a procedure was modelled by adding an interaction term between the corresponding covariate and some transformation of time. The restricted mean survival time (RMST) method was selected because it is not dependent on the number of events and on the assumption of PHs, as is the case in time-to-event analyses. RMST reflects the life expectancy of patients up to a specified time. Details regarding the statistical methods are provided in online supplemental appendix 1. As patients receiving invasive procedures may differ from the conservative ones, a propensity score (PS) was used to minimise the effects of confounding. Assumed confounders included age, sex, pre-existing comorbidities (Charlson comorbidity index), SAPS II score, year, reason for admission, availability of a palliative or geriatric care team in the hospital, preadmission location, ICU level and hospital characteristics (online supplemental figure S2 and table S1, appendix 1). However, the population at risk changes over time due to attrition (death or discharge). Therefore, we used an inverse probability of treatment weighting (IPTW) method adapted to the time-dependent context.[19] IPTW usually estimates the average effect of treatment when the entire sample is moved from control to treated. But this seemed unrealistic for invasive support in the elderly population, so here IPTW targeted the average treatment effect in the treated (ATT). We divided the time span into strata within which a distinct PS could be calculated. These strata were each day until day 14, then periods 14–20, 20–30, every 15 days until 120 and then every 30 days until 365 (case base). This time-stratified PS was built using a Cox model that predicted the use of invasive procedures by variables available at admission. The influence of continuous variables (age and SAPS II) was modelled by fractional polynomials. Variable balance was assessed by examining the standardised mean differences before and after weighting. Weights were trimmed at the 1st and 99th percentiles. To remove residual confounding as much as possible, we combined weighting at the design stage with regression adjustment on the same confounders (as listed in online supplemental figure S2 and table S1, appendix 1) at the analysis stage when estimating treatment effects.[20] A robust sandwich-type estimator was used to calculate SEs.

We performed sensitivity analyses to assess the robustness of the overall HR associated with invasive procedures: initially by using ATT weights truncated at the 5th and 95th percentiles, then by using time strata defined by every day, an invasive procedure or death occurred.

All tests were two sided, and a p value<0.05 was considered statistically significant. The analysis used the SAS Enterprise Guide V.7.15 (SAS Institute Inc., Cary, NC, USA) provided by the SNDS infrastructure.

Patient and public involvement

None.

RESULTS

The final analysis included 107 014 first stays of patients aged 80 years or older who were admitted to an ICU for medical reasons at 822 hospitals, mostly publicly funded (65%), in France between 2013 and 2018. Among those patients, 51 680 (48%) received invasive ventilation or vasopressors, and 55 334 (52%) received neither of the two. A flowchart of patients and stays in the study is shown in figure 1.

The demographic characteristics and the outcomes since ICU admission are shown in table 1. The mean age was 84.6 years. More than half (52%) were male in the invasive group, and 52% were female in the conservative group. Overall, 89% were admitted from home, with most of them having a stop at the emergency department (59%). Patients in the invasive group had a significantly higher severity of illness at admission as reflected by a higher SAPS II but fewer general coexisting conditions as reflected by a lower Charlson comorbidity index. Over the years, the flow of patients was increasingly directed towards the invasive group. Among 51 680 (48%) patients in the invasive group, 70% were dead at 1 year, while among 55 334 (52%) patients in the conservative group, 41% were dead at 1 year (χ^2 test, p<0.001).

Outcomes of patients in the invasive group since ICU admission are detailed in table 2. Among 38 427 patients who underwent vasopressors, 72% were dead at 1 year. Among 40 495 patients who received invasive ventilation, 72% were dead at 1 year. Patients who received a first invasive procedure were likely to receive the other one in 53% of cases, and 1 year mortality was then 77%, whereas it was 60% and 63%, respectively, for vasopressors only or ventilation only. Among 8761 patients who underwent RRT (regardless of the group), 74% were dead at 1 year. The

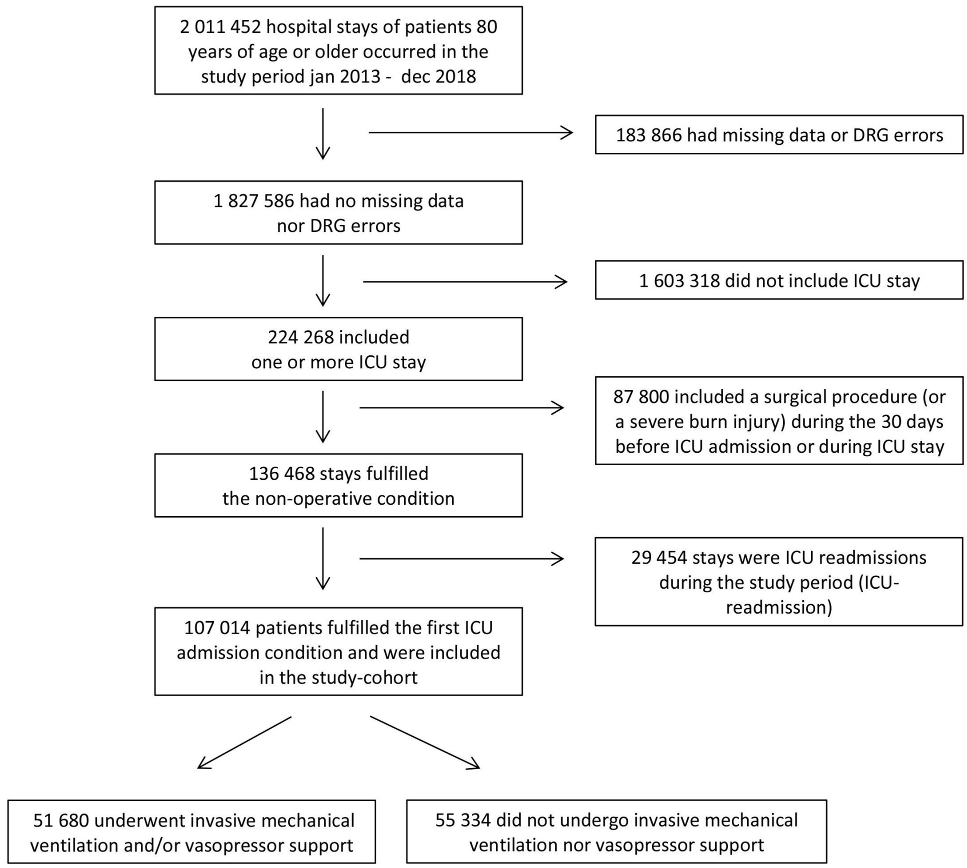

Figure 1 Flowchart of patients and stays in the study. DRG errors correspond to stays that could not be assigned to a DRG, mainly due to coding inconsistencies or inaccuracies in the classification of hospital stays, such as misclassification of diagnoses, procedures or administrative coding discrepancies. DRG, diagnosis-related group; ICU, intensive care unit.

median number of days in the ICU was 4 (IQR 2–8). The median number of days in the hospital was 8 (IQR 2–16). The median duration of ventilation was 3 days (IQR 2–7). There were 2582 patients who underwent prone positioning. In their case, the median number of sessions was 2 (IQR 1–3) per patient. The median duration of vasopressor support was 2 days (IQR 1–4). The time of the initial invasive procedure was the day of ICU admission for 79% of patients in the invasive group and the following day for an additional 9% (online supplemental figure S1, appendix 1). More than half of the patients in the invasive group had both procedures, generally on the same day (86%). If vasopressors predated ventilation (6%) or ventilation predated vasopressors (9%), the median interval of initiation was 1 day (IQR 1–3). 24% of deaths in the invasive group occurred on the day of the initiation of any procedure, and 7% the following day.

After the calculation of the time-stratified PS, the balance obtained on ATT weighted samples was good, with absolute standardised differences less than 0.1 (online supplemental figure S2, appendix 1). The test of Schoenfeld residuals for the PHs assumption was significant, as the HR was decreasing over time (online supplemental figure S4, appendix 1). Kaplan–Meier survival curves obtained before and after the time-stratified ATT weighting are presented in figure 2. ATT weighting induced a decrease in 1-year survival rate in the conservative group from 59% to 43% (95% CI 0.421 to 0.441) versus 27% in the invasive group (95% CI 0.268 to 0.276, remained unchanged after ATT weighting, as expected). The mortality in the invasive group remained significantly higher after time-dependent IPTW (HR 1.64; 95% CI 1.60 to 1.69; p<0.001). Life expectancy limited to 1 year was 117.5 days in the invasive group versus 185.2 days in the conservative group, resulting in a significant loss of 67.7 days (RMST, 95% CI 65.7 to 69.8).

In the sensitivity analysis, neither the use of ATT weights truncated at the 5th and 95th percentiles nor the use of a different time-stratification pattern changed substantially the HR associated with invasive procedures. Finally, the combination of weighting and further adjustment on baseline covariates (year, age, sex, coexisting conditions, admission source, severity and academic status) produced a similar HR (HR 1.67; 95% CI 1.63 to 1.73; p<0.001) (online supplemental appendix 1).

DISCUSSION

Several studies support conservative management over invasive approaches,[18 21 22] and there is concern that invasive procedures may worsen the prognosis of older ICU patients.[23 24] Our large nationwide study was designed

Table 1 Patient characteristics*

	All Patients (n=107 014)	Invasive group (n=51 680)	Conservative group (n=55 334)	P value
Percentage of patients	100	48	52	
Mean age—Yr	84.6±3.6	84.3±3.4	84.9±3.7	<0.001
Male sex—no (%)	53 457 (50)	26 785 (52)	26 672 (48)	<0.001
Year of enrolment—no (%)				<0.001
2013	17 138 (16)	7756 (15)	9382 (17)	
2014	17 484 (16)	8013 (16)	9471 (17)	
2015	18 286 (17)	8612 (17)	9674 (18)	
2016	18 312 (17)	9143 (18)	9169 (17)	
2017	18 284 (17)	9236 (18)	9048 (16)	
2018	17 510 (16)	8920 (17)	8590 (16)	
Admission source—no (%)				<0.001
Home	31 703 (30)	15 079 (29)	16 624 (30)	
Emergency department	63 032 (59)	30 446 (59)	32 586 (59)	
Other skilled facility	12 279 (11)	6155 (12)	6124 (11)	
Hospital status—no (%)				<0.001
Private	17 411 (16)	5226 (10)	12 185 (22)	
Public academic	28 394 (27)	15 024 (29)	13 370 (24)	
Public non-academic	61 209 (57)	31 430 (61)	29 779 (54)	
Geriatric team in the hospital—no (%)	78 973 (74)	41 717 (81)	37 256 (67)	<0.001
Palliative care team in the hospital—no (%)	61 089 (57)	33 089 (64)	28 000 (51)	<0.001
Coexisting conditions—no (%)				<0.001
Cardiac disease	39 659 (37)	18 384 (36)	21 275 (39)	
Respiratory disease	31 807 (30)	14 046 (27)	17 761 (32)	
Renal disease	28 344 (27)	12 937 (25)	15 407 (28)	
Neurological disease	12 062 (11)	6305 (12)	5757 (10)	
Cognitive impairment	10 651 (10)	4996 (10)	5655 (10)	
Cirrhosis	3622 (3)	1936 (4)	1686 (3)	
Diabetes	16 191 (15)	7723 (15)	8468 (15)	
Cancer	19 162 (18)	9083 (18)	10 079 (18)	
CCI				<0.001
Median (IQR)	2 (1–4)	2 (1–4)	2 (1–4)	
CCI=0	23 972 (22%)	12 698 (25%)	11 274 (20%)	
Immunodeficiency—no (%)	20 753 (19)	9884 (19)	10 869 (20)	<0.001
Median SAPS II—(IQR)	45 (34–63)	59 (45–76)	37 (30–46)	<0.001
Diagnosis category—no (%)				<0.001
Circulatory	40 189 (38)	20 773 (40)	19 416 (35)	
Respiratory	29 926 (28)	13 682 (27)	16 244 (29)	
Neurometabolic	36 899 (35)	17 225 (33)	19 674 (36)	
Outcomes†				<0.001
1-year mortality—no (%)	58 955 (55)	36 019 (70)	22 936 (41)	
ICU mortality—no (%)	32 160 (30)	26 152 (51)	6008 (11)	
In-hospital mortality—no (%)	37 354 (35)	28 438 (55)	8916 (16)	
Median length of stay—days (IQR)				<0.001
In ICU	4 (2–8)	5 (2–11)	3 (1–6)	

Continued

Table 1 Continued

	All Patients (n=107 014)	Invasive group (n=51 680)	Conservative group (n=55 334)	P value
In hospital	8 (2–16)	7 (1–18)	8 (3–14)	
ICU readmission within the year—no (%)				<0.001
In patients from enrolment	23 846 (22)	6894 (13)	16 952 (31)	
In ICU survivors	23 846 (32)	6894 (27)	16 952 (34)	
Hospital discharge for survivors—no (%)				<0.001
Home	35 312 (51)	9016 (39)	26 296 (57)	
Other skilled facility	34 348 (49)	14 226 (61)	20 122 (43)	

P values correspond to statistical tests assessing whether there is a significant difference between the two groups. Variation in comorbidity burden and underlying physiological robustness may have influenced the decision to initiate invasive care, contributing to baseline differences between groups.
*Plus–minus values are means ±SD. Percentages may not sum to 100 because of rounding.
†Crude unweighted outcomes since ICU admission, without regards fto the time-to-event analysis.
CCI, Charlson comorbidity index; ICU, intensive care unit; SAPS II, simplified acute physiology score II.

to describe the association between invasive care and mortality in real-world clinical practice. Our findings suggest that invasive procedures are a negative determinant, but as an observational study, it cannot be concluded as evidence of harm or non-inferiority between the two groups.

However, the high mortality rate in the invasive group is per se our main finding. With a 1-year survival rate of 27%, it seems reasonable that a large portion of elderly patients may not be best served by invasive care. This calls into question the upward trend of time-limited trials that could lead to ethical misunderstanding, especially as the survival curves separated early on with a rapid decrease in the invasive group. The high proportion of early deaths in the invasive group most likely reflects the natural progression of an irreversible disease rather than complications from the procedure. This interpretation is supported by the strong culture of safety and patient-family engagement in ICU care, which prioritises harm prevention and appropriate treatment escalation.[25]

The need for invasive care is not merely a treatment choice but also a marker of increased severity. Thus, the poor prognosis associated with invasive care is expected and reflects underlying disease severity rather than the direct impact of invasiveness itself. However, if invasiveness reflects increased severity, then a strict dichotomy between invasive and non-invasive approaches may seem overly simplistic, given that the relationship between the degree of invasiveness and prognosis is likely more gradual. This is supported by the sigmoidal relationship between SAPS II and mortality,[26] resembling a dose–response effect. Nevertheless, we deliberately adopted this classification to avoid borderline situations and to describe the two extremes of the therapeutic spectrum in intensive care.

Admittedly, the non-invasive group likely comprises two distinct populations: patients who are not severe enough to require invasive intervention and those who are too critically ill to benefit from it. However, when considered as a whole, the non-invasive group remains fundamentally distinct from the invasive cohort, where a paradigm shift in care is always required. The two populations we studied differ not in the degree of care received but in the nature of care itself. This distinction is crucial, as

Table 2 Outcomes in the invasive group (n=51 680)*

		Mortality—no (%)			Median length of stay—days (IQR)	
	No (%)	ICU	Hospital	1 year	ICU	Hospital
All vasopressors (± ventilations)	38 427 (74)	20 606 (54)	22 281 (58)	27 694 (72)	5 (2–12)	8 (3–18)
All ventilations (± vasopressors)	40 495 (78)	22 632 (56)	24 217 (60)	29 331 (72)	5 (2–12)	7 (1–18)
Vasopressors only	11 185 (22)	3520 (32)	4221 (38)	6688 (60)	5 (2–8)	9 (2–17)
Ventilations only	13 253 (26)	5546 (42)	6157 (47)	8325 (63)	4 (2–9)	9 (3–18)
Vasopressors and ventilations	27 242 (53)	17 086 (63)	18 060 (66)	21 006 (77)	6 (2–14)	7 (2–16)

This table reports the subsets of patients according to the invasive procedures exposure.
*Crude incidence and unweighted outcomes since ICU admission, without regards to the time-to-event analysis. Percentages may not sum to 100 because of rounding.
ICU, intensive care unit.

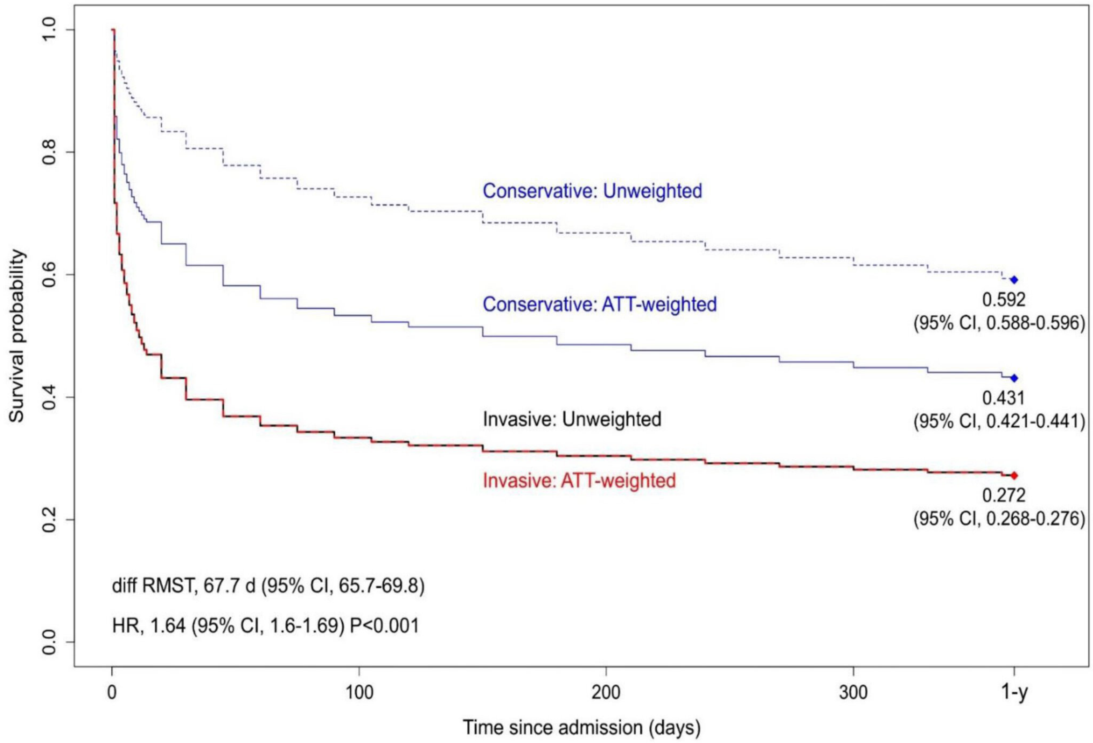

Figure 2 Probability of survival from ICU admission to 1 year, according to conservative or invasive approach, before and after time-dependent PS weighting (ATT). Kaplan–Meier method adapted to time-dependent covariate (with 95% CI). Dashed lines represent the time-dependent Kaplan–Meier plot of the probability of survival from ICU admission to 1 year among the original unweighted population. Solid lines represent the time-dependent Kaplan–Meier plot of the probability of survival on IPTW-ATT weighted sample using weights trimmed at the 1st and 99th percentile. Invasive curve remained unchanged after weighting, as expected. HR denotes the HR obtained from the ATT99 weighted Cox model and diff-RMST the difference in (1 year) RMST (days). ATT, average treatment effect in the treated; ICU, intensive care unit; IPTW, inverse probability of treatment weighting; PS, propensity score; RMST, restricted mean survival time.

the decision between invasive and non-invasive management is never incidental[27]; it is always an active choice that carries significant implications for the patient, their family and the medical team. For this reason, we did not include different modalities of oxygenation, such as high-flow nasal insufflation or NIV, in our analysis.

Furthermore, we aimed for the invasive group to reflect the maximal therapeutic investment—at least at the moment of procedure initiation. In this regard, NIV is a treatment that has been shown to improve survival and, as such, is not purely a palliative intervention. However, its role in alleviating respiratory discomfort is increasingly well documented. NIV has been found to be more effective than oxygen in reducing dyspnoea and decreasing the need for morphine in palliative care patients.[28] This modality is used both to enhance comfort at the end of life[29] and for patients who have declined tracheal intubation.[30] More broadly, it is now integrated into an approach that seeks to improve palliative care in the ICU.[31]

Finally, this distinction between invasive and non-invasive care also implies the notion of immediacy, which is why we excluded chronic conditions requiring invasive procedures. Both NIV and RRT are commonly used in chronic settings—NIV for chronic respiratory failure (eg, amyotrophic lateral sclerosis) and RRT for end-stage renal disease. The coding system does not allow for differentiation between acute and chronic indications. Including these cases would have introduced additional confounding factors, whereas our focus was on invasive procedures initiated for acute conditions. Nevertheless, our findings suggest that renal support worsens prognosis regardless of the treatment group, as among the 8761 patients who underwent RRT, 74% died within 1 year.

The strength of this study is the size of the cohort with few missing data and the national-level database needed to overcome sampling biases[32] that often limit epidemiological studies of the critically ill elderly. With 107014 patients under observation, we had the statistical power to robustly assess this issue in the target population of medical ICU patients adjusted for known prognostic factors specified a priori. The comprehensive multicentre design enhances the generalisability of our findings, particularly important given that older patients are frequently excluded from clinical trials[33] but are commonly treated in the ICU. Our study further provides valuable information on the epidemiology of circulatory and respiratory failures in older patients.

The main limitation of our study is the risk of confounding inherent to any observational study, which the PS cannot entirely eliminate. As a summary of measured covariates, the PS cannot account for unmeasured confounding.[34] In contrast to randomised controlled trials, where randomisation is expected to balance both measured and unmeasured covariates across treatment arms, observational studies remain subject to residual confounding.[35] Nonetheless, best practices for the use of PS methods with survival or time-to-event[36] outcomes using IPTW can help mitigate the effects of confounding in observational studies.[37 38]

Residual confounding may result from the lack of detailed clinical or contextual data involved in the decision to initiate an invasive procedure. These parameters not only influence the decision itself but also impact patient outcomes. The initiation of vasopressor therapy relies on critical information, such as arterial pressure, heart rate and urinary output, while the decision to proceed with invasive mechanical ventilation depends on the patient's level of consciousness, signs of respiratory failure and oxygen saturation. Comparing patients without this information is challenging. Nevertheless, although our methods do not directly incorporate these physiological parameters individually, they each contribute to the SAPS II score, which serves as the primary severity adjustment factor in our PS model. Notably, the density plots indicate that the SAPS II distribution is not only the strongest determinant of risk in our model but also closely aligned between invasive and conservative groups after weighting (online supplemental figure S3). In addition, the reason for admission integrates some clinical data.

We acknowledge that clinical parameters influencing invasive procedures are strong predictors of mortality, regardless of the level of invasiveness. Moreover, the need for invasive care serves as a marker of disease severity rather than a direct determinant of prognosis. In our study, the two populations inherently differ in acute severity, which is a key driver of treatment decisions. However, our aim was not to assess the appropriateness of invasive procedures but rather to describe patient outcomes based on treatment intensity, once a treatment pathway has been adopted in real-world practice.

The predominant contribution of SAPS II to our PS substantially mitigates the risk of confounding, although it cannot be broken down into its circulatory and ventilatory components, which would have allowed for a more refined adjustment. Nevertheless, SAPS II integrates various parameters that are associated with both prognosis and the decision to initiate an invasive procedure. This duality reflects the inherent overlap between prognosis and therapeutic decision-making in intensive care, where addressing clinical imbalance is expected to neutralise risk.

For instance, in haemodynamics, the 65 mm Hg mean arterial pressure threshold was originally established based on the retrospective cohort studies[39 40] that demonstrated a strong association between time spent below this threshold and mortality in patients with septic shock. However, vasopressors have since been shown to exert pleiotropic effects,[41] making their overall impact more difficult to predict, or even potentially leading to increased mortality in older patients.[42]

Thus, the traditional perspective in which invasive procedures were assumed to have an inherently positive—or at worst, neutral—impact by counteracting the excess risk associated with a high severity score has evolved. It is now recognised that their effect is far less predictable and, particularly in older patients, unlikely to be neutral.[43]

Our aim was to describe the trajectories of two distinct ICU populations rather than to compare treatment efficacy. Thanks to the inclusion of all treated patients nationwide over a 6-year period, any biases in our data are more likely to reflect the overall clinical practice rather than individual decisions regarding the appropriateness of invasive or conservative treatment. This is arguably the main advantage of real-world evidence over randomised trials in informing public health decision-making.[44]

Other limitations of our study include potential biases due to coding errors. Moreover, our study did not include the functional status nor the quality of life among survivors, which are more important than survival for many older persons.[45–47] The study also lacks consideration for pre-existing frailty, despite its recognised importance as a determinant of mortality.[48–50] However, while elderly patients with a higher functional baseline are more likely to survive, their chances of returning to their prior level are reduced compared with those with a lower functional baseline.[51 52] In addition, whoever with a good functional status is resuscitated until it becomes poor is doomed to die with a poor functional status.

The absence of consideration for triage process, treatment appropriateness or therapeutic limitations may introduce selection bias but reflects the real-world shared decision-making process among physicians, patients and families. Current studies suggest that the risk of overutilisation of invasive procedures outweighs the risk of underutilisation.[22 24 53–55]

The *Principles of Biomedical Ethics* by Beauchamp and Childress, developed in 1979, outlines the four principles of medical care: autonomy, non-maleficence, beneficence and justice. Individuals have a significant preference for non-maleficence over the other principles, but it does not appear to be directly used in the decision-making process.[56] Advance care planning is essential to support clinicians in targeting appropriate invasive, rehabilitative or palliative strategies, which are not exclusive. As stated in a recent review: all critically ill patients, by definition, have serious illness and, thus, have palliative care needs.[57] The retrospective meaning of 'end-of-life care' seems problematic unless considering the oldest patients are living the last part of their lives. Oldest patients, similar to paediatric patients, have distinct healthcare trajectories and goals supported by physiological evidence for geriatric specificities.

To clarify, our study does not suggest that elderly patients should be denied ICU admission. On the contrary, it highlights the potential benefits of an intensive integrative approach in the ICU rather than a purely technical approach that may only prolong the dying process.[58] The conservative group exhibits a low mortality rate, including patients who were refused invasive treatments due to futility, and it is unlikely to be further reduced with a more invasive approach. Similarly, the high mortality rate observed in the invasive group is unlikely to be exacerbated by a less aggressive strategy.

Our findings have strong ethical implications. Despite being highly selected for favourable outcomes in real-world practice, patients who received invasive procedures had a low survival rate. The incentive care policy for a standard of care regardless of age is questionable in the light of medical appropriateness[22 24 53–55] and patients' wishes.[24–26] While age should not be the sole criterion for ICU triage, the combination of age and the need for an invasive procedure must be considered attentively when deciding on treatment options. Growing evidence suggests a gap between patient preferences and the actual care provided[59] and that focusing resources on patient preferences is possible.[60] Age remains a potent trigger for clinicians to ensure that patients and families are well informed about the benefits, risks and harms associated with invasive care.[61]

CONCLUSIONS

In conclusion, in our nationwide study, an invasive approach was associated with a lower 1-year survival rate among elderly patients who were admitted to the ICU for medical reasons compared with a conservative approach. Early discussion, including the requirement for an invasive procedure, may reduce the incidence of avoidable aggressive end-of-life care and improve goal-concordant care achievement.

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Contributors This analysis is an investigator-initiated study led by CL, he supervised the analyses, drafted the manuscript and is the guarantor. All coauthors contributed to the study design and made substantial contribution. AG and CL conceptualised the study and prepared the original study protocol, which was subsequently reviewed by MdS and PA. CL, AG and PA developed the statistical methods. CL and PA had full access to the data and take responsibility for the integrity of the data and accuracy of the analysis. All authors contributed to data interpretation, critically revised the drafted manuscript and approved the final submitted version. The guarantor accepts full responsibility for the conduct of the study, had access to the data and controlled the decision to publish. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

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