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Towards an Individualized Care Pathway for the Elderly Intensive Care Patients : Retrospective Analysis of Factors Associated with Mortality in 684 Cases

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Abstract

As the population ages, the number of elderly patients admitted to the ICU continues to rise. The physiological changes associated with ageing represent a challenge for the management of this often-fragile population at high cognitive risk. An epidemiologic and evolution profile in our Moroccan context is necessary to improve survival and its quality in post-intensive care in our elders.

This is a retrospective analytic study including all patients over 65 years of age admitted to the A4 polyvalent intensive care unit of the Hassan II University Hospital in Fez, from January 2017 to December 2021, excluding patients initially admitted for COVID-19 infection. The epidemiology, stay, management and outcome data were collected and analyzed.

INTRODUCTION

As the population ages, the number of elderly patients admitted to the ICU continues to rise. The physiological changes associated with ageing represent a challenge for the management of this often-fragile population at high cognitive risk. An epidemiologic and evolution profile in our Moroccan context is necessary to improve survival and its quality in post-intensive care in our elders. Thus, the management of elderly patients in intensive care requires careful consideration to address these clinical and ethical challenges. In order to minimize the risk of morbidity and mortality and optimize chances of functional recovery, specific and tailored care protocols for this age group before, during, and after their stay in intensive care are necessary. Non-pharmacological approaches such as early mobilization, functional rehabilitation, family contact, infection prevention, and pain management are of paramount importance. This requires a multidisciplinary approach involving, among others, the treating physician, anesthesiologist-intensivist, paramedical staff, psychologists, and physiotherapists but also active and informed family participation is imperative. A comprehensive assessment, taking into account medical, functional, psychosocial, and environmental dimensions, is necessary to develop an individualized care plan and pathway. It is worth noting that this topic is important in our context, given the reality of the aging Moroccan population but also the almost complete absence of studies specifically addressing this age group in intensive care. This study aims to address this gap and has the following objectives: to provide a detailed overview of the management of elderly patients in a Moroccan intensive

care setting, to identify factors associated with mortality, and to propose a care pathway for elderly patients in intensive care that is adapted to our context.

MATERIALS & METHODS

This is a retrospective analytic and descriptive study including all patients over 65 years of age admitted to the A4 polyvalent intensive care unit of the Hassan II University Hospital in Fez, from January 2017 to December 2021, excluding patients initially admitted for COVID-19 infection.

Patients in the unit are mainly those undergoing preoperative scheduled or emergency surgery (digestive, urological, thoracic, vascular) and medical-surgical emergencies (metabolic disorders, ARDS, sepsis, severe infectious diseases, severe acute pancreatitis, organ failures, severe burns, severe trauma, decompensated chronic diseases...).

Data collection & Statistical methods: Data was collected retrospectively from the admission registry and electronic medical records of each patient (Hosix software) The epidemiology, stay, management and outcome data were collected and analyzed. All statistical analyses were performed using IBM STATISTICS 2020 software at the epidemiology laboratory of the Faculty of Medicine and Pharmacy in Fes.

Results were expressed as frequencies and percentages for qualitative variables, and as means +/- standard deviations (SD) for quantitative variables. Univariate analysis was conducted using the Student's t-test for quantitative variables and the chi-squared test for qualitative variables. Multivariate analysis using a logistic regression model was conducted to determine risk factors associated with mortality in the study population. The threshold for statistical significance was set at p=0.05. Relative risks and confidence intervals were estimated.

RESULTS

- **Study population**

During the study period (January 2017 - December 2021), a total of 3521 non-COVID admissions were recorded at the A4 General Intensive Care Unit of Hassan II University Hospital in Fes. Out of these admissions, 684 patients (19.5%) were aged 65 years or older (Figure *1*).

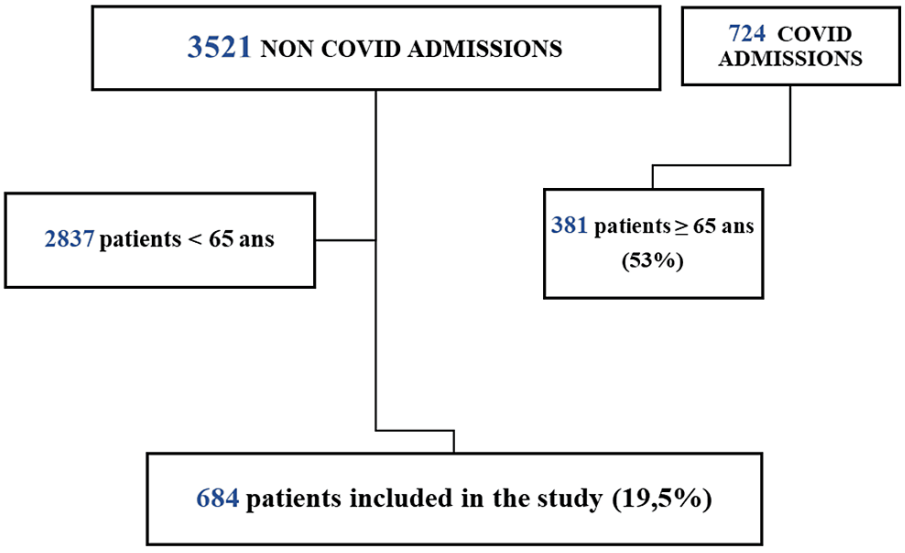

Figure 1: Flowchart of the study

According to the years of admission (Figure 2): Subjects ≥ 65 years old accounted for an average of 20% of non-COVID admissions in the ICU: 29% in 2017, 27% in 2018, 32% in 2019. There was a significant decrease in admissions of older adults in 2020 (12% of total non-COVID admissions) and 2021 (5%).

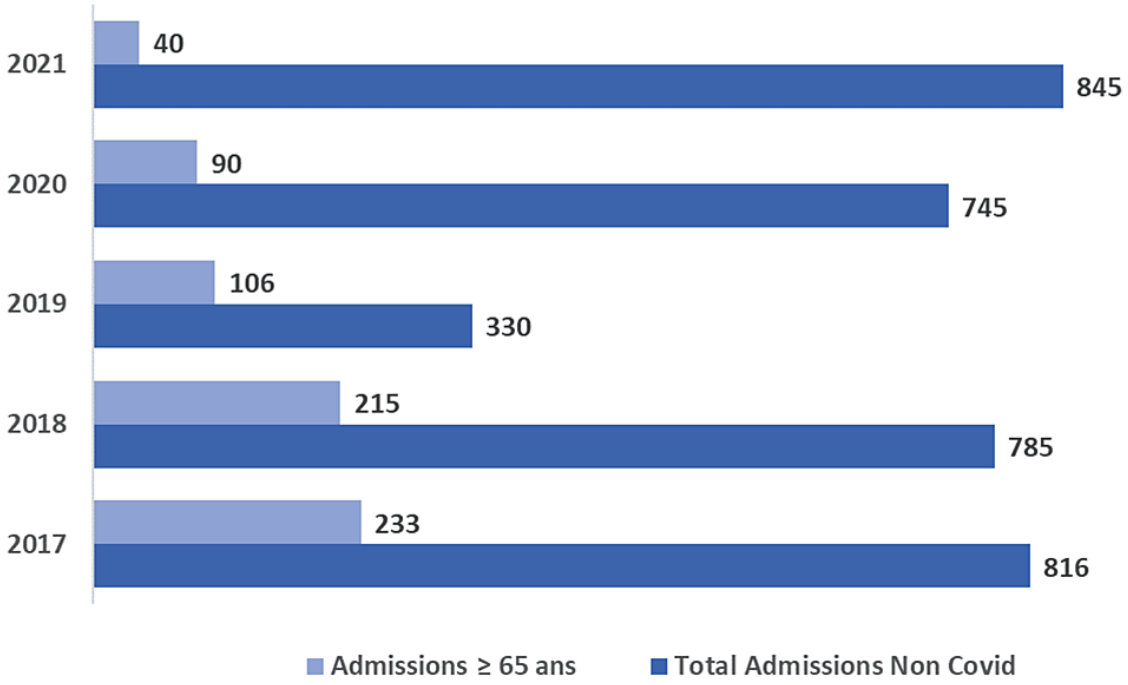

Figure 2: Distribution of admissions of elderly patients in our ICU unit from 2017 to 2021

- **The demographic characteristics of the population: age, origin, sex, and comorbidities**

The mean age of our patients is 74 ± 7.032 years (range 65-100 years). Figure 3 shows the distribution according to three age groups: 65-74 years (young old), 75-84 years (old old), and ≥85 years (very old). Two-thirds of the elderly subjects are under 75 years old, and the very old subjects (≥85 years) make up only 7% of the elderly population.

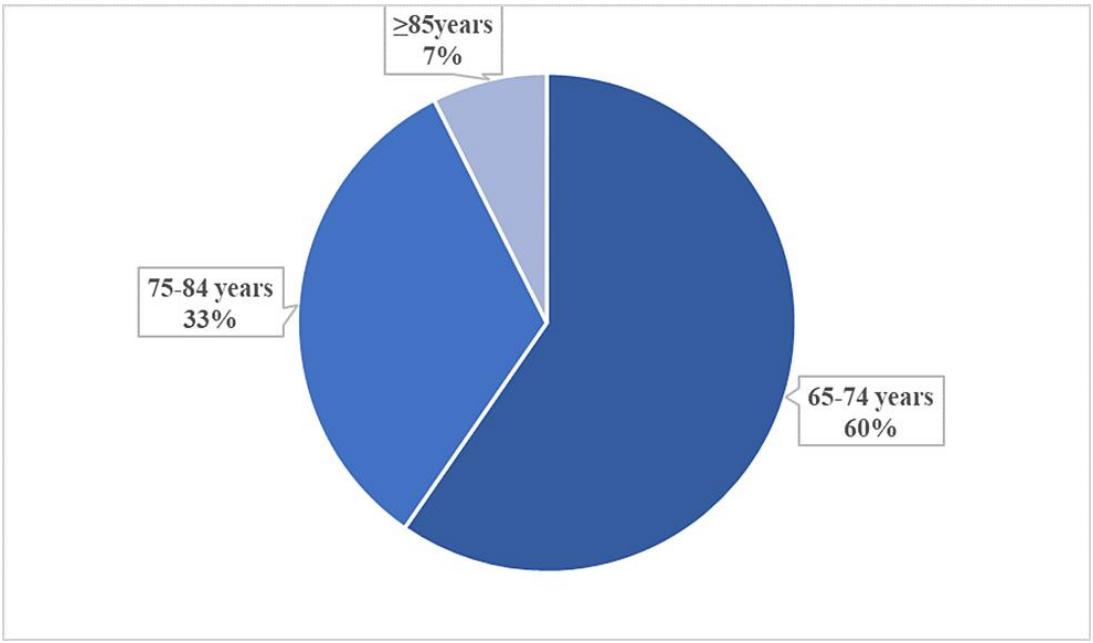

Figure 3: Distribution of elderly subjects by age groups

The majority of our patients were of urban origin. Only 29.5% came from rural areas (202 patients). There was a predominance of males in our population, with 55.8% being men and a sex ratio (M/F) of 1.26. Several comorbidities were observed in almost half of our patients. A maximum comorbidity rate of 9 was found in only one patient. The majority of our patients had a Charlson score of 3 or higher. The results were classified into three levels: Charlson 1-2: 11.45% of cases, Charlson 3-4: 65.43% of cases, Charlson ≥ 5: 23% of cases. Comorbidities were dominated by pre-existing tumor pathology, hypertension, and diabetes. 47% of our patients had a history of tumor pathology. 38% of the patients had hypertension, of which 70% was either untreated or uncontrolled. 29% of the study population were diabetic (222 patients), of which 57% were non-insulin dependent and 42% required insulin. 27% of our elderly subjects had heart disease (185 patients), with ischemic (18%) and valvular (8%) origins being the most common. Pre-existing chronic respiratory disease was present in 9% of the patients, with COPD being dominant in 76% of cases. A history of stroke was noted in 7.6% of the patients, with ischemic strokes accounting for 85% of cases. A psychiatric history was present in 2.2% of the patients. Pre-existing loss of autonomy was reported in 11.34% of the total number of our patients.

In our study, post-operative admissions were the most predominant (348 patients), followed by emergency department admissions (242 patients) and surgical department admissions (66 patients). The general surgery department and the gastroenterology department were the most referred departments.

- **Admission Diagnoses**

Admission diagnoses were classified as medical or surgical . The most common medical diagnoses reported outside the operating room context were, in order of frequency: severe acute non surgical pancreatitis (43 cases), severe acute cholangitis (26 cases), severe acute pneumonia (16 cases), hemorrhagic shock, and electrolyte disturbances.

Postoperative admissions accounted for 67% of cases (459 admissions), with a predominance of postoperative admissions for cancer surgeries (72.5% of the total surgical admissions). A major predominance of digestive cancer surgery, which accounts for 96% of the total postoperative admissions for tumor cases, followed by reperfusion vascular surgery (67 patients). Colorectal surgery is the most frequently encountered cancer surgery in our series.

- **Severity at admission**

The severity at admission was assessed using classic resuscitation scores and was as follows:

- Mean Apache II score: 14.33 ± 7.79 (range 4-43).
- Mean SAPS II score: 29.36 ± 17.41 (range 10-102).
- Mean SOFA score: 3.025 ± 3.97 (range 1-19).
- Mean Barthel score (autonomy): 89.21% ± 15.49 (range 0-100).

- **Therapeutic management**

Monitoring:

All our patients received:

- Standard monitoring of heart rate and rhythm (cardioscope), non-invasive blood pressure, pulse oximetry (pulse oximeter), temperature, and blood glucose.
- Hourly urine monitoring:
- By urinary catheter in 78% of patients.
- By penile sheath (Peniflex) in 10 patients.
- By suprapubic catheterization in 1 patient.

- Minimal laboratory monitoring: complete blood count + platelets, liver function tests, kidney function tests, coagulation profile, electrolyte balance, blood glucose, C-reactive protein, ABO-Rh typing.
- Two peripheral venous accesses of good caliber (18G or 16G).

95 patients (14%) received arterial catheterization.
239 patients (35%) received ultrasound-guided central venous catheterization:
186 in the internal jugular site.
40 in the femoral vein site.
13 in the subclavian site.

Respiratory management:

Oxygen therapy was prescribed and administered to all patients via nasal cannula, nebulizer mask, or high-concentration mask. All patients underwent respiratory physiotherapy at some point during their management, including postural measures, incentive spirometry, and bronchial secretion drainage. Invasive mechanical ventilation was required in 167 patients (24.4%) based on criteria such as respiratory, hemodynamic, and neurological conditions.

The average duration of invasive ventilation was 1.02 +/- 3.27 days (range 1-39 days).

Hemodynamic management:

All patients received fluid replacement with crystalloids (0.9% saline and/or lactated Ringer's solution). Colloids were not administered. The use of catecholamines was noted in 191 patients (28%), mainly for septic shock in 51% of cases (98 patients). Norepinephrine was the most commonly used catecholamine. Intravenous hydrocortisone hemisuccinate was administered to 68 patients with refractory septic shock.

Renal support

The average creatinine clearance in our patients was 89.23 ml/min, with a range of clearance between 30 ml/min and 135 ml/min, and creatinine levels ranging from 0.045 mg/dl to 3.21 mg/dl (equivalent to 4 and 283 µmol/L).

All patients received volume optimization and avoidance of nephrotoxic agents.

Forced diuresis with diuretics (intravenous furosemide) was used in 15 patients (2%).

Extrarenal clearance was necessary in 27 patients (4%) due to persistent anuria in 13 cases, hyperkalemia in 10 cases, and severe acidosis in 4 cases.

Antibiotic therapy:

Empirical intravenous antibiotic therapy, initiated upon suspicion of infection, was required in 364 patients. The most commonly used antibiotics are shown in Table *1*. Empirical combination therapy was used in 75% of cases (Figure *4*).

Class	Name of antibiotics	Number of patients
Penicillin	Amoxicillin-clavulanate potassium	102
Cephalosporins	Ceftriaxon	124
	Ceftazidim	14
	Cefepim	2
Carbapenems	Imipenem	7
Aminoglycodies	Gentamycin	78
	Amikacin	98
Glycopeptides	Vancomycin	4
Fluoroquinolones	Ciprofloxacin	76

	Levofloxacin	12
Macrolide	Azithromycin	3
Nitroimidazoles	Metronidazole	100

Table 1: The classes of antibiotics used in our serie

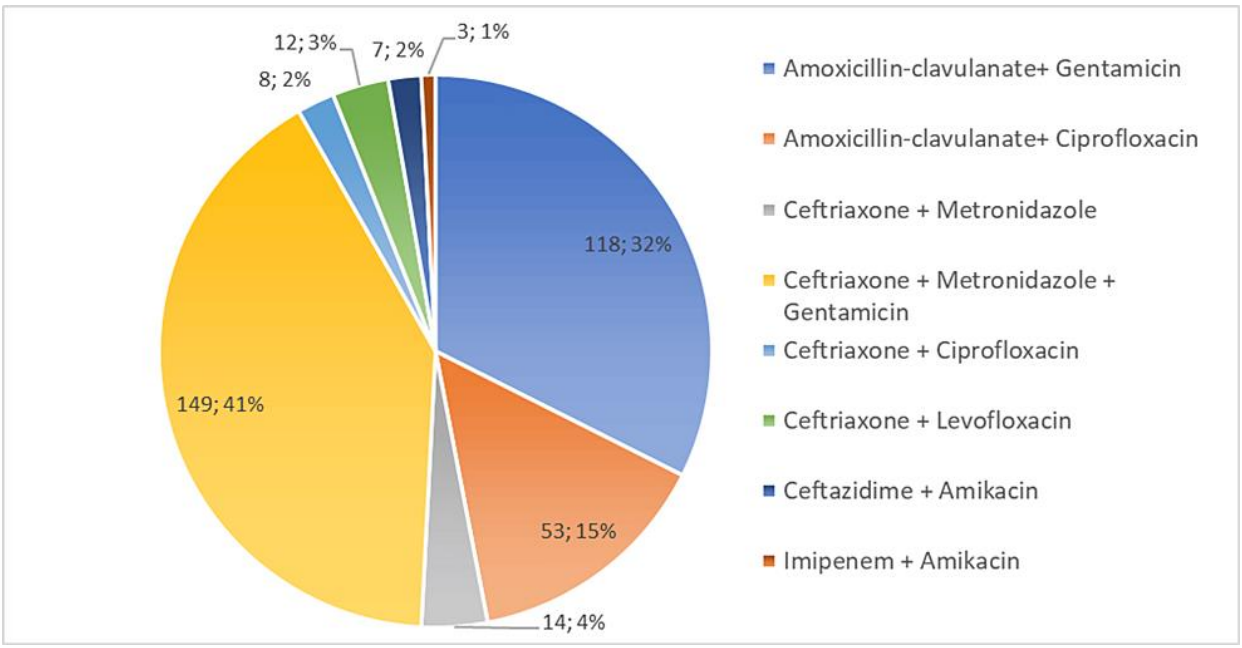

Figure 4: Empiric first-line antibiotic combination in our study

- **Results of bacteriological samples**

Bacteriological samples were collected from 364 patients, resulting in a total of 646 positive samples. Figure *5* and Table *2* summarize the isolated germs in our study, as well as their resistance profile.

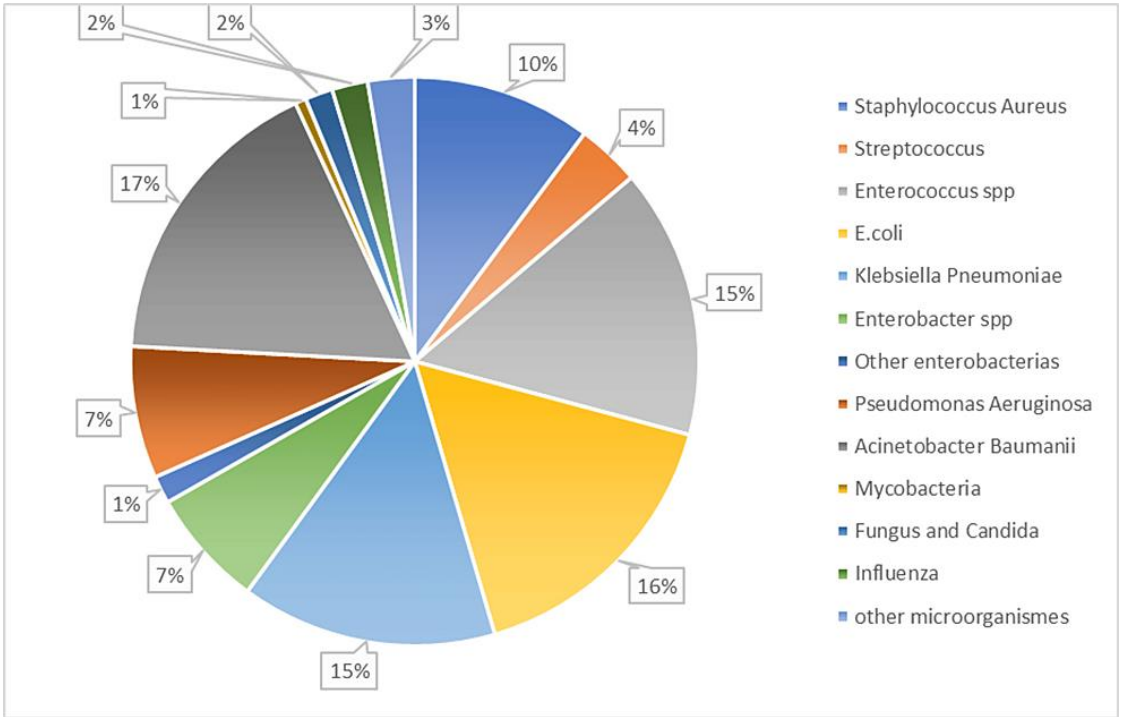

Figure 5: Distribution of isolated germs in our population

Germs	Type of infection	Antimicrobial resistant bacteria
Cocci gram + Staph Aureus (10%)	Infection of the wall Infection of catheter sites Perioperative pus	Staph coagulase negative (0,08%)
Streptococcus (3,5%)		MRSA (0,01%)
Enteroccus spp(15,17%)		Blactamases (0,14%)
Other cocci+ (0,3%)		None
Enterobacterias E.coli (16,09%)	Urinary infection Respiratory infection Digestive infection	Sensible (0,18%)
Klebsiella Pneumoniae (14,39%)		BLSE (0,3%)
Enterobacter spp(6,65%)		OXA-48 (0,19%)
Other Enterobacterias (1,54%)		KPC (0,07%)
		NDM-1 (0,08%)
Bacilles gram – non enterobacter	Respiratory infection Operation site infection Catheter sites infection	Sensible (1,2%)
Pseudomonas Aeruginosa (7,43%)		
Acinetobacter Baumanii (17%)		KPC (0,03%)
Other BGN (0,4%)		

Table 2: Resistance profile of isolated pathogens in the entire population of our serie

Bacteriological samples were collected from 364 patients, resulting in a total of 646 positive samples. Figure 13 and Table *2* summarize the isolated germs in our study, as well as their resistance profile. Initial antibiotic therapy was maintained in 291 out of 364 confirmed patients. A change in antibiotic therapy during hospitalization occurred in 83 patients and consisted of a therapeutic escalation based on the results of infectious sampling in 56 cases. The following molecules were used: Piperacillin/Tazobactam + Amikacin (19 cases), Imipenem + Gentamicin (4 cases), Imipenem + Colistin (20 cases), Imipenem + Teicoplanin (2 cases), Tigecycline + Ceftazidime (4 cases), Ertapenem + Amikacin (7 cases). Broadening of the empirical spectrum in 10 cases.

- **Surgical intervention**

Surgical reintervention was indicated in 32 patients in our series for secondary peritonitis (75%), wall abscesses (12.5%), intestinal obstruction (9%), and digestive fistula (3.5%).

- **Other therapies**
- All 684 patients received pain treatment.
- The pain was evaluated using the Visual Analog Scale (VAS).
- The main analgesics used were paracetamol (Class I), Nefopam (Class II), and morphine (Class III), often as part of multimodal analgesia (84% of cases). Morphine patient-controlled analgesia (PCA) was used in 3 patients.
- Perioperative analgesia, such as Transversus Abdominis Plane (TAP) or paravertebral block, or epidural analgesia, was mainly performed in patients undergoing elective surgery. All patients recei-

ved nutritional support and electrolyte balance.

- All patients received gastric protection against stress ulcers with proton pump inhibitors.
- Thromboembolic disease prophylaxis was based on:
- Subcutaneous low molecular weight heparin injection in 587 patients when creatinine clearance (≥30 ml/min/1.73m2) and clinical-biological hemostasis allowed it (no hemorrhagic syndrome, PT >50%, platelets > 50,000 elements/mm3). Unfractionated heparin was used in 23 patients. -Compression stockings were worn by 39 patients with hemostatic disorders.
- All patients received nursing care including regular eye, mouth, and body care. Regular changes in position and the use of anti-decubitus mattresses were used in case of difficulty with active mobility. Early mobilization with motor physiotherapy was initiated as soon as possible.
- **Patients & families consents**

All patients and/or their families were regularly informed about the prognosis and treatment plan based on daily discussions with the attending intensivist. The therapeutic decision, which was multidisciplinary, included the patient and/or their family according to the local protocol of the intensive care unit.

EVOLUTION

Length of stay in intensive care

The average length of stay was 4 ±5.38 days (range 1-40 days). There is a predominance of short stays of 1-7 days (87%), and particularly stays of < 48 hours (40% of cases).

The discharge from the intensive care unit occurred in 546 patients (80%), with the following:

- Transfer to a surgical department in 458 cases, mainly visceral surgery (66% of total admissions).
- Transfer to a medical department in 47 cases.
- Transfer to another city/country at the request of the patient/family in 3 cases.

Direct discharge home without the need for transfer to another department in 38 cases, representing 5.5% of total admissions.

Complications reported in our series are as follows:

- Infectious: 101 patients developed nosocomial infections, of which 32% progressed to septic shock (32 patients).
- Renal: Persistent acute kidney injury after the acute episode in 26 patients.
- Respiratory: 75 cases of healthcare-associated pneumonia, including 46 cases of acute respiratory distress syndrome (ARDS).
- Neurological: 52 cases of cognitive impairment.
- Pressure ulcers: 30 cases of pressure ulcers at pressure points.
- Loss of autonomy: 194 cases of loss of autonomy at discharge from the intensive care unit.

Variable	Number of patients (N = 684)
Age (mean +/- SD)	74 +/- 7,032
Origin (%) Urban	482 (70,5%)
Sex (%) Male	382 (55,8%)
Type of admission (%)	
Traumatic condition	(0,70%)
Scheduled surgery	351 (51,3%)

Medical condition	201 (29,4%)
Unscheduled surgery	127 (18,6%)
Referral service (%)	
Central OR	348 (50,9%)
The emergency department	242 (35,4%)
Surgical services	66 (9,6%)
Medical department	28 (4,1%)
Number of comorbidities ≥ 1	498 (73%)
Unbalanced comorbidities	163 (24%)
Medical history (%)	
Neoplasm	323 (47%)
Hypertensive Disease	260 (38%)
Diabetes	201 (29,36%)
Heart Disease	185 (27%)
Surgery in the past 24 months	121 (18%)
Respiratory Insufficiency	59 (9%)
Stroke	52 (8%)
Kidney Failure Known	27 (4%)
Liver Disease	20 (3%)
Psychiatric Illness	15 (2,2%)
Number of treatments ≥ 1 (%)	433 (63,30%)
Presence of weight loss. (%)	244 (35,67%)
Loss of independence upon admission (%)	207 (30,26%)
BARTHEL score upon admission (%)	89+/-15,49
APACHE II score upon admission (mean +/- SD)	14+/- 7,79
SAPS II score upon admission (mean +/- SD)	29+/-17,41
SOFA score upon admission (mean +/- SD)	3 +/-3,97
Invasive mechanical ventilation use (%)	167 (24,4%)
Days of mechanical ventilation (mean +/- SD)	1+/- 3,27 day
Use of dialysis (%)	27 (3,94%)
Use of catecholamines (%)	191 (28%)
Hospital-acquired infection (%)	101 (15%)
Septic shock (%)	98 (14%)
Length of stay in intensive care unit (average +/- standard deviation)	4+/- 5,38
Mortality (%)	138 (20%)

Table 3: DESCRIPTIVE SUMMARY OF OUR POPULATION

MORTALITY AND RISK FACTORS FOR MORTALITY

Overall Mortality

The mortality rate in the intensive care unit was 20% (138 patients). The causes of death in our series were mainly due to multi-organ failure secondary to:

Refractory septic shock: 59.4% (82 patients), accounting for 12% of total admissions of elderly subjects.

Cardiogenic shock: 20% (28 patients)
Ischemic heart disease (22 cases)
Severe pulmonary embolism (5 cases)
Toxic origin (1 case)
Hemorrhagic shock: 6.5% (9 cases).
Neurological origin (stroke, hemorrhagic stroke, metabolic causes): 6.5% (9 cases).
Acute Respiratory Distress Syndrome (ARDS): 5% (7 cases).
Ischemia-reperfusion syndrome: 1.4% (2 cases).
Hepatocellular insufficiency: 1 case.

Risk factors for mortality in univariate analysis

To highlight statistically significant variables, a summary of the results is presented in Table *4*. This table includes variables with a statistically significant p-value ($p < 0.05$). These variables include length of stay, history of heart disease, chronic renal insufficiency, hepatopathy, neoplasia, previous surgery, number of comorbidities, presence of unbalanced comorbidities, Charlson score, Barthel score, presence of admission failures, creatinine clearance rate at admission, SOFA score at admission, SAPS II score, APACHE II score, organ failures at admission, use of mechanical ventilation and its duration, use of dialysis, use of catecholamines, placement of central venous catheters, occurrence of nosocomial infections, progression to septic shock, and occurrence of surgical re-intervention during hospitalization.

Variable	P-value (significant<0.01)
Length of stay	<0.001
History of heart disease	0,004
History of chronic kidney disease	0,047
History of liver disease	<0.001
History of neoplasia	<0.001
History of surgery in the past 24 months	<0.001
Number of comorbidities	<0.001
Presence of unbalanced comorbidities	<0.001
Charlson Score	0,016
Barthel Score	<0.001
Hemodynamic failure on admission	<0.001
Hematologic failure on admission	<0.001
Hepatic failure upon admission	<0.001
Days of mechanical ventilation	<0.001
Use of dialysis	<0.001
Use of catecholamines	<0.001
Central venous catheterization	<0.001
Nosocomial infection occurrence	<0.001
Evolution towards septic shock	<0.001
Resumption of surgery during hospitalization	<0.001
Loss of autonomy	<0.001

Table 4: Summary of statistically significant values in univariate analysis

the level of significance was established on the p Value <0.01

Risk factors in multivariate analysis

Multivariate analysis showed a statistically significant association between the variables shown in Table *5* and mortality. The results of the univariate analyses showed statistically significant associations between various variables and the mortality of the study patients. Table *5* presents these associations, along with the corresponding p-values. In our study, death was significantly associated with the studied scores, creatinine clearance and pre-existing chronic renal insufficiency, the use of mechanical ventilation, persistent hemodynamic failure, and surgical reintervention during the hospital stay.

Variable	P-Value
Length of stay	0,019
BARTHEL score at admission	<0,01
SAPS II Score (Simplified Acute Physiology Score)	<0,01
SOFA Score (Sequential Organ Failure Assessment score)	<0,001
Charlson Score	0,02
History of chronic kidney disease	<0,01
Creatinine clearance during the hospital stay	<0,001
Use of mechanical ventilation	0,005
Days of mechanical ventilation	0,028
Persistence of hemodynamic failure during the stay	0,031
Surgical revision	<0,001

Table 5: Summary of statistically significant values in multivariate analysis

p Value <0.01 was significant in our study

DISCUSSION

- **Older subjects in the ICU: Some reminders**

According to the World Health Organization (WHO), the term "elderly" refers to individuals aged 60 years and above. However, this definition may vary from country to country depending on the socio-economic and cultural context [1]. The concept of "aging" is a complex process that cannot be reduced to a simple chronological criterion. The physical, social, and functional characteristics of individuals, as well as their ability to fully participate in society, must be taken into account. Aging involves progressive changes in the physiological functions of the body, which can influence the hospital management of these patients. One of the major aspects of aging is the decrease in muscle mass and strength, which can lead to decreased mobility, increased risk of falls, and reduced functional autonomy. Senescence also affects the cardiovascular system, particularly by reducing the flexibility of the arteries and increasing the stiffness of blood vessels, and is responsible for the development of hypertension, atherosclerosis, and other cardiovascular diseases. It affects the respiratory system with a progressive decrease in lung capacity and gas exchange efficiency and an increased risk of developing lung diseases such as chronic obstructive pulmonary disease (COPD). Aging of the immune system, or immunosenescence, makes older people more vulnerable to infections. The immune response is less effective, and the risk of bacterial, viral, and fungal infections is increased. In the nervous system, there is a decrease in the ability of nerve cells to regenerate and an impairment of communication between neurons, which can contribute to the development of neurodegenerative diseases such as Alzheimer's disease and Parkinson's disease. Aging affects the endocrine system, particularly by decreasing the production of hormones such as estrogen (in postmenopausal women) and testosterone (in men). These

hormonal changes can impact bone health, libido, mood, and other aspects of overall health in older individuals. Pharmacological changes related to age must also be taken into consideration. In addition to complications related to poor medication adherence in these patients, there are also complications related to the risk of overdosing and toxicity (anticoagulants, antibiotics, anesthesia drugs, delayed recovery, etc.) due to delayed renal elimination due to reduced nephron reserve, as well as therapeutic inefficiency related to poor digestive absorption, for example. Hence the importance of drug dosage in certain cases. The elderly are therefore part of a category of patients who have specific characteristics in terms of overall care, especially in the intensive care setting. Due to this natural process, older people often have a lower capacity for recovery compared to younger patients in intensive care, which can increase the risk of complications and influence therapeutic choices. This frailty can also increase the risk of post-intensive care complications and influence care goals. Additionally, elderly individuals may have an increased risk of surgical interventions due to tissue fragility, dehiscence, delayed healing, and increased infections related to the onset of immunosuppression. It is therefore important to consider these factors when planning and performing surgical procedures in the intensive care setting. Finally, cognitive disorders such as dementia are common in elderly patients. These disorders can exacerbate difficulties in intensive care, particularly in terms of collaboration and communication with the patient. The management of elderly patients in intensive care must therefore take into account their chronic diseases, frailty, polypharmacy, risks associated with surgical interventions, cognitive disorders, and the need for a comprehensive and personalized approach that takes into account their preferences, values, and life goals, as well as medical and functional particularities. It is important to assess the patient's health status and frailty in order to ensure optimal and respectful care [2,3].

- **Discussion of our results**

Number, average age

The number of subjects over the age of 65 was 684 patients, accounting for 20% of the total admissions during this period, while excluding patients diagnosed with SARS-COV infection. This exclusion can be explained by the clinical and biological changes mainly related to the infection and the inflammatory storm, which alter the management of these subjects in the intensive care unit and require a specific therapeutic approach [4] . The mean age of our population is 74 years with a standard deviation of 7.032, comparable to the 4 studies found in the literature, including the L.A Sanchez and al [5], the Lankoande and al [6], the Belayachi and al [7] studies, with an average age of 82 years in the Australian study [8] and the Siddiqui S and al study [9], and 79.3 with a standard deviation of 3.4 in the French study [10].

Literature series present similar data to our study over shorter study periods (1 year) like L.A Sanchez and al [5], (total of 929 patients, of which 26.16% were elderly). A lower admission rate was reported in the Sub-Saharan study of Lankoande and al [6], with 11.2% Longer study periods (5 years) in the Australian/New Zealand study and the Moroccan study [7, 8] with a larger number of patients (120,123 patients from 57 intensive care units, with a prevalence of 13% in elderly patients for the Australian and 1,072 admissions, of which 16.6% were elderly for the Moroccan), were observed, which indicates a high trend of admissions of elderly subjects in the intensive care unit worldwide.

Sex

In terms of gender distribution, 55.8% of the participants were male, which matches the male predominance found in the literature series, such as L.A Sanchez study [5] with 69%, Lankoande and al study [6] with 69% , Belayachi and al study with 55% [7]. The latest Asian study conducted in Singapore where 58% of admissions were male [9].

Type of admission

Regarding the type of admission, the majority of patients were admitted for scheduled surgery (51.3%), which may present a selection bias as our anesthesia and intensive care service is a referral service for the management of patients requiring visceral surgery, especially for tumors in the Fez-Meknes region, followed by unscheduled surgery (18.6%), medical conditions (29.4%), and traumatic injuries (0.7%).

Admission diagnoses

Our results were compared to those found in other studies and are interpreted in the following table.

Background and comorbidities

Studies	Admission Assessment
Our study	Surgical conditions (post-operative) (67.10%)
	Medical conditions accounted for 32.89%, distributed as follows:
	Pancreatitis (19.14%)
	Cholangitis (11.5%)
	Severe pneumonia (7%)
	Hemorrhagic shock (6.4%)
	Electrolyte disturbances (5.7%)
	Heart failure (5.7%)
	Respiratory failure (4.82%)
	Decompensation of cirrhosis (4.8%)
	Intoxication (4%)
	Others (23%)
L.A. Sánchez-Hurtado and al [5]	Ischemic heart disease (37.82%)
	Septic shock (19.56%)
	Postoperative of aortic surgery (12.17%)
	Hemorrhagic shock (11.74%)
	High-risk surgery (9.56%)
Lankoandé M and al [6]	Stroke (27.4%)
	Prostate tumor (11.4%)
	Sepsis (11%)
	Trauma/burn (10.5%)
	Occlusion syndrome (5.5%)
	Heart disease (2.5%)
	Coronary artery disease (8.4%)
	Kidney failure (6.7%)
	Others (11.4%)
Belayachi, J and al [7]	Infectious cause (54.2%)
	Respiratory failure (20.7%)
	Metabolic acidosis (23.5%)
	Heart failure (14%)
	Cerebrovascular impairment (7.8%)
	Intoxication (4%)
Siddiqui S and al [9]	STEMI/NSTEMI (37.2%)

	Postoperative complications after surgery (12.3%)
	Shock state (15.7%)
	Coma (2.2%)
	Others (31.3%)
Daubin, C and al [10]	Cardiac causes (20%)
	Respiratory causes (48%)
	Neurological causes (12%)
	Abdominal surgery (7%)

Table 6: Comparison of admission diagnoses to the literature

In our population, the presence of several comorbidities is observed, with 73% of patients having at least one comorbidity and 23.83% presenting with unbalanced comorbidities. Among the medical history, hypertension (38%), diabetes (29.36%), and heart diseases (27%) are the most frequent. These data present statistically higher but close frequencies to those reported [5, 9, 10]. This disparity can be explained by several factors:

Accumulation of exposure to risks over time: Over time, individuals are generally exposed to a greater number of health risk factors, such as diet, lifestyle, infections, etc. This accumulation can contribute to the emergence of various health problems over time.

Effects of aging on the body: The aging process induces physiological changes that can increase the likelihood of developing certain pathologies. For example, aging of the immune system makes individuals more vulnerable to infections and diseases.

Health-related behaviors: Behaviors such as smoking, alcohol consumption, region-specific diet, and reported level of physical activity are also risk factors associated with the occurrence of relatively common diseases in certain regions or countries compared to others. Understanding these local factors is important in explaining the high prevalence of comorbidities in our population. This knowledge can contribute to the development of prevention and management strategies for comorbidity-related diseases, in order to promote health and improve clinical outcomes. The presence of comorbidities as a risk factor associated with mortality has also been found in various publications such as L.A Sanchez and al [5], Lankoande and al [6] and Belayachi and al [7]. Thus, the clinical assessment scores upon admission of patients have proven to be very interesting in evaluating both pre-existing health status and predicting the course of our patients in the intensive care unit, as well as preparing the necessary resources to manage any failures effectively.

Clinical assessment scores upon admission

The results of the clinical assessment scores obtained in our study are as follows: the Barthel score upon admission has a mean of 89.21 +/- 15.49, the APACHE II score has a mean of 14.33 +/- 7.79, the SAPS II score has a mean of 29.36 +/- 17.41, and the SOFA score has a mean of 3.025 +/- 3.97. When comparing with existing articles in the scientific literature, it is important to note that, for example, comparing the Barthel score upon admission, our mean of 89.21 is relatively high compared to other studies that have reported lower means in similar populations. This may suggest a better functional autonomy of patients upon admission in our population.

As for the APACHE II, SAPS II, and SOFA scores, it should be noted that these scores assess the severity of disease, severity of organ failure, and sequential organ failure, respectively. The means obtained in our study (APACHE II: 14.33, SAPS II: 29.36, SOFA: 3.025) were compared to values

reported in the literature [5,6,7,9,10], for example the SAPS II score in L.A Sanchez and al [5] it was 37.2+/-16.38, in Lankoande and al [6] it was 7.9+/-3.5 of Belayachi and al [7] , was found to be 35+/-11.3 , lastly, in the French study of Daubin and al [10] it was 53, whereas for the APACHE II score, the Singapore study had a mean of 18, the Moroccan study in Rabat had a mean of 15+/-5.5, the L.A Sanchez study had a mean of 15.87+/-7.74, and the French study had a mean of 24. The SOFA score in the Moroccan study in Rabat was 5.6+/-4.3, followed by the French study which was 7, unlike ours which was 3.025 +/- 3.97. However, it is important to note that these scores could not be evaluated, for example, in the Lankoande and al study [6] regarding the SOFA score. The results of these scores can also vary depending on the specific characteristics of each population, the scale used, and the thresholds defined for each score. Therefore, direct comparisons require caution and reference to specific studies with similar contexts.

This literature review allowed us to compare our results with other relevant studies and evaluate our clinical assessment scores, which fall within the expected range with the L.A Sanchez study [5] especially.

On the other hand, our study shows significant differences compared to the Lankoande and al [6], Siddiqui and al [9], and al, and Daubin, C and al [10] respectively. Furthermore, it would be useful to consider the thresholds of clinical assessment scores used to predict clinical outcomes, such as mortality, in order to determine if our scores are associated with similar or different outcomes. This comparative analysis allowed us to better assess the severity of patients' health status, place our results in a broader context, and have more solid data on the importance of these scores and the need to prioritize them in the clinical evaluation of our patients in the intensive care setting in Morocco.

Complications and medical interventions during the stay

Regarding medical interventions, the table *7* designed summarizes all the results found in our series as well as in the literature, allowing for a clear comparison with our own results.

	Mortality	Length of stay in intensive care	Use of mechanical ventilation	Use of dialysis	Use of central catheters	Use of catecholamines during the stay	Hospital-acquired infections
Our study	20%	4,18+/-5,38	24,41%	3,94%	27,92%	34,94%	14,76%
L.A Sanchez and al [5]	12,1%	3,55+/-2,56	38,2%	0,7%	47,4%	47,4%	19,56%
Lankoande and al [6]	73%	5,3+/-7,4	0,8%	0%	6,3%	6,3%	10,5%
Belayachi, j and al [7]	44,7%	6,6+/-6	43,6%	2,5%	82%	78%	34%
Siddiqui, S and al [9]	12%	2,77+/-4,13	35%	7%	12%	23%	1%
Daubin, C and al [10]	61%	5,23+/-2	63%	12%	32,2%	26%	19,2%

Table 7: Complications during the stay reported in the literature

In terms of mortality rate, unlike our study and the other studies [5, 6, 7, 9] where the inclusion criterion was an age of 65 years, but rather due to the very high rate of comorbidities reported in this study and a high threshold of dependence at admission, as well as the different results of clinical scores, which were obviously very serious compared to our study, for example with an APACHE II score of 24 compared to 14.33 in our study, SAPS II score of 53/29.36 with a SOFA score of 7/3.02, respectively, the French study [10] had the highest percentage in all the studies, which is probably due to selection bias explained by the age of the admitted patients, who were over 75 years old,

Regarding the length of stay in the intensive care unit, our average was 4.18 +/- 5.38 days, which is low compared to the Moroccan study conducted in Rabat and the French study, as well as the Sub-Saharan study in Burkina Faso, but high compared to the Mexican and Asian studies in Singapore.

The use of vasoactive drugs was reported in all the studies, and we noticed that our series had the highest rate compared to other studies. This is mainly due to the predictive and anticipatory protocol established by our department regarding the management of hemodynamic failure and early management of low cardiac output to prevent any complications evolving into organ failure.

Nosocomial infection, developed during the stay in the intensive care unit, an inevitable consequence of prolonged stay, frail immunological state, and advanced age, was reported in all the studies, with a high rate reported in the study by Belayachi et al. followed by the study by Reyes, José et al. and the study by Daubin et al., and then our study ranking in fourth place. Low rates were reported in the studies by Lankoandé M et al [6] and Siddiqui S et al [9], respectively.

- **Results of our univariate analysis compared to the literature**

The univariate analysis was conducted to identify factors associated with mortality in the study. Several variables were examined, including age, sex, origin, length of stay in the intensive care unit, medical history (such as heart disease, chronic renal failure, hepatopathy, neoplasm, recent surgery), comorbidities, severity scores (Charlson, Barthel, SOFA, SAPS II, APACHE II), treatments received (mechanical ventilation, catecholamines, dialysis, central venous catheterization), as well as evolving elements (nosocomial infections, septic shock, loss of autonomy, surgical intervention, cognitive impairment).

Age, age group, presence of hypertension, insulin-dependent or non-insulin-dependent diabetes, chronic respiratory failure, history of psychiatric disorders and stroke, as well as the presence of cognitive impairment during hospitalization were not identified as significant risk factors for mortality.

However, factors associated with mortality in univariate analysis reported in Table *4* included length of stay, history of heart disease, chronic renal failure, hepatopathy, neoplasm, recent surgery, number of comorbidities, presence of unbalanced comorbidities, severity scores (Charlson, Barthel, SOFA, SAPS II, APACHE II), presence of organ failure on admission, use of mechanical ventilation, duration of mechanical ventilation, use of catecholamines, dialysis, placement of central venous catheters, onset of nosocomial infections, septic shock during stay, pressure sores, surgical intervention, and loss of autonomy.

In L.A Sanchez and al analysis [5], the variables (age, presence of comorbidities, APACHE II score, presence of organ failure on admission, use of mechanical ventilation and duration of ventilation, use of dialysis, development of nosocomial infection) were consistent with the results obtained in our study, unlike the Belayachi and al study [7] where variables (alcoholism, pneumonia, shock, dehydration, diuresis, urea and creatinine levels, abnormal x-ray, APACHE and SOFA scores) were identified as mortality factors without the SAPS II score being significant. The Daubin, C and al. [10] analysis

reported several predictive factors of mortality in the univariate analysis, such as the SOFA score, presence of organ failure on admission, use of dialysis, length of stay, and readmission to the intensive care unit after discharge.

- **Risk factors for mortality**

The multivariate analysis showed a statistically significant association between the factors represented (Table *5*) and mortality. Thus, death was significantly associated with the studied scores, creatinine clearance and pre-existing chronic renal failure, use of mechanical ventilation, persistence of hemodynamic failure, and surgical intervention during the stay. The results differ from what is found in the literature (Table *8*)

Studies	Multivariate Analysis Results (Mortality risk factors)
Our study	Length of stay
	Barthel score at admission
	score at admission SOFA
	SAPS II
	Charlson index
	Presence of chronic renal insufficiency at admission
	Abnormal creatinine clearance at admission
	Persistent HD failure during the stay
	Use of mechanical ventilation
	Surgical reintervention
L.A Sanchez and al [5]	Age
	APACHE II
	Presence of respiratory failure
	Use of mechanical ventilation
Lankoande and al [6]	Presence of shock
	Severe head trauma
	Coma upon admission
	Surgery
	SAPSII greater than 8
	Presence of complications during hospitalization
	Stroke
Belayachi, j and al [7]	Presence of shock at admission
	Presence of pneumonia
Daubin, C and al [10]	Charlson index
	Persistence of organ failure during hospital stay

Table 8: Risk factors for mortality and results of multivariate studies

When comparing the results with different studies, we observe a certain similarity between our results and those of the L.A Sanchez and al. and Belayachi, j and al [5, 7] respectively. However, the presence of severe traumatic brain injury identified as a mortality factor in the sub-Saharan study of Lankoande and al [6] makes it different. This is because our results may have a selection bias, considering that our unit is the referral unit in the region for the collection and pre- and post-operative management of

visceral surgery, and that the number of admissions for severe traumatic brain injuries was low in our unit as they were admitted to another dedicated intensive care unit within our hospital.

- **Admission perspectives and specific considerations for managing elderly patients in intensive care**

The specific considerations for elderly patients in intensive care are essential to ensure optimal management. Here are some important points to consider:

Admission criteria for intensive care:

When it comes to triaging elderly patients for admission to intensive care, several factors come into play. Physicians need to assess criteria such as:

- *Dementia*
- *Autonomy*
- *Patient/family wishes*
- *Chronic diseases*
- *Nutritional status*
- *Recent hospitalization*
- *Previous treatments*
- *Social context*

The decision for admission should be based on objective criteria, and sometimes it is preferable to admit an elderly person to intensive care to assess their response to treatment and gather additional information. In this regard, Guidet et al [11] proposed an algorithm outlining the admission process for elderly patients in intensive care, which is of interest. Figure *6* depicts three distinct phases (pre-intensification with initial triage, intensive care with evaluation/care objectives/scores, and post-intensive care with transfer service/follow-up).

In other cases, these hospitalizations have been limited from the start:

Impact of age

The age of patients admitted to intensive care has significantly increased in recent years. The aging population leads to a high demand for admissions to intensive care, especially for patients over 80 years old. It is essential to identify patients who will benefit the most from intensive care to avoid under-admission or over-admission. Studies have shown that autonomy, nutritional status, and comorbidities have a major impact on the prognosis of elderly patients and can compromise admission to intensive care units [11,12].

Quality of life after declined intensive care

Overall, the quality of life for elderly subjects after a stay in intensive care is generally good, except for the oldest (age ≥ 86 years). Physical activities may be impaired, as well as mental and social components, which is why the patient or their family may refuse hospitalization in the intensive care unit [12,13].

In summary, the management of elderly patients in intensive care requires a multidisciplinary approach and a careful evaluation of admission criteria, taking into account age and potential quality of life.

- **Perspectives and proposed care pathways**

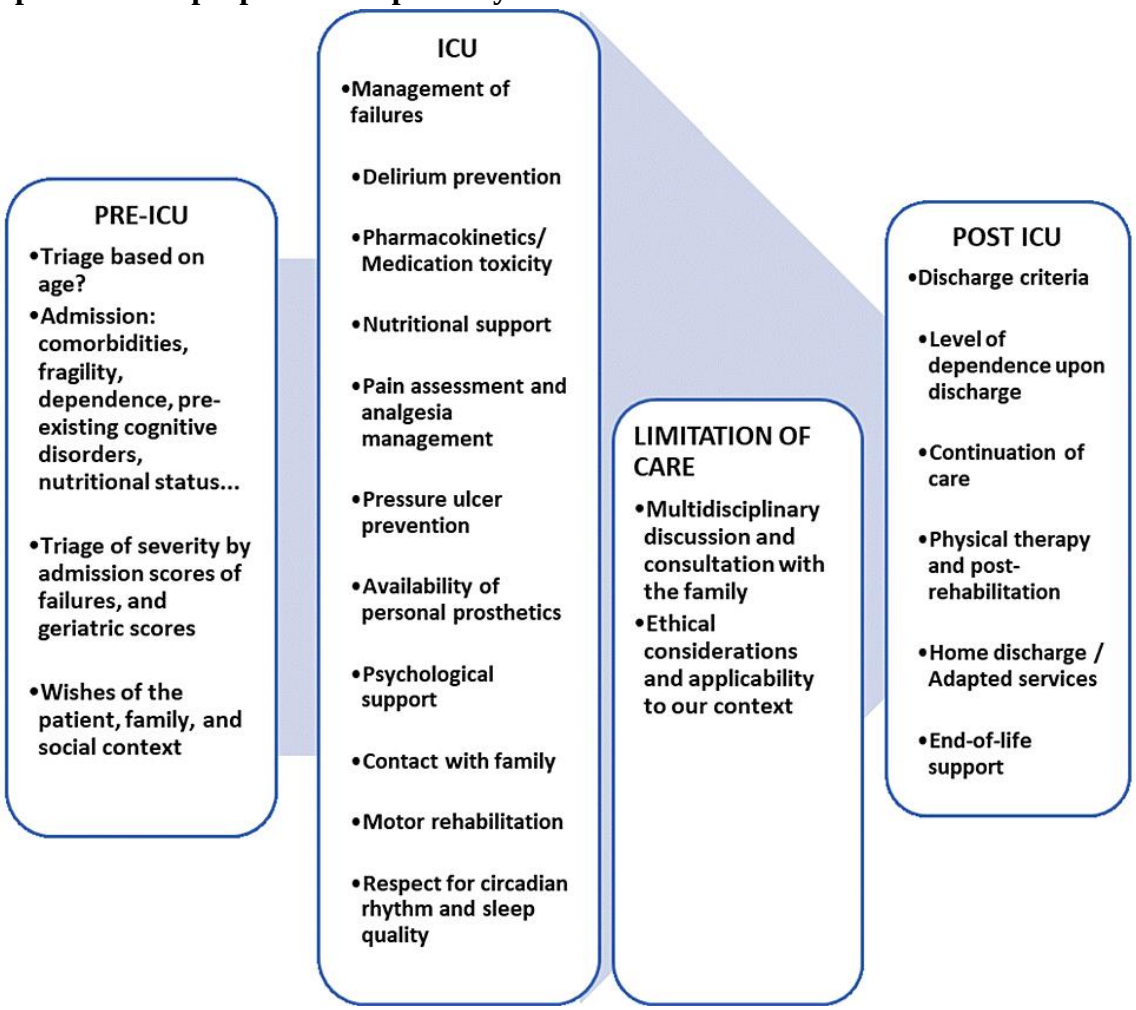

Figure 6: Care pathway for elderly patients in intensive care and key points

Image created by authors following the worlwide guidelines in our department of intensive care A4 of the Hospital University of Hassan II of Fez, Morocco [11,12] In order to integrate quality indicators and skills into the daily practice of anesthesiologists and intensive care physicians, it is recommended to develop practice guidelines focused on optimal care for elderly patients. These guidelines should be evidence-based best practices [14], evaluated by experts, and include key assessments, strategies, and interventions. The first guideline - the "ACS NSQIP/AGS Best Practice Guidelines: Optimal Preoperative Assessment of the Geriatric Surgical Patient" [15] - focuses solely on the preoperative period, provides a summary of evidence, and includes various key assessments (screening tools, algorithms, etc.), strategies, and interventions. The guideline also includes a 13 points preoperative assessment checklist covering cognitive function and mental health, cardiac and pulmonary status, frailty, nutritional status, medications, treatment goals, available social support, and preoperative testing. The rest of the guideline focuses on different elements involved in the optimal preoperative assessment of the elderly surgical patient, and is summarized in the appendix (Appendix 1).

It is also recommended for intensivists to identify risk factors for the development of intensive care delirium in each patient and document them in the medical record. Delirium prevention involves approaches such as daily reorientation, maintaining good sleep hygiene, early mobilization, and avoiding

inappropriate medications (e.g. opioids, benzodiazepines, antihistamines, etc.), adequate multimodal analgesia, easy access to visual and auditory aids, early removal of urinary catheter, and implementation of a standardized bowel regimen (Appendix 1).

Discussions, established between the intensivist, other specialists, and the patient, documented in the medical record, should explicitly determine the patient's preferences and expectations regarding treatment, with the involvement of family members or possible decision-makers who may be necessary. The presence of family and social support systems should also be well established, and in cases of limitation, consultation with a social worker should be considered [16,17].

Rehabilitation and post-intensive care rehabilitation centers, though rare in Morocco compared to the USA or Europe, are recommended to meet the needs of elderly patients. This specialized field of rehabilitation medicine can provide care for elderly patients after their stay in intensive care and facilitate their recovery.

Frailty, characterized by a decrease in physiological reserve and resistance to stressors, makes elderly patients more vulnerable to complications. An enhanced recovery after surgery (ERAS) strategy that limits unnecessary invasive catheters and focuses on early physiotherapy can help prevent complications in frail elderly patients. Multivitamin support, limitation of unnecessary invasive catheters with early physiotherapy initiated from intensive care admission, may help counteract the effects of frailty in intensive care.

In a recent study, the rates of malnutrition were 5.8% in elderly people in the community, 13.8% in nursing homes, 38.7% in hospitals, and 50.5% in rehabilitation centers [18,19]. Poor nutritional status is associated with an increased risk of postoperative adverse events, primarily infectious complications. Therefore, the patient's size, weight, and body mass index (BMI) should be documented. Serum albumin and pre-albumin levels should also be measured, and the patient should be asked about any unintentional weight loss in the previous 12 months. Several parameters are known risk factors for severe nutritional risk. Patients considered to be at severe nutritional risk should undergo a comprehensive nutritional assessment by a dietitian and be considered for preoperative nutritional support.

Compared to younger individuals, elderly patients are at increased risk of medication-related adverse effects. They are more likely to have diminished renal function and chronic kidney disease, and they are more sensitive to psychoactive medications (including frequently used ones such as opioids, antihistamines, benzodiazepines, etc.) and at risk for polypharmacy, drug interactions, and overdosing. Intensivists should review and document the patient's complete medication list, including over-the-counter agents and herbal products. Treatment regimens should be modified to reduce medication-related adverse effects by discontinuing inappropriate medications and substituting non-nephrotoxic drugs. It is also important to start using perioperative injectable medications that improve postoperative outcomes (i.e. beta-blockers and statins) and dose renally cleared medications perioperatively. New prescriptions for benzodiazepines should be avoided [20].

A study of deceased individuals aged 60 and older found that nearly 30% of them needed to make decisions regarding medical care towards the end of life but lacked the capacity to make decisions. About two-thirds of them had advanced directives, and these individuals received care strongly associated with their preferences. While patients often believed that their family members could represent their wishes, these family members often failed to accurately predict preferences regarding assisted medical end-of-life care or in-home care. Few patients had already discussed their preferences with family members and physicians [21,22,23]. It is also important to respect laws and religious beliefs

regarding end-of-life decisions. The "do not resuscitate" decision is not debatable and is prohibited in our legal context, as our country is predominantly Muslim [24].

Recent studies have shown that routine preoperative screening may have low yields and high costs. It is recommended to focus on selective diagnostic tests in high-risk patients. Integration of specific quality indicators and skills for elderly patients is essential to improve the management of this population. Practice guidelines focused on optimal care for elderly patients can be helpful in this area [25, 26].

- **Limitations of the study: Methodological limitations, potential biases**

Our study has several limitations; firstly, due to its retrospective nature, it was conducted in a single department, while our university hospital has three intensive care units + emergency departments where an intensive care unit is present, which represents a selection bias. Additionally, a specific mix of intensive care patients was implemented: elderly patients admitted and requiring medical care were preselected through postoperative admissions from the central operating block, especially in visceral surgery, as our intensive care unit is the reference in this field in the Fes-Meknes region. Our data collection, based on already available data, may not establish causality relationships as robustly as a prospective study. It may be more difficult to determine the direction of the relationship between variables and exclude other possible explanations. Finally, we did not evaluate the impact of pre-hospitalization functional status. In our elderly population, mortality rates were similar regardless of age group. The lack of significant differences between age groups in our study may be related to the small proportion of very elderly subjects (>80 years old). Triage decisions regarding admission to our intensive care unit required input from senior practitioners and were guided by recommendations from learned societies, which may have introduced possible selection bias through admissions for visceral surgery. Through this work, we aim to provide useful information on clinical outcomes, predictors of death, and long-term quality of life in an elderly population requiring intensive care. Our local results can be correlated with what is found in the literature regarding the care provided and protocols used since we used the most commonly used scoring systems, particularly the Charlson index, SAPS II, and SOFA, which remain valid for geriatric populations.

CONCLUSIONS

The management of elderly patients in intensive care is a current and highly important topic due to the global and Moroccan population aging. The demographic transition towards an older population poses major challenges for the healthcare system, particularly in intensive care and critical care. Elderly individuals often have complex care needs and require an individualized approach to ensure optimal outcomes.

It is essential to establish individualized care pathways to address the specific needs of these patients. This involves considering their degree of autonomy, comorbidities, and individual preferences. Additionally, it is necessary to identify risk factors for mortality in elderly patients in order to tailor medical interventions accordingly. However, focusing solely on mortality as the evaluation criterion is not sufficient, as quality of life after intensive care is also of great importance. Elderly patients may experience physical sequelae, cognitive impairments, and psychosocial issues following their stay in intensive care.

Practice guidelines focused on optimal care for elderly patients can help improve the management of this specific population.

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APPENDICES

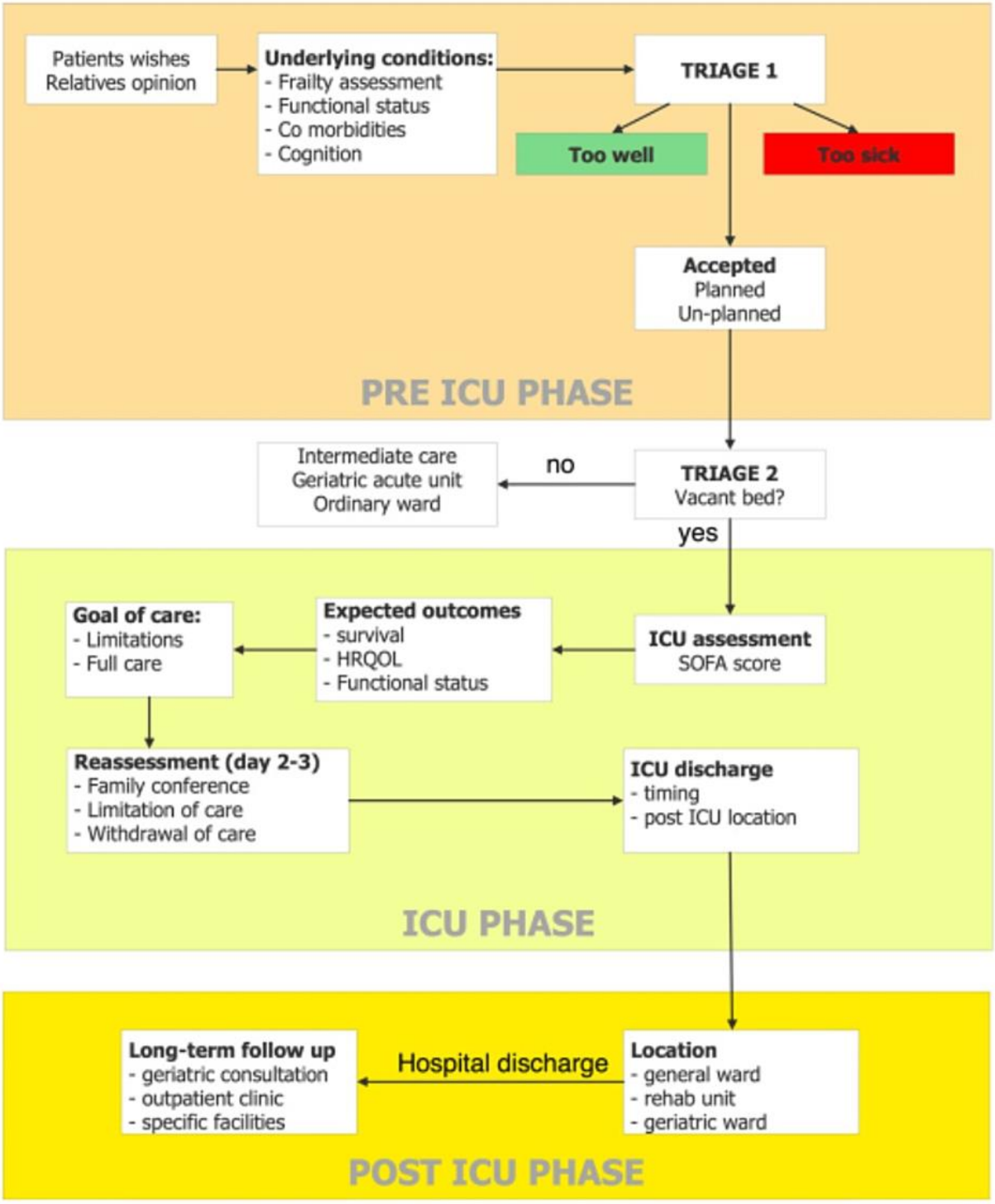

Figure 7: Assesment tool for triaging elder patients from pre- ICU phase to post- ICU phase ([11])