European Geriatric Medicine (2022) 13:253–265
https://doi.org/10.1007/s41999-021-00557-6

RESEARCH PAPER

Mechanical ventilation for older medical patients in a large tertiary medical care center

Bella Smolin[1,2] · Ayelet Raz-Pasteur[2,3] · Tatiana Mashiach[4] · Hisam Zaidani[1,2] · Leon Levi[5] · Alexander Strizevsky[6] · Daniel A. King[7] · Tzvi Dwolatzky[2,7,8]

Received: 11 March 2021 / Accepted: 26 August 2021 / Published online: 20 September 2021

Key summary points

Aim The aim of the study is to determine the factors influencing the outcomes of older ventilated medical patients in a large tertiary medical center.

Findings Of 554 older patients (mean age 79 years) who underwent mechanical ventilation for the first time during the study period in-hospital mortality was 64.1% and overall 6-months survival was 26%. A combination of age 85 years and older, poor functional status prior to ventilation, and associated morbidity were the strongest negative predictors of survival after discharge from the hospital.

Message The identification of factors predicting poor survival of mechanical ventilation will assist policy makers in clinical decision-making particularly at times of limited health resources.

Abstract

Background The development of technologies for the prolongation of life has resulted in an increase in the number of older ventilated patients in internal medicine and chronic care wards. Our study aimed to determine the factors influencing the outcomes of older ventilated medical patients in a large tertiary medical center.

Methods We performed a prospective observational cohort study including all newly ventilated medical patients aged 65 years and older over a period of 18 months. Data were acquired from computerized medical records and from an interview of the medical personnel initiating mechanical ventilation.

Results A total of 554 patients underwent mechanical ventilation for the first time during the study period. The average age was 79 years, and 80% resided at home. Following mechanical ventilation, 8% died in the emergency room, and the majority of patients (351; 63%) were hospitalized in internal medicine wards. In-hospital mortality was 64.1%, with 48% dying during the first week of hospitalization. Overall 6-months survival was 26%. We found that a combination of age 85 years and older, functional status prior to ventilation, and associated morbidity (diabetes with target organ injury and/or oncological solid organ disease) were the strongest negative predictors of survival after discharge from the hospital.

Conclusion Mechanical ventilation at older age is associated with poor survival and it is possible to identify factors predicting survival. In the midst of the COVID-19 pandemic, the findings of this study may help in the decision-making process regarding mechanical ventilation for older people.

Keywords Aging · Mechanical ventilation · Internal medicine · Survival

Bella Smolin and Ayelet Raz-Pasteur contributed equally as first authors.

✉ Tzvi Dwolatzky
tzvidov@gmail.com

1 Internal Medicine Division, Rambam Health Care Campus, Haifa, Israel

2 The Ruth and Bruce Rappaport Faculty of Medicine, Technion – Israel Institute of Technology, Haifa, Israel

3 Internal Medicine Ward "A", Rambam Health Care Campus, Haifa, Israel

4 Epidemiology and Statistics Unit, Rambam Health Care Campus, Haifa, Israel

5 Medical Administration, Rambam Health Care Campus, Haifa, Israel

6 Emergency Medicine Unit, Rambam Health Care Campus, Haifa, Israel

7 Pulmonary and Respiratory Intensive Care Division, Meir Medical Center, Kfar Saba, Israel

8 Geriatric Unit, Rambam Health Care Campus, 8 Ha'Aliyah Street, Box 9602, 3109601 Haifa, Israel

Introduction

Technological developments have made an important impact on improving health care and prolonging life. Mechanical ventilation for advanced respiratory support is now widely available. The growing number of acute patients requiring mechanical ventilation places an increasing burden on limited high-cost Intensive Care Unit (ICU) beds. Although the age structure in Israel is still relatively young, there is a marked increase in the number of people of more advanced old age [1]. As a result, Israel has witnessed a rise in the number of older ventilated patients which has greatly surpassed the availability of ICU beds, the consequence of which is that the majority of ventilated patients are now treated in special units within Internal Medicine wards.

Many studies have sought to examine the causative factors resulting in mechanical ventilation, and to determine the outcomes of this intervention. The majority of these studies were conducted in the ICU setting [2–7]. Many studies show higher mortality and poorer outcomes in older patients [8]. Nevertheless, several studies found that age was not an independent predictor of mortality [9]. It has been suggested that it is not advanced age per se that determines prognosis in older patients but rather other age-related factors, such as comorbidities and physical and cognitive function [10–12].

Relatively few studies have included patients treated by mechanical ventilation outside the ICU [13–16]. These studies were largely designed to compare the outcomes of those treated in ICUs with those who were not managed in ICU to determine which patients are likely to most benefit from ICU admission [3].

The decision to proceed to mechanical ventilation for older critically ill patients has important ramifications not only for patients and their families, but also for the health care system. This is of particular interest in the legal, religious and cultural milieu of Israel. The religious principle of the holiness of life in Judaism and Islam makes many patients and family decision makers request ventilation at all cost, and legal requirements forbid the discontinuation of life-maintaining interventions such as mechanical ventilation. These factors have resulted in an increase in the number of people treated by chronic mechanical ventilation in special long-term units. Obviously, better clinical prognostication for critically ill older patients is required prior to mechanical ventilation and advanced life support. Apart from the personal unfavorable consequences of mechanical ventilation in older patients with underlying untreatable disease, the economic demands placed on a health system that is battling to finance current needs have major implications on both acute and chronic care settings.

The scope of our study was to investigate the decision-making process at the initiation of mechanical ventilation and the natural history of a study population comprising all mechanically ventilated older medical patients in a large acute tertiary care medical center.

Materials and methods

Study design and participants

This was a prospective, observational cohort study performed at the Rambam Health Care Campus, a 1000-bed tertiary hospital in Haifa, Israel. We included all medical patients aged 65 years and older who underwent tracheal intubation with mechanical ventilation during the study period for indications unrelated to trauma and/or surgical interventions. For those patients who were successfully weaned from the initial mechanical ventilation and who then underwent a repeat tracheal intubation and mechanical ventilation during the study period, the second event was excluded from the study. Patients who had a permanent tracheostomy were included in the study if they were mechanically ventilated during hospitalization. We also included patients who underwent tracheal intubation and mechanical ventilation during the course of cardiopulmonary resuscitation in the emergency medicine unit or in the internal medicine wards and who died soon after the event. The investigators were not involved in the decision to ventilate the patients. Survival was determined for up to 2 years following the initiation of ventilation. The study was approved by the Committee for Research in Human Subjects (the Helsinki Committee) of the Rambam Health Care Campus, and the need for informed patient consent was waived for this study.

Questionnaire and data collection

Data were collected from computerized hospital records and from a questionnaire administered by a study nurse to the physician or paramedic who was directly involved in the decision to intubate and ventilate the patient. The collected data included age, gender, Charlson comorbidity index, main diagnoses (based on ICD-9 classification), place of residence prior to admission (home, assisted living, nursing home, geriatric hospital or other in-patient facility), baseline functional status (independent, frail, nursing care), laboratory investigations (hemoglobin, hematocrit, blood urea nitrogen, creatinine, glucose, albumin, sodium, potassium, calcium) and the Norton Pressure Ulcer Prediction Scale [17].

With regard to the initiation of mechanical ventilation, we determined when the ventilation was commenced, who had made the decision to ventilate (physician or paramedic) and where the decision was made (patient's home, nursing home, geriatric hospital, emergency medicine unit or in-patient unit). The presence of advanced directives was ascertained, and the physician or paramedic was asked whether the decision to ventilate had been made following a prior discussion with the patient and/or family members.

Statistical analysis

Bivariate analysis of factors associated with in-hospital mortality was performed by logistic regression, followed by multivariate stepwise logistic regression to determine factors predicting outcome. Multivariate logistic regression models were used to estimate the independent (adjusted) effects of patients' characteristics on the in-hospital mortality. Bivariate analysis of factors associated with post-discharge survival was performed by Cox regression, followed by multivariate Cox regression. The SPSS (Statistical Package for the Social Sciences, SPSS Inc, Chicago, IL, USA) statistical software (Version 21.0) was used for data processing and statistical analysis. Statistical significance was set at $P<0.05$ throughout.

Results

Table 1 provides the baseline patient characteristics and their influence on in-hospital mortality. The study group consisted of 554 patients who underwent mechanical ventilation for the first time during the 18 months of recruitment (from 1 March 2015 to 30 September 2016). The mean age was 79 years (65–100). Seventy-five percent of the patients were in their eighth and ninth decade of life, while 7% were above the age of 90. The vast majority (443; 80%) of patients lived at home prior to hospitalization, 225 (51%) lived with a spouse and 59 (13%) were cared for by a live-in foreign worker. Other sources of referral were assisted living facilities (14; 2.5%), nursing homes (71; 1.8%) and geriatric hospitals (17; 3.1%).

While 240 (43.7%) had been functionally independent prior to the initiation of mechanical ventilation, the majority of patients were functionally impaired prior to the event, with 105 (19.1%) classified as frail and 204 (37.2%) as requiring nursing care. As expected, comorbidities were common. The most frequent conditions were moderate or severe renal failure in 254 patients (46%), myocardial infarction in 189 (34%), chronic pulmonary disease (31%), cerebrovascular disease (30.5%), heart failure (27%), and diabetes mellitus (26%) (Table 1).

Ninety-eight percent of study patients were admitted to the emergency room urgently. Of the 544 subjects in the study cohort, 44 (7.9%) died in the emergency room following intubation and mechanical ventilation. A total of 351 (63%) were transferred directly to internal medicine wards, 58 (10.4%) were transferred to the medical ICU and 41 (7.4%) to the Coronary Care Unit. The remaining 30 (5.4%) patients were admitted to other in-patient wards.

Decision-making process: mechanical ventilation

The findings relating to the decision-making process regarding mechanical ventilation are presented in Table 1. Paramedics performed intubation and initiated mechanical ventilation in 137 (24.6%) patients prior to arrival at the hospital, with 25 (4.5%) patients being ventilated by physicians in referring hospitals. The decision to perform mechanical ventilation was made by a physician in the emergency room in 202 (36.5%) cases, and in one of the hospital wards in 172 (31%) instances. The decision to intubate and ventilate the patient was usually made urgently by a single physician (356; 91%) in the 391 in-hospital events. Family members of the patient were present in the vicinity in 428 (77.2%) of all cases (both prior to acute hospitalization and in the hospital), and in 186 (33.6%) cases the decision was shared with the family. In only 11 instances were advanced directives available at the time of the decision to commence mechanical ventilation.

General outcomes of treatment

The findings relating to the outcomes following mechanical ventilation are presented in Table 1 (in-hospital mortality) and Table 2 (post-discharge survival). Mortality was high and 355 (64.1%) ventilated patients died during hospitalization, with 172 (48.4%) of the deaths occurring during the first week of hospitalization. Of those patients who survived the hospitalization, 30 (14.1%) remained on chronic mechanical ventilation, and for those who were weaned from mechanical ventilation, 29 (13.6%) remained with tracheostomy. Seventy-eight (36.6%) patients were discharged to their homes, 49 (23%) to a rehabilitation framework, and 45 (21.1%) were transferred to nursing care institutions, including institutions for chronically ventilated patients. Overall survival at 6 months was 26% for the entire cohort. Most patients who died after the acute hospitalization did so in the first 6 months following hospital discharge. Overall survival for patients 85 years and older was 14% at 6 months and 11% at 2-years follow-up. It is interesting to note that for those discharged from hospital the survival rate did not change significantly over time (69% survived 6 months, 63% survived a year, and 57% survived 18 months). The best outcome of successful weaning from the ventilator during hospitalization, discharge home and survival at 6 months was found in 59 (10.6%) patients.

Table 1 Patient characteristics and bivariate analysis of factors associated with in-hospital mortality

Characteristic	Patients groups	All patients	In-hospital mortality (Number and % of all patients)				95% CI	
		Number	Number	%	*P* value	OR	Lower	Upper
	Total	554	355	64.1	–	–	–	–
Age groups (years)	65–69	96	54	56.3	0.012	1.00		
	70–79	228	136	59.6	0.571	1.15	0.71	1.86
	80–89	189	133	70.4	0.018	1.85	1.11	3.08
	90+	41	32	78.0	0.018	2.77	1.19	6.42
Age groups (years)	<85	424	259	61.1	–	1.00	–	–
	≥85	130	96	73.8	0.008	1.80	1.16	2.79
Gender	Female	282	182	64.5	–	1.00	–	–
	Male	272	173	63.6	0.818	0.96	0.68	1.36
Place of living	Home	443	275	62.1	0.238	1.00	–	–
	Assisted living	14	9	64.3	0.867	1.10	0.36	3.34
	Nursing home	71	53	74.6	0.043	1.80	1.02	3.18
	Geriatric hospital	17	13	76.5	0.237	1.99	0.64	6.19
	Other	9	5	55.6	0.691	0.76	0.20	2.88
First place of hospitalization	Internal medicine	351	224	63.8	0.247	1.00	–	–
	Neurology	30	14	46.7	0.067	0.50	0.23	1.05
	ICU	58	29	50.0	0.047	0.57	0.32	0.99
	ICCU	41	25	61.0	0.721	0.89	0.46	1.72
	Emergency room	44	44	100.0	0.997	–	0.37	0.00
	Other	30	19	63.3	0.958	0.98	0.45	2.12
Performance (functional) status before admission	Independent	240	132	55.0	<0.001	1.00	–	–
	Frail*	105	66	62.9	0.175	1.39	0.87	2.22
	Nursing care**	204	153	75.0	<0.001	2.46	1.64	3.69
	Missing	5	4	80.0	–	–	–	–
Mentally frail	No	438	272	62.1	–	1.00	–	–
	Yes	116	83	71.6	0.060	1.54	0.98	2.40
Oncologic disease	No	442	282	63.8	–	1.00	–	–
	Yes	112	73	65.2	0.786	1.06	0.69	1.64
Place of initiation of mechanical ventilation	Hospital physician	391	260	66.5	0.014	1.64	1.10	2.44
	Out of hospital physician	25	20	80.0	0.024	3.31	1.17	9.32
	Missing	1	0	0.0	–	–	–	–
	Home/ambulance	122	66	54.1	0.077	1.00	–	–
	Nursing home/geriatric hospital	3	2	66.7	0.669	1.70	0.15	19.21
	Emergency room	202	134	66.3	0.029	1.67	1.06	2.65
	Hospital departments	172	119	69.2	0.009	1.91	1.18	3.08
	Other hospital	26	19	73.1	0.081	2.30	0.90	5.88
	Missing	29	15	51.7	–	–	–	–
Tracheostomy during hospitalization	No	415	285	68.7	–	1.00	–	–
	Yes	138	70	50.7	<0.001	0.47	0.32	0.70
	Missing	1	0	0.0	–	–	–	–
Weaning attempt from mechanical ventilation	No	356	324	91.0	–	1.00	–	–
	Yes	198	31	15.7	<0.001	0.02	0.01	0.03
Decision-making initiation mechanical ventilation	Team discussion	175	123	70.3	0.097	1.00	–	–
	Single hospital physician	356	216	60.7	0.031	0.65	0.44	0.96
	Ambulance physician	1	1	100.0	1.000	–	4.21	0.00
	Missing	22	15	68.2	–	–	–	–

Table 1 (continued)

Characteristic	Patients groups	All patients	In-hospital mortality (Number and % of all patients)				95% CI	
		Number	Number	%	*P* value	OR	Lower	Upper
Discussion with family before initiation of mechanical ventilation	No	242	134	55.4	< 0.001	1.00	–	–
	Yes	186	133	71.5	0.001	2.02	1.35	3.04
	Family not present	103	72	69.9	0.012	1.87	1.15	3.06
	Missing	23	16	69.6	–	–	–	–
Patient has advance directive	No	275	178	64.7	0.876	1.00	–	–
	Yes	11	7	63.6	0.941	0.95	0.27	3.34
	Missing	243	152	62.6	0.607	0.91	0.64	1.30
Asked about advance directive	No	25	18	72.0	–	–	–	–
	Yes	507	321	63.3	–	1.00	–	–
	Missing	23	17	73.9	0.305	1.64	0.64	4.24
Main ward/unit of hospitalization	ICU	86	44	51.2	0.202	1.00	–	–
	ICCU	50	29	58.0	0.441	1.32	0.65	2.66
	Internal Medicine	330	212	64.2	0.027	1.72	1.06	2.77
	Recovery room	1	0	0.0	1.000	0.00	0.00	0.00
	Other	34	18	52.9	0.861	1.07	0.49	2.38
	Missing	53	52	98.1	–	–	–	–
Timing (day from admission) of mechanical ventilation	Before admission to hospital	15	8	53.3	0.001	1.00	–	–
	0 + 1	123	62	50.4	0.831	0.89	0.30	2.60
	2 +	415	285	68.7	0.218	1.92	0.68	5.40
	Missing	1	0	0.0	–	–	–	–
Application for admission to ICU	Approved by ICU	3	1	33.3	0.592	1.00	–	–
	Rejected by ICU	400	250	62.5	0.327	3.33	0.30	37.08
	No application to ICU	127	81	63.8	0.309	3.52	0.31	39.91
	Missing	24	23	95.8	–	–	–	–
First albumin (< = 4 days from admission)	3.5 +	29	13	44.8	< 0.001	1.00	–	–
	3–3.4	89	45	50.6	0.592	1.26	0.54	2.92
	2.5–2.9	137	74	54.0	0.370	1.45	0.65	3.23
	< 2.5	152	101	66.4	0.030	2.44	1.09	5.46
	Missing	147	122	83.0	< 0.001	6.01	2.57	14.04
First blood urea nitrogen (< = 3 days from admission)	≤ 30	271	148	54.6	< 0.001	1.00	0.00	0.00
	30.01–40	78	49	62.8	0.199	1.40	0.84	2.36
	40.01–60	68	52	76.5	< 0.001	2.70	1.47	4.97
	> 60	74	59	79.7	< 0.001	3.27	1.77	6.05
	Missing	63	47	74.6	0.004	2.44	1.32	4.52
Recurrent mechanical ventilation during hospitalization	No	464	305	65.7	–	1.00	–	–
	Yes	88	49	55.7	0.073	0.66	0.41	1.04
	Missing	2	1	50.0	–	–	–	–
Pneumonia	No	482	310	64.3	–	1.00	–	–
	Pneumonia	72	45	62.5	0.765	0.93	0.55	1.54
Myocardial infarction (MI)	No	365	230	63.0	–	1.00	–	–
	MI	189	125	66.1	0.468	1.15	0.79	1.66
Congestive heart failure (CHF)	No	404	268	66.3	–	1.00	–	–
	CHF	150	87	58.0	0.070	0.70	0.48	1.03
Peripheral vascular disease (PVD)	NO	518	329	63.5	–	1.00	–	–
	PVD	36	26	72.2	0.295	1.49	0.71	3.17
Cerebrovascular disease	No	385	243	63.1	–	1.00	–	–
	Cerebrovascular	169	112	66.3	0.476	1.15	0.79	1.68

Table 1 (continued)

Characteristic	Patients groups	All patients	In-hospital mortality (Number and % of all patients)				95% CI	
		Number	Number	%	*P* value	OR	Lower	Upper
Dementia	No	524	336	64.1	–	1.00	–	–
	Dementia	30	19	63.3	0.930	0.97	0.45	2.07
Pulmonary disease	No	381	257	67.5	–	1.00	–	–
	Pulmonary disease	173	98	56.6	0.014	0.63	0.44	0.91
Connective tissue disease (CTD)	No	546	349	63.9	–	1.00	–	–
	CTD	8	6	75.0	0.521	1.69	0.34	8.47
Ulcer	No	544	351	64.5	–	1.00	–	–
	Ulcer	10	4	40.0	0.124	0.37	0.10	1.32
Mild liver dysfunction	No	534	342	64.0	–	1.00	–	–
	Mild liver dysfunction	20	13	65.0	0.930	1.04	0.41	2.66
Diabetes mellitus (DM)	No	408	256	62.7	–	1.00	–	–
	DM	146	99	67.8	0.274	1.25	0.84	1.87
Hemiplegia	No	548	354	64.6	–	1.00	–	–
	Hemiplegia	6	1	16.7	0.044	0.11	0.01	0.95
Moderate/severe renal failure	No	300	170	56.7	.	1.00	–	–
	Moderate/severe renal failure	254	185	72.8	0.000	2.05	1.43	2.94
DM with TOD (target organ disease)	No	448	286	63.8	.	1.00	–	–
	DM with TOD	106	69	65.1	0.809	1.06	0.68	1.65
Any tumor	No	459	290	63.2	–	1.00	–	–
	Any tumor	95	65	68.4	0.333	1.26	0.79	2.03
Moderate liver dysfunction	No	551	354	64.2	–	1.00	–	–
	Moderate liver dysfunction	3	1	33.3	0.298	0.28	0.03	3.09
Malignant solid tumor	No	526	333	63.3	–	1.00	–	–
	Solid tumor	28	22	78.6	0.108	2.13	0.85	5.33
Malignant lymphoma	No	546	349	63.9	–	1.00	–	–
	Malignant lymphoma	8	6	75.0	0.521	1.69	0.34	8.47
Leukemia	No	547	349	63.8	–	1.00	–	–
	Leukemia	7	6	85.7	0.258	3.40	0.41	28.48
Charlson index	0–1	110	64	58.2	0.034	1.00	–	–
	2–3	170	100	58.8	0.915	1.03	0.63	1.67
	4–5	119	72	60.5	0.721	1.10	0.65	1.87
	6+	135	99	73.3	0.013	1.98	1.16	3.38
	Missing	20	20	100.0	–	–	–	–
Performance (functional) status before admission	All other	245	136	55.5	–	1.00	–	–
	Dependent	309	219	70.9	< 0.001	1.95	1.37	2.77
Gender and performance status	Female and independent	245	136	55.5	< 0.001	1.00	–	–
	Other	175	128	73.1	< 0.001	2.18	1.44	3.32
	Male and dependent	134	91	67.9	0.019	1.70	1.09	2.64
Age and performance status	Age < 85y and independent	212	115	54.2	–	1.00	–	–
	Age ≥ 85y or dependent	342	240	70.2	< 0.001	1.99	1.39	2.83
Age and performance status and comorbidity (at least one of the following: moderate/severe renal failure; cerebrovascular; malignant solid tumor; malignant lymphoma; leukemia)	Age < 85y and independent and w/o comorbidity	72	27	37.5	< 0.001	1.00	–	–
	Age < 85y and independent and with comorbidity	140	88	62.9	< 0.001	2.82	1.57	5.08
	Age ≥ 85y or dependent and w/o comorbidity	119	74	62.2	< 0.001	2.74	1.50	5.01
	Age ≥ 85y or dependent and with comorbidity	223	166	74.4	< 0.001	4.85	2.76	8.53

Table 1 (continued)

Characteristic	Patients groups	All patients	In-hospital mortality (Number and % of all patients)				95% CI	
		Number	Number	%	*P* value	OR	Lower	Upper
	Pneumonia	71	45	63.4	< 0.001	1.00	–	–
	Infectious diseases (excluding pneumonia)	58	43	74.1	0.194	1.66	0.77	3.54
Main diagnosis	Lung diseases (excluding pneumonia)	121	59	48.8	0.051	0.55	0.30	1.00
	Cardiac diseases	96	60	62.5	0.907	0.96	0.51	1.82
	Cerebrovascular disease	63	41	65.1	0.838	1.08	0.53	2.19
	Coma and metabolic disease	31	19	61.3	0.841	0.92	0.38	2.18
	Other	64	39	60.9	0.770	0.90	0.45	1.81
	Missing	50	49	98.0	< 0.001	28.31	3.69	217

OR odds ratio, *HR* hazard ratio, *CI* confidence interval

*Frail refers to those who are mobile and require help in bathing and/or dressing and/or toileting

**Nursing care refers to those who are not mobile and require help in the majority of the basic activities of daily living

Factors affecting in-hospital mortality and post-discharge survival

We identified a number of predictors of in-hospital mortality. These included age, functional status, initiation of mechanical ventilation by a paramedic out of the hospital as compared to that performed by a physician in the hospital, performing ventilation in the emergency room rather than in an in-patient ward, laboratory results (a decreased albumin or hematocrit and an elevated blood urea nitrogen), lung disease, heart failure, renal failure, and a Charlson comorbidity index score above 6 (Table 1). We found the interaction of age, functional status, and concomitant morbidity to be a strong predictor of in-hospital mortality (Table 1).

Table 3 presents the results of a model based on a multivariate logistic regression analysis of the factors predicting in-hospital mortality. Four independent variables were associated with the risk for in-hospital mortality, namely age over 85 years, poor functional status prior to hospitalization, comorbidities (moderate to severe renal insufficiency, cerebrovascular disease, solid tumors, lymphoma, leukemia) and elevated blood urea nitrogen. The in-hospital mortality and respiratory outcomes (breathing spontaneously or ongoing mechanical ventilation) at discharge according to the variables of this model are presented in Fig. 1. With regard to post-discharge mortality, a multivariate cox regression model found that age ≥ 85 years, gender and performance status, a diagnosis of diabetes mellitus with target organ involvement, as well as malignancy due to solid tumor, were significant predictors of poorer survival (Table 4).

Discussion

We found that mechanical ventilation of older medical patients in the acute care setting has a poor outcome with high mortality. Our finding of 64.1% in-hospital mortality closely resembles that of 68.2% found in a previous study of similar design performed in a tertiary medical center in southern Israel [12, 18]. In most instances, the decision to initiate mechanical ventilation was made urgently by a single physician or paramedic.

It is of great importance for clinicians to have a better understanding of the factors influencing the survival of older people requiring mechanical ventilation, in order enable them to identify those with better prognosis according to the "choosing wisely" concept. We demonstrated a gradual increase of in-hospital mortality with advancing age (from "young old" to "oldest old"). Although advanced age is associated with increased mortality in intensive care unit patients, some studies have shown that older age of mechanically ventilated patients is not necessarily associated with mortality [19]. While these studies were conducted in the ICU, most of the patients in our study were treated in Internal Medicine wards, and the difference in our findings may be due to differences in patient selection. Due to the limited availability of ICU beds, patient selection to the ICU is much stricter and treatment outcomes are often better. Since only a small number of patients in our study were treated initially in the ICU, we could not demonstrate significant differences in outcomes between ICU and the high care units in Internal Medicine wards.

Table 2 Patient characteristics and bivariate analysis of factors associated with post-discharge

Characteristic	Description	Number	Post-discharge survival				*P* value	HR	95% CI	
			6 months (%)	1 year (%)	1.5 years (%)	2 years (%)			Lower	Upper
	Total	199	69	63	57	51				
Age groups (years)	65–69	42	79	76	69	66	0.164	1.00		
	70–79	92	70	61	55	50	0.088	1.69	0.93	3.07
	80–89	56	64	55	52	42	0.024	2.06	1.10	3.87
	90+	9	56	56	56	56	0.362	1.68	0.55	5.10
Age groups (years)	< 85	165	73	66	60	54		1.00		
	85+	34	53	50	44	36	0.027	1.73		
Gender	Women	100	77	68	67	59		1.00		
	Men	99	62	58	48	43	0.022	1.61	1.07	2.42
Place of living	Home	168	74	67	63	56	< 0.001	1.00		
	Assisted living	5	60				0.889	1.11	0.27	4.51
	Nursing home	18	39	28	11	11	< 0.001	3.34	1.93	5.78
	Geriatric hospital	4					0.472	1.67	0.41	6.83
	Other	4	25				0.185	2.19	0.69	6.95
Initial treatment unit	Internal medicine	127	66	61	53	47	0.234	1.00	0.00	0.00
	Neurology	16	69	56	56	56	0.548	0.79	0.36	1.72
	Intensive care unit	29	62	62	62	56	0.418	0.78	0.42	1.43
	Coronary care unit	16	88	88	88	79	0.029	0.28	0.09	0.87
	Emergency room	11	82	64	55	29	0.821	1.09	0.50	2.39
Performance (functional) status before admission	Independent	108	80	74	71	62	< 0.001	1.00		
	Frail*	39	64	51	46	43	0.016	1.90	1.13	3.20
	Nursing care**	51	51	49	37	35	< 0.001	2.47	1.55	3.92
	Missing	1								
Mentally frail	No	166	72	65	61	54		1.00		
	Yes	33	58	52	39	36	0.046	1.64	1.01	2.66
Oncological disease	No	160	72	66	61	55		1.00		
	Yes	39	59	51	41	35	0.015	1.77	1.12	2.79
Decision-making about initiation of mechanical ventilation	Paramedic	62	71	63	58	56	**0.083**	1.00		
	Hospital physician	131	71	65	59	50	0.684	1.10	0.70	1.71
	Out of hospital physician	5	20				0.027	3.28	1.15	9.41
	Missing	1								
Tracheostomy status on discharge	No	130	72	65	59	52		1.00		
	Yes	68	65	59	53	48	0.465	1.17	0.77	1.77
	Missing	1								

Table 2 (continued)

Characteristic	Description	Number	Post-discharge survival				*P* value	HR	95% CI	
			6 months (%)	1 year (%)	1.5 years (%)	2 years (%)			Lower	Upper
Pneumonia	No	172	68	62	57	50		1.00		
	Yes	27	78	67	59	54	0.715	0.89	0.49	1.64
Myocardial infarction (MI)	No	135	68	63	56	51		1.00		
	MI	64	72	63	61	52	0.795	0.95	0.62	1.45
Congestive heart failure (CHF)	No	136	69	62	56	50		1.00		
	CHF	63	70	65	60	54	0.684	0.91	0.59	1.41
Peripheral vascular disease (PVD)	NO	189	69	63	57	52		1.00		
	PVD	10	60	50	50	33	0.535	1.30	0.57	2.97
Cerebrovascular disease	No	142	71	66	61	54		1.00		
	Cerebrovascular	57	65	56	49	43	0.191	1.33	0.87	2.03
Dementia	No	188	71	64	60	53		1.00		
	Dementia	11	46	36	18	18	0.006	2.62	1.32	5.22
Pulmonary disease	No	124	66	60	56	50		1.00		
	Pulmonary disease	75	75	68	60	52	0.435	0.85	0.56	1.29
Connective tissue disease (CTD)	No	197	70	63	57	51		1.00		
	CTD	2					0.746	1.39	0.19	9.95
Ulcer	No	193	69	63	58	52		1.00		
	Ulcer	6	33	33			0.232	1.85	0.68	5.03
Mild liver dysfunction	No	192	70	63	58	52		1.00		
	Mild liver dysfunction	7	29	29			0.162	1.90	0.77	4.69
Diabetes mellitus (DM)	No	152	66	61	57	51		1.00		
	DM	47	81	68	60	50	0.757	0.93	0.58	1.48
Hemiplegia	No	194	70	63	58	51		1.00		
	Hemiplegia	5	40	40			0.577	1.39	0.44	4.38
Moderate/severe renal failure (RF)	No	130	72	65	59	54		1.00		
	RF	69	65	58	54	44	0.189	1.32	0.87	1.99
DM with TOD (target organ disease)	No	162	72	67	60	55		1.00		
	DM with TOD	37	60	46	43	33	0.028	1.68	1.06	2.67
Any tumor	No	169	70	64	59	53		1.00		
	Any tumor	30	67	57	47	39	0.174	1.43	0.86	2.39
Moderate liver dys-function	No	197	70	63	57	51		1.00		
	Liver dysfunction (mod)	2					0.116	3.09	0.76	12.55
Malignant solid tumor	No	193	70	63	58	51		1.00		
	Solid tumor	6	33	33			0.265	1.77	0.65	4.82

Table 2 (continued)

Characteristic	Description	Number	Post-discharge survival				P value	HR	95% CI	
			6 months (%)	1 year (%)	1.5 years (%)	2 years (%)			Lower	Upper
Malignant lymphoma	No	197	70	63	57	51		1.00		
	Malignant lymphoma	2					0.602	1.69	0.24	12.14
Leukemia	No	198	70	63	58	51		1.00		
	Leukemia	1					0.141	4.44	0.61	32.27
Charlson index	0–1	46	78	74	67	65	0.036	1.00		
	2–3	70	73	69	61	57	0.377	1.31	0.72	2.40
	4–5	47	57	49	47	41	0.016	2.14	1.15	3.98
	6 +	36	67	56	50	32	0.026	2.09	1.09	3.97
Age and performance status	Age < 85y and independent	97	83	76	73	63		1.00		
	Age ≥ 85 years or dependent	102	57	50	42	40	< 0.001	2.25	1.49	3.42
Age and performance status and comorbidity (DM with target organ failure/malignant solid tumor)	Age < 85 years and independent and w/o comorbidity	45	82	80	75	68	< 0.001	1.00		
	Age < 85 years and independent and with comorbidity	52	83	73	71	59	0.638	1.17	0.60	2.29
	Age ≥ 85 years or dependent and w/o comorbidity	45	69	60	51	48	0.074	1.81	0.94	3.47
	Age ≥ 85 years or dependent and with disease	57	47	42	35	33	< 0.001	3.16	1.73	5.76
Discharge to	Home	78	80	74	68	63	0.004	1.00		
	Rehabilitation	49	69	61	59	51	0.207	1.42	0.82	2.46
	Complex nursing care/chronic mechanical ventilation	45	62	56	49	44	0.030	1.81	1.06	3.09
	Other general hospital/other/missing	27	52	44	37	28	< 0.001	2.83	1.58	5.05
Ventilation status on discharge	Spontaneous breathing	140	71	65	60	54	0.048	1.00		
	Mechanical ventilation	30	77	70	63	55	0.745	0.91	0.50	1.65
	Spontaneous breathing and tracheostomy	29	52	45	38	34	0.020	1.84	1.10	3.08
Outcome	Best: spontaneous breathing + discharge to home + survival > 6 m	59	100	93	86	74	< 0.001	1.00		
	Spontaneous breathing + discharge to home + survival < 6 m	15					< 0.001	18.73	8.41	41.69
	Spontaneous breathing + discharge other than home	66	62	55	50	42	< 0.001	4.09	2.13	7.85
	Mechanical ventilation on discharge	59	64	58	51	45	< 0.001	3.84	1.98	7.46

OR odds ratio, *HR* hazard ratio, *CI* confidence interval

*Frail refers to those who are mobile and require help in bathing and/or dressing and/or toileting

**Nursing care refers to those who are not mobile and require help in the majority of the basic activities of daily living

Table 3 Factors predicting in-hospital mortality: multivariate logistic regression model

Patient groups		Adjusted OR (95% CI)
Age < 85 years and independent	Without comorbidity	1 [Reference]
	With comorbidity	2.54 (1.40–4.61)*
Age ≥ 85 years or dependent	Without comorbidity	2.54 (1.38–4.67)*
	With comorbidity	3.84 (2.15–6.86)**
	BUN > 40 mg/dl	2.13 (1.43–3.19)**

Comorbidity includes the following diseases: moderate to severe chronic renal failure, cerebrovascular disease, solid tumors, lymphoma, and leukemia

OR odds ratio, *CI* confidence interval, *BUN* blood urea nitrogen

AUC_{ROC}0.702 (95% CI 0.66–0.75); *$P < 0.05$; **$P < 0.001$

Clearly chronological age is no longer a barrier to intensive treatment and invasive interventions for stable older patients [20, 21]. Our finding that patients aged 85 years and older had a poorer prognosis for all measured outcomes, and this should be considered in the context of the acute and critical nature of their condition that resulted in intubation and mechanical ventilation. In our study, almost all patients were ventilated as an urgent procedure due to an acute respiratory failure, often with associated multi-organ failure. However, in all our models, advanced age remained an independent predictor of poorer survival, most probably related to the limited physiological reserves of people of this age group. Not surprisingly, poor functional status prior to hospitalization as well as a higher comorbidity burden, were also independent predictors for both in-hospital and post-discharge mortality.

Apart from the issue of survival, the quality of life of survivors is particularly relevant. Of those who survived the hospitalization, 30 (15.1%) patients required chronic mechanical ventilation. We did not identify previous studies relating to long-term mechanical ventilation following intubation for acute illness in older patients). This finding is of particular importance in the context of the Israeli health care system. As mentioned previously, religious, cultural and legal considerations in Israel have resulted in an increasing number of chronically ventilated patients in special units within long-term care institutions. To date there are 770 beds for chronically ventilated patients in Israel, and additional

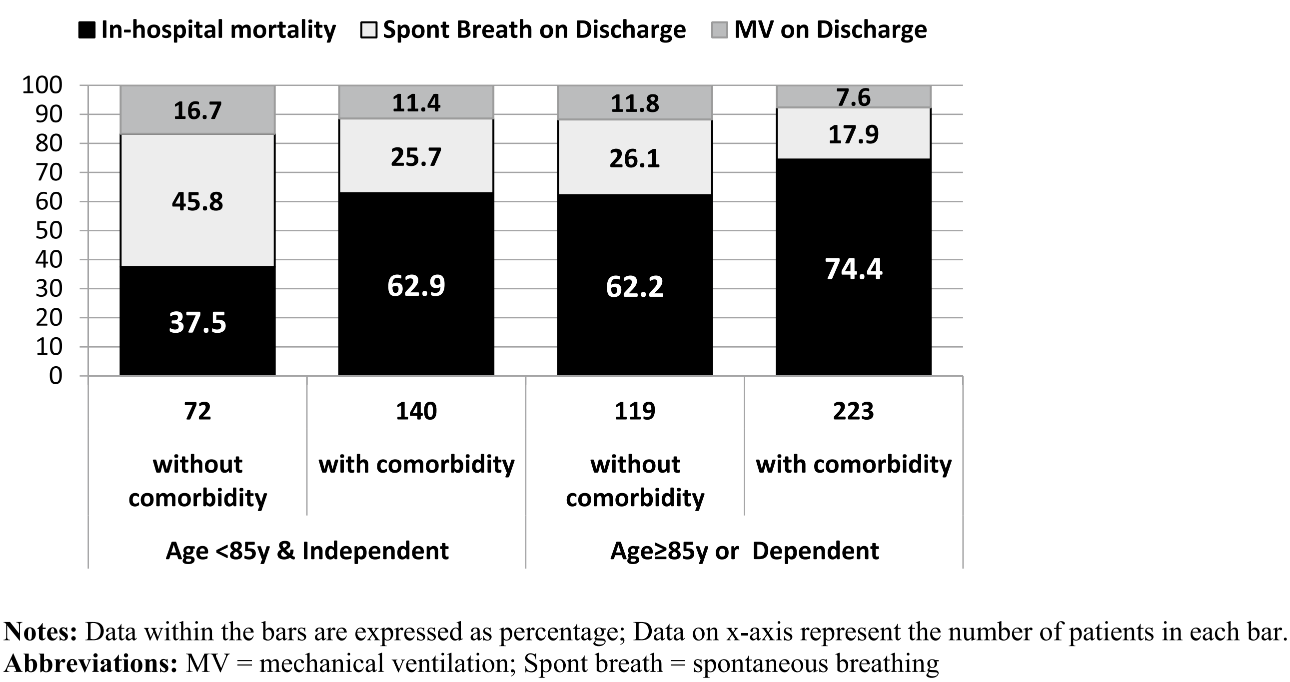

Fig. 1 In-hospital mortality and respiratory outcomes at discharge: illustration of multivariate logistic regression model (Table 3)

Table 4 Factors predicting post-discharge mortality: multivariate Cox regression model†

Patient groups	Adjusted OR (95% CI)
Gender and functional status	
Female independent	1 [Reference]
Other	1.02 (0.51–2.01)
Male dependent	2.92 (1.78–4.80)**
Age ≥ 85 years	
No	1 [Reference]
Yes	1.92 (1.16–3.19)*
Diabetes mellitus with target organ involvement	
No	1 [Reference]
Yes	2.05 (1.29–3.27)*
Malignant solid tumor	
No	1 [Reference]
Yes	2.88 (1.03–8.08)*

OR odds ratio, *CI* confidence interval

† For XBeta 0.72 (95% CI 0.65–0.79); $*P<0.05$; $**P<0.001$

ventilated patients in acute care hospitals are "waiting" for transfer to these units.

Indeed, the "chronic critical illness" syndrome is present in up to 10% of those patients who survive a severe insult and require prolonged mechanical ventilation [22, 23]. These patients tend to suffer recurrent infections, organ dysfunction, profound weakness and delirium, and as many as half have died by 1 year. Among those who survive, readmission rates are high, most require long-term institutional care, and less than 12% are at home and functionally independent a year after their acute illness [18].

A limitation of our study is that although we had access to data regarding post-discharge mortality for up to 2 years, we do not have follow-up details regarding the post-discharge clinical and functional status of the patients. The number of patients discharged with permanent tracheostomy, as well as those needing institutional care, suggest a deterioration in quality of life for many of the patients [4, 24–27].

Endotracheal intubation may be delayed or traumatic in older patients and may thus be associated with poorer outcomes. We must emphasize that in our Center endotracheal intubation is usually performed by skilled and highly trained staff and is generally not delayed or traumatic. In addition, those who were intubated prior to arrival at hospital were intubated by experienced paramedics. All paramedics and physicians who were responsible for the initiation of mechanical ventilation were interviewed regarding the circumstances at the time of intubation and none reported events resulting in delayed or traumatic intubation. With respect to the decision regarding the initiation of mechanical ventilation, most of the decisions to ventilate were made by a single physician urgently in the hospital. Although families were present in the vicinity in many instances, they were seldom asked regarding the existence of advanced directives. In fact, in very few instances had patients prepared their preferences as advanced directives. The importance of autonomy and respecting the wishes of patients at the time of critical medical decision-making should encourage a much wider use of advanced directives for the older population.

Conclusion

Our findings suggest that mechanical ventilation has limited value when used for very old, frail and chronically ill patients with acute medical conditions. This study is published in the midst of the COVID-19 pandemic, where ICU resources are stretched to their limits. In normal circumstances, Israel is unique in the developed world in that most ventilated patients are not admitted to the intensive care unit but rather to dedicated high care units in medical wards. As such, the care of older ventilated patients in medical wards may present a reasonable alternative. In addition, the question regarding the initiation of mechanical ventilation for older frail patients is raising difficult, painful questions for the providers of health care at a time of crisis. Although this study does not relate specifically to the severe respiratory complications of Covid-19 infections, the findings of this study make an important contribution to the decision-making process regarding mechanical ventilation for older people.

Acknowledgements The authors thank Ms. Lea Vugman for collecting the data and interviewing the physicians and paramedics who initiated mechanical ventilation for the study patients. We also thank Mr Elad Rubin for collating and organizing the data for analysis.

Author contributions BS, AR-P and TD designed the study and submitted for ethics committee approval and funding. All the authors were involved in conducting the study and writing the manuscript. TM performed the statistical analysis. All the authors approved the submitted manuscript.

Funding This work was supported by a grant provided by the Israel National Institute for Health Policy Research (Grant Number 2014/85).

Availability of data and material Data and study materials are available from the authors on request.

Code availability Not relevant.

Declarations

Conflict of interest The authors report no conflicts of interest in this work.

Ethics approval The study was approved by the Committee for Research in Human Subjects (the Helsinki Committee) of the Rambam Health Care Campus, and the need for informed patient consent was waived for this study.

Consent to participate Waived in accordance with Ethics Committee decision.

Consent for publication Waived in accordance with Ethics Committee decision.

References

1. Dwolatzky T, Brodsky J, Azaiza F et al (2017) Coming of age: health-care challenges of an ageing population in Israel. Lancet 389:2542–2550. https://doi.org/10.1016/S0140-6736(17)30789-4
2. Van Den Noortgate N, Vogelaers D, Afschrift M, Colardyn F (1999) Intensive care for very elderly patients: outcome and risk factors for in-hospital mortality. Age Ageing 28:253–256. https://doi.org/10.1093/ageing/28.3.253
3. Ely EW, Evans GW, Haponik EF (1999) Mechanical ventilation in a cohort of elderly patients admitted to an intensive care unit. Ann Intern Med 131:96–104. https://doi.org/10.7326/0003-4819-131-2-199907200-00004
4. Montuclard L, Garrouste-Orgeas M, Timsit JF et al (2000) Outcome, functional autonomy, and quality of life of elderly patients with a long-term intensive care unit stay. Crit Care Med 28:3389–3395. https://doi.org/10.1097/00003246-200010000-00002
5. Chelluri L, Im KA, Belle SH et al (2004) Long-term mortality and quality of life after prolonged mechanical ventilation. Crit Care Med 32:61–69. https://doi.org/10.1097/01.CCM.0000098029.65347.F9
6. Simchen E, Sprung CL, Galai N et al (2007) Survival of critically ill patients hospitalized in and out of intensive care. Crit Care Med 35:449–457. https://doi.org/10.1097/01.CCM.0000253407.89594.15
7. Boumendil A, Aegerter P, Guidet B (2005) Treatment intensity and outcome of patients aged 80 and older in intensive care units: a multicenter matched-cohort study. J Am Geriatr Soc 53:88–93. https://doi.org/10.1111/j.1532-5415.2005.53016.x
8. de Rooij SE, Abu-Hanna A, Levi M, de Jonge E (2005) Factors that predict outcome of intensive care treatment in very elderly patients: a review. Crit Care 9:307–314. https://doi.org/10.1186/cc3536
9. Bo M, Massaia M, Raspo S et al (2003) Predictive factors of in-hospital mortality in older patients admitted to a medical intensive care unit. J Am Geriatr Soc 51:529–533. https://doi.org/10.1046/j.1532-5415.2003.51163.x
10. Fagon JY (2006) Acute respiratory failure in the elderly. Crit Care 10:3–5. https://doi.org/10.1186/cc4982
11. Demoule A, Cracco C, Lefort Y et al (2005) Patients aged 90 years or older in the intensive care unit. J Gerontol 60:129–132. https://doi.org/10.1093/gerona/60.1.129
12. Lieberman D, Nachshon L, Miloslavsky O et al (2010) Elderly patients undergoing mechanical ventilation in and out of intensive care units: a comparative, prospective study of 579 ventilations. Crit Care. https://doi.org/10.1186/cc8935
13. Hersch M, Sonnenblick M, Karlic A et al (2007) Mechanical ventilation of patients hospitalized in medical wards vs the intensive care unit-an observational, comparative study. J Crit Care 22:13–17. https://doi.org/10.1016/j.jcrc.2006.06.004
14. Cohen IL, Lambrinos J (1995) Investigating the impact of age on outcome of mechanical ventilation using a population of 41,848 patients from a statewide database. Chest 107:1673–1680. https://doi.org/10.1378/chest.107.6.1673
15. Smolin B, Levy Y, Sabbach-Cohen E et al (2015) Predicting mortality of elderly patients acutely admitted to the Department of Internal Medicine. Int J Clin Pract. https://doi.org/10.1111/ijcp.12564
16. Garrouste-Orgeas M, Carlet J (2005) Predicting whether the ICU can help older patients: score needed. Crit Care 9:331–332. https://doi.org/10.1186/cc3750
17. Perneger TV, Gaspoz JM, Raë AC et al (1998) Contribution of individual items to the performance of the Norton pressure ulcer prediction scale. J Am Geriatr Soc 46:1282–1286. https://doi.org/10.1111/j.1532-5415.1998.tb04547.x
18. Lieberman D, Nachshon L, Miloslavsky O et al (2009) How do older ventilated patients fare? A survival/functional analysis of 641 ventilations. J Crit Care 24:340–346. https://doi.org/10.1016/j.jcrc.2009.01.015
19. Zingone B, Gatti G, Rauber E et al (2009) Early and late outcomes of cardiac surgery in octogenarians. Ann Thorac Surg 87:71–78. https://doi.org/10.1016/j.athoracsur.2008.10.011
20. Engoren M, Arslanian-Engoren C, Steckel D et al (2002) Cost, outcome, and functional status in octogenarians and septuagenarians after cardiac surgery. Chest 122:1309–1315. https://doi.org/10.1378/chest.122.4.1309
21. Cox CE, Carson SS, Holmes GM et al (2004) Increase in tracheostomy for prolonged mechanical ventilation in North Carolina, 1993–2002. Crit Care Med 32:2219–2226. https://doi.org/10.1097/01.CCM.0000145232.46143.40
22. Scheinhorn DJ, Hassenpflug MS, Votto JJ et al (2007) Ventilator-dependent survivors of catastrophic illness transferred to 23 long-term care hospitals for weaning from prolonged mechanical ventilation. Chest 131:76–84. https://doi.org/10.1378/chest.06-1079
23. Nelson JE, Cox CE, Hope AA, Carson SS (2010) Chronic critical illness. Am J Respir Crit Care Med 182:446–454. https://doi.org/10.1164/rccm.201002-0210CI
24. Endeman H, Heeffer L, Holleman F et al (2005) Influence of old age on survival after prolonged mechanical ventilation. Eur J Intern Med 16:116–119. https://doi.org/10.1016/j.ejim.2004.10.012
25. Garland A, Dawson NV, Altmann I et al (2004) Outcomes up to 5 years after severe, acute respiratory failure. Chest 126:1897–1904. https://doi.org/10.1378/chest.126.6.1897
26. Barnato AE, Albert SM, Angus DC et al (2011) Disability among elderly survivors of mechanical ventilation. Am J Respir Crit Care Med 183:1037–1042. https://doi.org/10.1164/rccm.201002-0301OC
27. Curtis JR, Kross EK, Stapleton RD (2020) The importance of addressing advance care planning and decisions about do-not-resuscitate orders during novel coronavirus 2019 (COVID-19). JAMA 323(18):1771–1772. https://doi.org/10.1001/jama.2020.4894