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Liberation and discharge status of older patients after invasive mechanical ventilation: a retrospective cohort study

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Abstract

Background Data on the proportion of patients liberated from invasive mechanical ventilation (IMV) and the prognosis of those who have undergone IMV are limited. Objective data on prognosis are important when discussing preference for IMV. Therefore, this study explored both the proportion of liberation and prognosis after IMV in older patients in Japan.

Methods We conducted a retrospective cohort study using claim data from April 2014 to March 2019 from the National Health Insurance, Late Elders' Health Insurance, and Long-Term Care Insurance in Tsukuba City, Japan. Patients aged ≥ 65 years who underwent IMV were included, and patients who died within 3 days after intubation were excluded. A descriptive analysis of the liberation and the discharge status on day 180 was conducted including a stratification by age categories and care level (CL) < 3 or ≥ 3. The chi-square or Fisher's exact test was conducted to assess whether liberation and discharge status differed among age categories or CLs.

Results In total, 272 patients were included in the study, and the median age was 78 years (interquartile range: 73–84). The median duration of mechanical ventilation was 9.0 days. Pneumonia was the most frequent main diagnosis (12.5%). In total, 73.5% achieved liberation and 42.6% were discharged alive until day 180, while 19.9% were hospitalized and 37.5% were deceased on day 180. The proportion of liberation did not differ among age categories and CLs. However, the IMV duration for those requiring CL ≥ 3 was longer, and the proportion of hospitalized patients on day 180 among patients requiring CL ≥ 3 was significantly higher than that in patients requiring CL < 3 (35.1% vs 17.4%, $p = 0.012$).

Conclusions This study shows that many older patients can be successfully liberated from IMV. However, one third of patients died in the hospital and one fifth of patients required prolonged hospitalization. IMV and hospitalization were likely to be longer among patients requiring CL ≥ 3. Therefore, it may be important to discuss not only the potential difficulty of liberation, but also to convey the risks of undesired outcomes and physical function decline when considering IMV.

Keywords Invasive mechanical ventilation, Liberation, Prognosis, Long-term care level, Older patients, Japan, Claim date

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Background

Liberation of older patients from invasive mechanical ventilation (IMV) is occasionally challenging. Implementation of IMV is sometimes avoided in conventional practice in Japan, given the risk of mechanical ventilation (MV)-dependency, while discontinuation of IMV after its implementation is avoided for fear of litigation [1]. When starting IMV, the most desirable outcome is liberation from IMV and subsequent hospital discharge. It is also considered that death due to disease severity is sometimes inevitable in the acute phase despite treatment effort. Long-term MV dependency sometimes occurs and is considered an undesirable outcome. Therefore, it is emphasized in the discussion of treatment preferences.

The burden of treatment, including the length of the hospital stay, extent of testing and invasiveness of interventions, and the likelihood of the outcome, influence treatment preferences among older patients with limited life expectancy [2]. Decisions about treatment plans should be based on a shared understanding of prognosis between patients, clinicians, and patient families and surrogates [3]. Therefore, when clinicians discuss the use of IMV with patients and their families, objective data on prognosis including the risk of long-term MV dependency should be shared. However, data on the proportion of liberation among older patients are scarce. One single-center study has reported that the proportion of liberation among older patients (aged ≥ 65 years) with community-acquired pneumonia was 48% [4]. Moreover, even when liberation is achieved, it has been reported that the level of care required increases in older patients after MV [5], and that physical function may decrease after intensive care unit (ICU) management, such as MV [6]. These factors may affect the period of hospitalization and discharge destination. Previous studies have reported that in-hospital mortality rates of patients in whom IMV was initiated in the emergency department were 24–27% for all ages [7, 8], 33–35% for older patients (aged ≥ 65 years) [9, 10], and 42% for those aged ≥ 80 years who were transferred to emergency medical centers [11].

Given the paucity of data on the rates and outcomes of liberation from IMV, this study aimed to clarify prognosis, according to age and the level of long-term care required, in older patients who underwent IMV in Japan, which had the longest life expectancy in the world in 2019 [12].

Methods

Data source

We conducted a retrospective cohort study using claim data from the National Health Insurance, Late Elders' Health Insurance, and Long-Term Care Insurance in Tsukuba City, Ibaraki, Japan, a suburban medium-sized city with a population of 236,842, including 23,994 aged 65–74 years and 21,506 aged ≥ 75 years [13]. Data sets obtained between April 2014 to March 2019 were analyzed.

Japan's statutory health insurance system consists of two types of mandatory insurance: employment-based plans and residence-based insurance plans [14]. The National Health Insurance covers unemployed individuals aged < 75 years, excluding the dependents of employed individuals. It covered 72.9% of individuals aged 65–74 years in Tsukuba City in 2016 [15]. The Late Elders' Health Insurance covers individuals aged ≥ 75 years. Recipients of public assistance are excluded from these medical insurance systems; however, the proportion of recipients of public assistance among the population aged ≥ 65 years is small (estimated at 0.15% in Ibaraki Prefecture [16–18]). The dataset we used covers a considerable proportion of individuals who were aged ≥ 65 years.

The long-term care insurance system in Japan covers persons aged ≥ 65 years as insured persons who could be supported when requiring long-term care or support [19]. Municipalities, who are the insurers, provide long-term care requirement certification or support requirement certification based on voluntary application. Standards for long-term care requirement certification are uniformly and objectively determined nationwide. After initial certification, updates are required every 2 years to obtain continued support. Seven levels of long-term care requirement are defined: support levels 1–2 and care need levels 1–5, with care need level 5 being the most severe condition requiring the longest care. The type of residence is not relevant to certification. The level of long-term care required has been correlated with the Barthel Index, with median Barthel Index scores (interquartile range) by care level (CL) being as follows: CL3, 60 (40–75); CL4, 30 (20–40); and CL5, 20 (5–35) [20]. The details of the long-term care insurance system in Japan were explained in previous literature [21].

The study protocol was approved by the Ethics Committee, Faculty of Medicine, University of Tsukuba (approval number: 1445–13, date of approval: 21 September 2023). Data were anonymized before being provided to the researchers; thus, the need for obtaining informed consent was waived. The study was conducted according to the Strengthening the Reporting of Observational Studies in Epidemiology guideline [22].

Participants

Patients aged ≥ 65 years who underwent IMV were included. Patients with a claim of medical reimbursement classification code "lifesaving endotracheal intubation"

(procedure code J044) and "artificial ventilation" (J045) except the receipt billing codes for CPAP (140,010,050, 140,024,250) and nasal-mask ventilation (140,039,550, 140,039,650) on the same day or day after intubation was defined as patients who received IMV. "Lifesaving endotracheal intubation" (J044) does not include intubation associated with surgical anesthesia. "Artificial ventilation" (J045) includes not only IMV, but also non-invasive MV in patients with acute respiratory failure with PaO_2 / $FiO_2 \leq 300$ mmHg or $PaCO_2 \geq 45$ mmHg, as well as intubation associated with surgical anesthesia. CPAP and nasal-mask ventilation were excluded from the receipt billing codes. Although the data used in this study were recorded before the entry of billing codes became mandatory, it is thought that billing codes cannot completely reflect the procedure details. Using the combination of intubation and MV codes, only patients with IMV intubated outside the operating room could be included. Since decision-making around initiating IMV associated with surgical anesthesia differs significantly from those in patients requiring emergency endotracheal intubation, we excluded patients intubated during surgical anesthesia.

In patients with multiple intubation records, only data from the first episode was used. Patients who experienced tracheotomy or home MV before the first intubation record, and who had been in the hospital for less than 180 days after intubation at the study cutoff date (31 March, 2019) were all excluded. Patients who died within 3 days after intubation were also excluded, because early deaths are mostly due to the progression of the primary diagnosis with few impacts of complications from intensive care, and at least 3 days are necessary to properly observe the trajectory after MV [23].

Extracted data items

Data were extracted regarding the age, sex, main diagnosis recorded on receipt (multiple diagnoses could exist), past medical history, the level of long-term care required, the duration of MV, tracheotomy followed by MV management after intubation, the days of tracheotomy from intubation, and liberation and discharge status on day 180. The main diagnosis recorded on receipt was categorized using the International Classification of Diseases (ICD-10) code, based on previous research [24–27]. Patients who underwent open and closed chest cardiac massage were classified as having a diagnosis of cardiopulmonary arrest. The procedure codes and ICD-10 codes we used to determine each procedure and diagnosis are summarized in Appendix A. Age was categorized into three categories: 65–74 years, 75–84 years, and ≥ 85 years. The level of long-term care required was extracted from the latest long-term care requirement certification records before intubation, which is updated every 2 years from the initial certification.

The level of long-term care required was divided into two categories based on a previous study, which classified CL based on the degree of bedriddenness and the level of independence of older individuals with dementia [28]. They revealed that among older individuals requiring CL ≥ 3, more than half were bedridden, and more individuals exhibited a functional decline in both level of independence among patients with dementia and degree of bedriddenness compared to other patients. Therefore, patients classified CL < 3 (including no certification) were categorized as mild to moderate and those classified CL ≥ 3 as severe.

Liberation was defined as liberation from MV without any implication about extubation. If there was an interruption in the MV record of ≤ 3 days during MV management, we considered it as a continuous MV period.

Analyses

A descriptive analysis of the liberation and discharge status was conducted. Data were analyzed using descriptive statistics, including frequency counts, percentages, median, and graphical representations. Liberation and discharge status were summarized as changes over time until day 180. If patients achieved liberation even once, they were treated as liberated patients, even if they underwent MV again 4 or more days after the end of the initial MV.

The stratified results of liberation and discharge status by age categories and CL ≥ 3 or < 3 are also presented. We conducted chi-square test or Fisher's exact test to assess whether liberation and discharge status differed among age categories or CLs.

Two sensitivity analyses were conducted: sensitivity analysis 1 in which an interruption in the MV record of ≤ 7 days during MV management was considered as a continuous MV period; and sensitivity analysis 2 in which cases that started IMV during cardiopulmonary resuscitation were excluded. Patients with a claim of medical reimbursement classification code "lifesaving endotracheal intubation" (procedure code J044) and "closed-chest cardiac massage" (J046) or "open-chest cardiac massage" (K545) except on the same day or one day before intubation was defined as patients in whom IMV was introduced during cardiopulmonary resuscitation.

Results

Among the 1,507 patients with the "Artificial ventilation" code except the "CPAP" or "nasal-mask ventilation" receipt billing code, 591 also had "Lifesaving endotracheal intubation" code assigned on the same day or one day previously. Seventeen patients were

excluded based on the exclusion criteria: two patients underwent home MV before intubation, two underwent tracheotomy before intubation, and 13 remained in the hospital but had been hospitalized for less than 180 days after intubation by the final day of the observation period. In addition, 302 patients who died within 3 days after intubation were excluded. Finally, 272 patients who were alive on day 4 after initiating IMV were included. The details of the selection process are described in Fig. 1.

The characteristics of the included patients are summarized in Table 1. Among the 272 included patients, the median age was 78 (interquartile range [IQR]: 73–84) and 22.8% were > 85 years old; 62.1% were male individuals. The most frequent main diagnosis was pneumonia, followed by cerebrovascular diseases, and cardiopulmonary arrest. Chronic lung disease was diagnosed in 37.5% and 28.3% had a history of neuromuscular disease. 13.6% of cases were certified as CL ≥ 3 before intubation. The median duration of MV was 9.0 days, and 22.1% underwent tracheotomy during the MV period, at a median of 11.0 days after starting ventilation. There were no associations between liberation or discharge status and past-medical histories (Appendix B).

Figure 2 shows whether patients were liberated from MV and discharge status until day 180. The stratified results of liberation and discharge status on day 180 are summarized in Table 2.

Liberation status

Among all patients, 73.5% achieved liberation from MV until day 180 and 26.5% did not. The proportion of liberation were 73.6% and 73.0% for CL < 3 and CL ≥ 3, respectively. The proportion of liberation were 67.8%, 79.7%, and 69.4% for the age categories 65–74, 75–84, and ≥ 85 years, respectively. No significant difference between proportion of liberation was found for CL or age categories.

Discharge status

Among all patients, 42.6% were discharged, 19.9% remained hospitalized, and 37.5% died in hospital up to day 180. No significant difference between 180-day mortality rate was found for CL or age categories. The proportions of hospitalized patients were 17.4% and 35.1% for CL < 3 and CL ≥ 3, respectively. The proportions of hospitalized patients were 19.5%, 21.1%, and 17.7% for the age categories 65–74, 75–84, and ≥ 85 years, respectively. The proportion of hospitalized patients among CLs were significantly different ($p = 0.012$).

Time-course of liberation and discharge

Figure 3 shows the number of days that elapsed until liberation or death until day 90. The proportion of liberation and death both increased steeply until about day 14, after which the increase became more gradual. Overall, 32.7% of patients were still hospitalized on MV on day 14. The same trend was seen in those requiring CL < 3 and in every age category. Among patients with CL ≥ 3, the

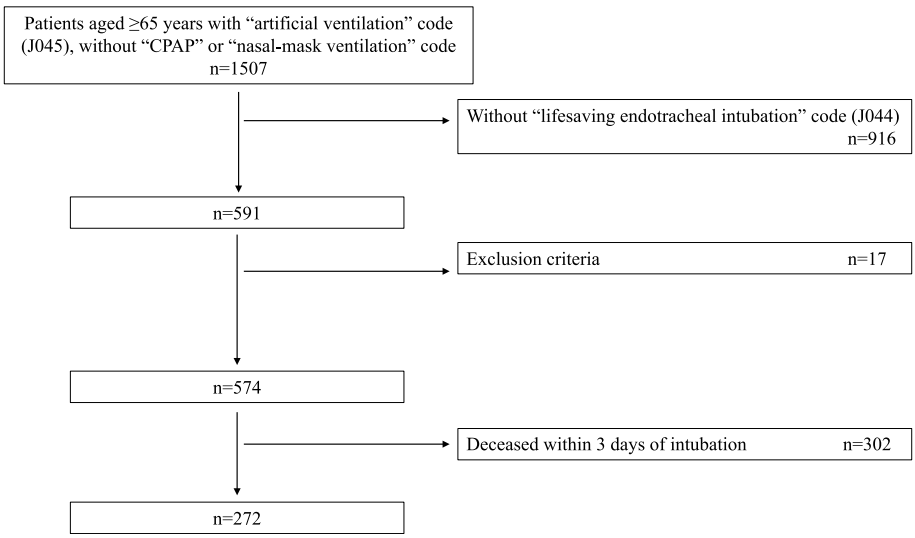

Fig. 1 Flow chart of data collection. "Lifesaving endotracheal intubation" (J044) does not include intubation associated with surgical anesthesia. "Artificial ventilation" (J045) includes invasive mechanical ventilation (IMV) and non-invasive mechanical ventilation in acute respiratory failure with PaO2/FiO2 ≤ 300 mmHg or PaCO2 ≥ 45 mmHg. PaO2: partial pressure of oxygen; PaCO2: partial pressure of carbon dioxide; FiO2: fraction of inspired oxygen

Table 1 Characteristics of the included cases

	All participants, $n=272$	
Age (years)	78	(73–84)
Age categories (years)		
65–74	87	(32.0)
75–84	123	(45.2)
≥ 85	62	(22.8)
Sex: male	169	(62.1)
Admission diagnosis		
Pneumonia	34	(12.5)
Cerebrovascular disease	31	(11.4)
Cardiopulmonary arrest	26	(9.6)
Heart failure	25	(9.2)
Ischemic heart disease	18	(6.6)
Head and neck trauma	14	(5.1)
Sepsis	14	(5.1)
Cancer	11	(4.0)
Others	34	(12.5)
Past medical history		
Chronic lung disease	102	(37.5)
Neuromuscular disease	77	(28.3)
Ischemic heart disease	97	(35.7)
Heart failure	94	(34.6)
Cerebrovascular disease	111	(40.8)
Level of long-term care required: Care level ≥ 3	37	(13.6)
Hospitalized from long-term care facilities	20	(7.4)
Duration of mechanical ventilation (days)	9.0	(4.5–18.5)
Tracheotomy after intubation	60	(22.1)
Duration from intubation to tracheotomy (days)	11.0	(8.5–15.0)

n (%) or median (interquartile range)

increase rate seemed to be more gradual, although the proportion of liberation until day 180 was similar to that in other subgroups.

Although most patients were either liberated or died early after implementation of IMV, a significant number of patients required prolonged hospitalization: 19.9% of all patients were still hospitalized on day 180. Longer hospitalization was required in cases of CL ≥ 3.

Sensitivity analysis

We conducted sensitivity analysis in which the cases requiring MV resumption until 7 days after liberation were treated as continuous a MV period. 71.7% were liberated on day 180, and there was no significant difference of liberation between CLs and age categories, similar to the main analysis (Appendix C).

In addition, we excluded the cases who underwent IMV during cardiopulmonary resuscitation. 73.0% liberated on day 180, and the results of association between outcomes and CLs or age categories were almost the same as the main analysis; more hospitalized patients in CL ≥ 3, and no associations between age categories and each of the outcomes. The association between discharge and CL was no longer present for this group ($p=0.053$) because all excluded cases were CL < 3 (Appendix D).

Discussion

Main findings

This study found that a limited number of older patients were dependent on permanent MV over 180 days. Many older patients could be liberated from MV, with approximately 40% able to discharge until day 180. However, patients with higher CLs needed to be on MV longer and had longer hospitalization.

IMV for older patients

The results of this study provide insights for clinical decision making regarding the initiation of IMV in older patients in Japan. It is commonly observed that physicians in Japan are reluctant to initiate IMV due to concerns about the difficulty of liberation and poor prognosis [29, 30]. However, our findings indicate that a substantial proportion of older patients can indeed be liberated from IMV, challenging the previously held assumptions due to a lack of evidence.

Nevertheless, it is crucial to carefully consider the post-liberation prognosis. Our findings suggest that many patients required prolonged hospitalization, and the in-hospital mortality rate remained high despite the high liberation rate. These results highlight the importance of not only discussing the potential for liberation, but also communicating the risks associated with prolonged MV and hospitalization which indicate potential declines in physical function with patients and their families.

Considering these findings, decision-making regarding the initiation of IMV in elderly patients should be balanced. While excessive caution may be unwarranted, it is equally important to have thorough discussions about the potential risks and outcomes of IMV with patients and their families.

Liberation

This study revealed that a limited number of older patients were dependent on permanent MV over 180 days. Our results showed that most older patients who experienced IMV achieved liberation from IMV. In Japanese medical practice, physicians sometimes refrain from initiating IMV due to the risk of not being able to liberate the patient due to age and CL, given that palliative withdrawal of IMV is discouraged in Japan [1]. However, there is also risk that patients and their families may

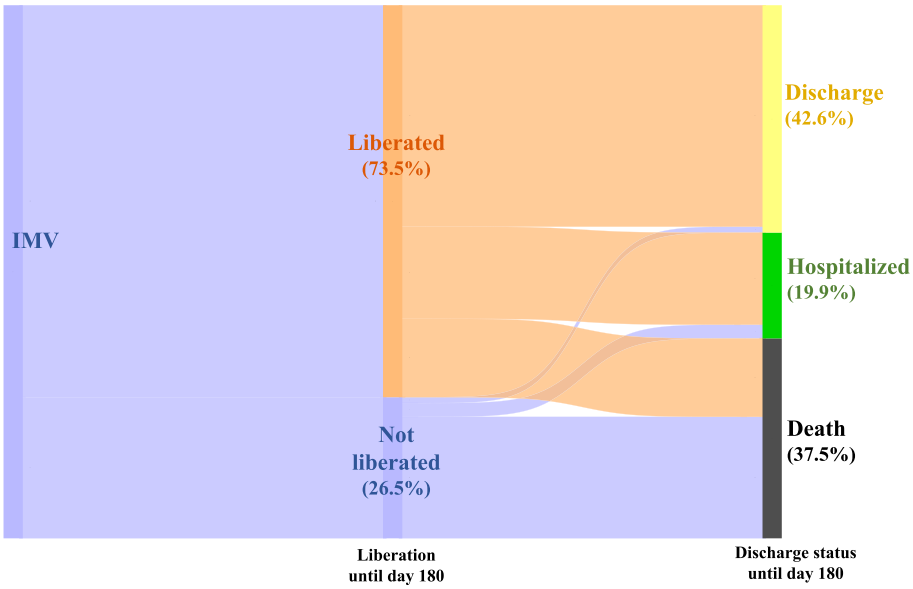

Fig. 2 Liberation status and discharge status on day 180. The blue band indicates the proportion of patients on MV and the orange band indicates the proportion of patients who achieved liberation from MV at least once. As discharge status, the yellow band implies the proportion of patients discharged alive, the green band implies the proportion of patients continuing hospital stay, and the gray band implies the proportion of patients who died in-hospital. IMV, invasive mechanical ventilation

Table 2 Liberation and discharge status on day 180 by care level before intubation and age categories

	All		**Care level < 3**		**Care level ≥ 3**		
	(*n* = 272)		**(*n* = 235)**		**(n 37)**		
	n	**(%)**	**n**	**(%)**	**n**	**(%)**	***p*-value**
Liberation	200	(73.5)	173	(73.6)	27	(73.0)	0.93
Discharge status							
Discharge	116	(42.6)	106	(45.1)	10	(27.0)	0.039
Hospitalized	54	(19.9)	41	(17.4)	13	(35.1)	0.012
Deceased	102	(37.5)	88	(37.4)	14	(37.8)	0.96
	Age 65–74		**Age 75–84**		**Age > 85**		
	(*n* = 87)		**(*n* = 123)**		**(*n* = 62)**		
	n	**(%)**	**n**	**(%)**	**n**	**(%)**	***p*-value**
Liberation	59	(67.8)	98	(79.7)	43	(69.4)	0.11
Discharge status							
Discharge	40	(46.0)	55	(44.7)	21	(33.9)	0.28
Hospitalized	17	(19.5)	26	(21.1)	11	(17.7)	0.86
Deceased	30	(34.5)	42	(34.1)	30	(48.4)	0.13

p-value: the results of Chi-square test or Fisher's exact test

feel forced to abandon IMV against their wishes if physicians over-emphasize the risk of MV dependency [31]. The results of this study raise concerns that excessive restraint might occur in such a situation.

Discharge

Although the proportion of liberation was high, 33.7% of patients died during hospitalization until day 180 even after excluding patients who died within 3 days after intubation. If patients who died within 3 days were included, 70.4% of patients died during hospitalization until day 180. Compared to a previous study from the United States, which reported in-hospital mortality among patients who were intubated in the Emergency Department and were aged ≥ 65 years as 33%, without excluding acute stage death [10], the in-hospital mortality in

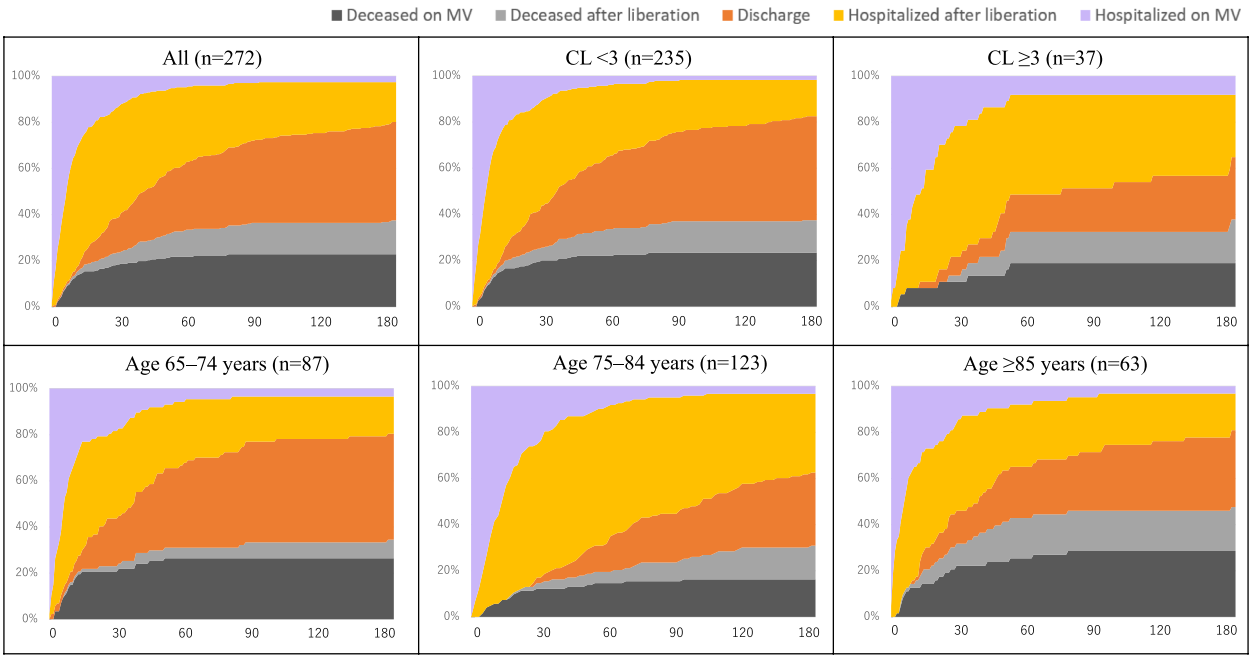

Fig. 3 Number of days until liberation from mechanical ventilation or discharge. The horizontal axis shows days after intubation and the vertical axis shows the percentage of the variable. The black band represents the proportion of patients who died on MV. The gray band represents the proportion of patients who were deceased after liberation from MV. The orange band represents the proportion of patients who were discharged alive. The yellow band represents patients who were still hospitalized after liberation. The purple band represents the proportion of patients who were hospitalized on MV. Patients who achieved liberation once, even if they underwent MV again after an interval of 4 days from liberation, were considered liberated. MV: mechanical ventilation; CL: care level

our study was exceedingly high. This might suggest that Japanese physicians tend to intubate more aggressively in older patients even though their prognosis might be poor.

The discharge outcome might be affected by characteristics of the Japanese medical scenarios in which hospitalizations are longer compared to other countries [32], and patients in the chronic phase could continue hospitalization. In our study, the mean hospitalization period from intubation was 49.5 days. In previous studies from the United States, the median length of stay among survivors was 9 days [9, 10].

Additionally, level of care requirements may worsen after MV [5] and a risk of physical function decline is associated with ICU management [6]. Even if patients achieved liberation, certain patients required prolonged hospitalization and/or died in hospital. The patients with CL ≥ 3 tended to require more days to be weaned from MV and longer hospitalization; therefore, the risk of adverse effects, such as worsening of CL or physical function decline, might be higher in this category of patients than in others.

Limitations of the study

This study had some limitations. First, more patients with a higher potential for liberation were included because, among those requiring IMV, only patients who actually underwent IMV were included in this study. The proportion of liberation might be higher and the in-hospital mortality rate might have been lower if all patients who required IMV actually received this support.

Second, among those who had not received long-term care certification, some individuals may have high care needs. However, since many individuals with CL ≥ 3 tended to have the degree of bedriddenness and level of independence of older individuals with dementia, we assumed that a large proportion of those not certified would correspond to CL < 3.

Third, with the limited information from receipt data, we could not assess or stratify the indication of IMV and severity of patients' condition, which have a significant impact on liberation.

Fourth, with the limited number of participants, it is underpowered to detect the differences between CLs or age categories. However, it is meaningful that the significant difference of discharged and hospitalized rate between CLs was shown in the limited participants.

Fifth, the coding methods we used had not been established. We used "lifesaving endotracheal intubation" (procedure code J044) and "artificial ventilation" (J045), and the receipt billing codes for CPAP (140,010,050,

140,024,250) and nasal-mask ventilation (140,039,550, 140,039,650) to detect IMV. Previously, only J045 was used to detect IMV [5], and there is no validation study about the coding method to detect IMV.

Further large-scale research is desired to assess the association between age or CL and prognosis of IMV patients, with more detailed information on the indication of IMV, as well as the severity of the condition, which are not provided from receipt data.

Conclusions

This study shows that a limited number of older patients were dependent on permanent MV over 180 days. For patients with higher care needs, the duration of IMV is longer, and the proportion of prolonged hospitalization is higher. It might be important not only to focus on the potential difficulty of liberation, but also to convey the risks of undesired outcomes and of physical function decline due to the duration of MV appropriately when conducting discussions with patients and their family members.

Abbreviations

CI	Confidence interval
CL	Care level
ICU	Intensive care unit
IMV	Invasive mechanical ventilation
IQR	Interquartile range
MV	Mechanical ventilation

Supplementary Information

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Supplementary Material 1.

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Authors' contributions

SA conceived the study. SA analyzed the data and RI checked the analyses. SA wrote the first draft of this manuscript. IR, IM, KN, IY, and TN critically revised the manuscript. All authors read and approved the final version of the manuscript.

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None.

Data availability

The data supporting the findings of this study are available from Tsukuba City, but restrictions apply to the availability of these data, which were used under license for the current study, and thus are not publicly available. Data are, however, available from the authors upon reasonable request and with permission of the Tsukuba City.

Declarations

Ethics approval and consent to participate

The study was conducted in accordance with the tenets of the Declaration of Helsinki. All methods were carried out in accordance with relevant guidelines and regulations. All data obtained from Tsukuba City were anonymized. The study protocol was approved by the institutional review board of the University of Tsukuba (approval number: 1445–13, date of approval: September 21, 2023). Data were anonymized prior to being provided to the researchers; thus, the need for obtaining informed consent was waived.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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