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Influence of ventilatory strategies on outcomes and length of hospital stay: assist-control and synchronized intermittent mandatory ventilation modes

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Abstract

The use of synchronized intermittent mandatory ventilation with pressure support ventilation (SIMV + PSV) mode has been discontinued. This study analyzed the association between medical outcomes related to the use of assist-control (A/C) and SIMV + PSV in an intensive care unit. In this observational and retrospective study, modes of ventilation and medical data were collected from electronic medical records for three consecutive years and were related to medical outcomes (mortality), duration of mechanical ventilation, length of hospital stay and the need for tracheostomy. Participants were divided into groups according to the modes of ventilation: A/C and SIMV + PSV. Statistical analyses were performed in the R environment. Alpha = 0.05. The using chi-square, Fisher's exact, Mann–Whitney and Kruskal–Wallis tests were used. 345 adult participants were included; 211/345 (61.16%) were males. Of the participants, 151/345 (43.77%) were on SIMV + PSV and 194/345 (56.23%) were on A/C. The comparative analysis between the modes of ventilation showed no significant differences in length of hospital stay ($p = 0.675$), duration of mechanical ventilation ($p = 0.952$), mortality ($p = 0.241$), failed extubation ($p = 0.411$) and the need for tracheostomy ($p = 0.301$). SIMV + PSV as a mode of ventilation showed similar statistical results to the A/C mode, when compared to analyzed medical outcomes.

Keywords Length of hospital stay · Intensive care unit · Mechanical ventilation · Mode of ventilation · Mortality · Ventilator weaning

Introduction

Mechanical ventilation (MV) involves interactions between pressure, flow, volume and time, and it is considered a complex [1] and indispensable tool in intensive care units (ICUs)

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[2]. However, especially in prolonged MV [3], it is associated with severe complications [2, 4]. Ventilator weaning should rest on a balance between daring and safety [5, 6], avoiding premature extubation or late weaning [7]. Importantly, information on MV in emerging countries is rather limited [8], and Brazil has a high mortality rate associated with the use of MV, showing an association with advanced age, high disease severity scores, tracheostomy, prolonged MV and medical diagnoses [8].

In clinical practice, there are several modes of ventilation used in ICUs worldwide [9]. Among the modes of ventilation, the use of synchronized intermittent mandatory ventilation (SIMV) has suffered a global decline after studies recommended its avoidance due to the increased withdrawal time of MV [10, 11]. Since then, assist-control (A/C) ventilation has been favored [12], with ventilator weaning being performed on the pressure support ventilation (PSV) mode [9]. However, there are few studies that compared SIMV + PSV and A/C as the main mode of ventilation (and not using SIMV for weaning). Recent data analyzing SIMV as the main mode of ventilation showed no differences between mortality, reintubation and tracheostomy rates, duration of MV and length of hospital stay when compared to A/C as a mode of ventilation [13–15].

The hospital where the study was conducted performed the first application of A/C as the main mode of ventilation in 2016 instead of SIMV, in line with the revised Brazilian guidelines for MV [11]. Then, we were able to analyze the outcomes related to the use of SIMV + PSV and A/C. In addition, the recent studies turn their attention to advanced modes of ventilation; however, the tools available in the Brazilian health services are, for the most part, conventional. Our study was conducted given the insufficient investigations regarding tools available in the current Brazilian health services.

Thus, the present study is a comparative analysis between the aspects related to the use of SIMV + PSV and A/C, aiming to verify the influence of the mode of ventilation on mortality rate, length of hospital stay and duration of MV, in order to understand the trend of selecting other ventilation strategies over the years. We hypothesized that A/C would show better performance in duration of ventilation and length of hospital stay, as well as lower rates of failed extubation and mortality compared to SIMV.

Material and methods

Study design

This is an observational and retrospective study, approved by the Research Ethics Committee of São Francisco University (CAEE—submission register: #97953518.2.0000.5514;

institutional review board—#3.139.823) and the study was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. Since this study was retrospective, the Ethics Committee authorized the data collection without the signature of the informed consent form by the participants or their guardians. The study assessed the electronic medical records of the ICU of the University Hospital at the São Francisco University in Providência de Deus, Bragança Paulista, São Paulo, Brazil.

Participants

The inclusion criterion was patients aged 18 years or older (at the time of admission) who had been hospitalized for clinical reasons in the ICU of a tertiary hospital within the three-year period of evaluation and who had undergone MV during hospitalization. Exclusion criteria were the presence of incomplete or inconclusive information in the medical records that could interfere with the development of the research and the performance of elective or urgent surgeries, except for postoperative chest drainage and tracheostomies. All patients who met the criteria of the study between 2015 and 2017 were included. Until 2015, MV patients had been predominantly ventilated with SIMV + PSV and A/C mechanical ventilation was avoided in ICUs. After 2016, they started to receive A/C ventilation, according to the new recommendations proposed by the Brazilian guideline of mechanical ventilation (2013) [11]. As an internal protocol, the weaning method has not been changed over the years and was performed under PSV. In addition, the extubation criteria were PS of ≤ 8 cmH$_2$O, arterial oxygen pressure ≥ 60 mmHg with fraction of inspired oxygen ≤ 0.4 and positive end-expiratory pressure ≤ 6 cmH$_2$O in both modes of ventilation.

Procedures

Data was collected from 2018 to 2019, by a single assessor and a main researcher, who transcribed the data collected from Tasy and Epimed systems into an Excel spreadsheet, identifying the following information: (i) date of hospital admission and discharge, (ii) date of birth, (iii) sex, (iv) medical diagnoses, (v) need for tracheostomy, (vi) cause of intubation, (vii) duration of each mode of ventilation, (viii) presence of failed extubation, (ix) simplified acute physiology score 3 (SAPS 3) scale and (x) medical outcomes (hospital discharge or death). The exposition variables—SIMV/PSV or A/C—were obtained from the medical records. The criterion to define the mechanical ventilation mode was to remain on that ventilatory mode during the hospital stay for the longest period. Therefore, the percentage of duration of

each MV mode was used as a criterion to define the groups receiving SIMV/PSV or A/C.

Statistical analysis

Study participants were assessed according to the MV mode they received for the longest period. They were further divided into two groups. Group A included patients who were hospitalized mainly between 2015 and 2016 and who predominantly used the SIMV + PSV mode during hospitalization. Group B included patients who predominantly used the A/C mode during hospitalization mainly from 2016 to 2017. For statistical analysis, the significance level was set at 5% and the MS Excel 12.0 (Office 2007) and RStudio (version 1.1.456) software programs were used. To evaluate data distribution, the Shapiro–Wilk test was used, resulting in non-normal distribution for all listed variables. Therefore, nonparametric tests were used in the inference analyses. For the inter-group comparison, the qualitative and quantitative variables between group A and B or between periods (2015 vs. 2016 vs. 2017) were analyzed using chi-square, Fisher´s exact, Mann–Whitney and Kruskal–Wallis tests, respectively.

A pre-specified sample size estimation was not performed considering that this was the first study about this topic conducted at the University Hospital and the authors had limited access to the prevalence of each event. Additionally, the G*Power vs. 3.1 was used to determine the sample power as a post-hoc method. The compute achieved power was calculated using alpha (0.05), two tails, sample size 1, sample size 2, and effect size based on mean group 1, mean group 2, SD group 1 and SD group 2 for Mann–Whitney test (two groups). The compute achieved power for the chi-square test (goodness-of-fit test) was calculated using alpha 0.05, sample size and effect size based on proportions in each group, considering the outcomes and total sample. The sample size

was calculated based on the analysis between group A and B without taking into account the subgroups analysis. The subgroup analysis was considered as exploratory and performed based on medical diagnoses that required initiation of MV for groups with a sufficient number of participants (respiratory diseases, infection or sepsis, non-surgical trauma, neurological or psychiatric disorders, cardiovascular diseases, and no definite diagnosis or diagnosis to clarify).

Results

The sample consisted of 345 participants (Fig. 1) aged between 18 and 92 years, of both sexes and predominantly males (211/345; 61.16%). Quantitative variables are presented as mean and standard deviation and qualitative variables as absolute number and frequency in Tables 1 and 2. In 2015, 2016 and 2017, 120/345 (34.78%), 100/345 (28.99%) and 125 (36.23%) participants, respectively, were included.

Following the analysis of the predominant mode of ventilation, 151/345 (43.8%) of participants were classified into group A (SIMV + PSV) and 194/345 (56.2%) into group B (A/C), as described in Table 1. Moreover, the mean percentage duration of SIMV + PSV was 95.29% (95% CI = 93.42 to 97.15) for group A, and the mean percentage duration of A/C was 91.74% (95% CI = 89.81 to 93.66) for group B. Age did not show significant differences between groups ($p = 0.556$). As for sex ($p = 0.209$), the proportion was maintained, with most patients being males.

Regarding the SAPS 3 severity scale, the mean of the total sample was 55.3 ± 18.2 points, remaining similar between groups ($p = 0.667$). The length of hospital stay was similar between groups ($p = 0.675$), with a mean of 18.3 ± 16.0 days, slightly longer in group A (group A: 19.7 ± 19.2; group B: 17.3 ± 12.9).

Fig. 1 Flowchart showing inclusion of patients in the study. *A/C* assist-control ventilation, *SIMV + PSV* synchronized intermittent mandatory ventilation with pressure support ventilation
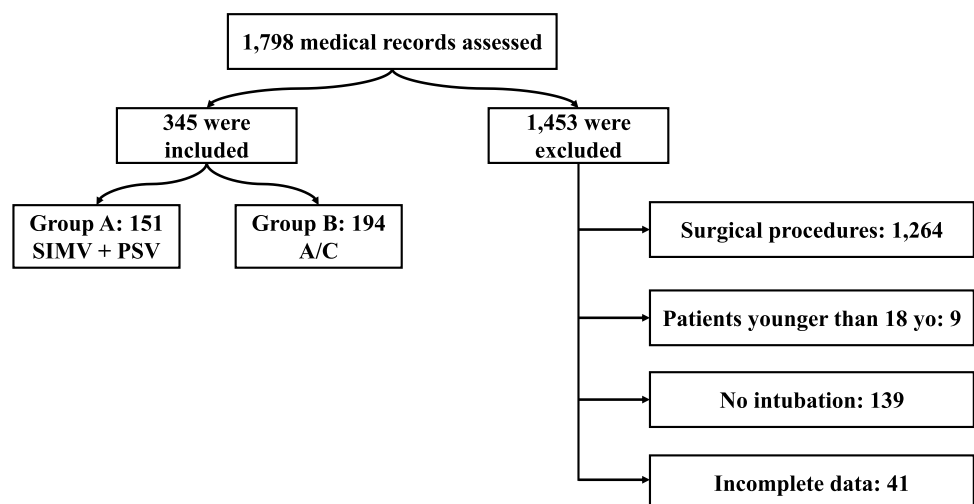
Table 1 General characteristics of study participants according to the ventilatory strategy for assist-control and synchronized intermittent mandatory ventilation modes

Marker	Group A (SIMV + PSV)	Group B (A/C)	Total	p
Number of patients	151 (43.8)	194 (56.2)	345	NA
Sex				
Male	98 (64.9)	113 (58.3)	211 (61.2)	0.209
Female	53 (35.1)	81 (41.8)	134 (38.8)	
Age (years)	54.8 ± 17.6; 57.7 (18.6 to 92.2)	56 ± 16.8; 58.2 (18.3 to 91.4)	55.5 ± 17.1; 58 (18.3 to 92.2)	0.556
Length of hospital stay (days)	16.7 ± 19.22; 13 (1 to 145)	17.3 ± 12.9; 14 (1 to 67)	18.4 ± 16; 14 (1 to 145)	0.675
Duration of mechanical ventilation (days)	8.6 ± 7.1; 7.5 (0.5 to 33.5)	8.8 ± 7.7; 6.3 (0.5 to 44)	8.7 ± 7.4; 6.5 (0.5 to 44)	0.952
Percentage of duration of mechanical ventilation during hospitalization	51.1 ± 26.8; 45.5 (2.1 to 100)	54.9 ± 27.2; 53 (3.3 to 100)	53.3 ± 27.1; 50 (2.1 to 100)	0.187
Pressure support ventilation (days)	2.7 ± 3.8; 1 (0 to 16)	2.6 ± 4.6; 0.5 (0 to 26)	2.7 ± 4.2; 1 (0 to 26)	0.643
Pressure support ventilation (%)	22.3 ± 22.9; 20 (0 to 93.3)	21.9 ± 24.9; 14.3 (0 to 100)	22.1 ± 24; 14.3 (0 to 100)	0.755
Severity scale – SAPS 3	56 ± 17.7; 57 (16 to 99)	54.8 ± 18.7; 56 (16 to 101)	55.3 ± 18.2; 56 (16 to 101)	0.667
Traqueostomy[a]	43 (28.9)	45 (23.3)	88 (25.7)	0.301
Failed extubation	31 (20.5)	32 (16.5)	63 (18.3)	0.411
Death (outcome)[b]	53 (35.1)	83 (42.8)	136 (39.4)	0.241

Values are expressed in absolute numbers and percentage [N (%)] or mean ± standard deviation of the mean; median (minimum value to maximum value). NA, not applicable; SAPS 3, Simplified Acute Physiology Score III scale; SIMV + PSV, synchronized intermittent mandatory ventilation with pressure support ventilation; A/C, assist-control ventilation

[a]Three participants did not have the data collected

[b]Data were not obtained in seven medical records due to transfer (5 cases) and not included (2 cases). Alpha = 0.05. Statistical analyses were performed using chi-square and Mann–Whitney tests

Regarding days on MV, the total mean was 8.8 ± 7.7 days, with group B remaining longer on MV compared to group A (group A: 8.6 ± 7.1; group B: 8.8 ± 7.7), but with no significant differences (p = 0.952). Additionally, the proportion of time spent on MV had a mean of 54.3% of the total ICU time. The inter-group analysis showed that group A remained 51.8% of the time on MV and group B remained 56.2% (p = 0.187). The PSV mode was used for ventilator weaning in both groups, being used for 2.7 ± 3.8 days in group A and for 2.6 ± 4.6 days in group B (p = 0.643), proportionally 22.3% of total MV time in group A and 21.8% in group B (p = 0.755).

In total, 88/345 (25.5%) participants underwent tracheostomy and no statistical differences between groups (p = 0.301) were observed. Additionally, extubation failed in 63/345 (18.3%) of cases, 31/345 (20.5%) in group A and 32/345 (16.5%) in group B (p = 0.411). Death occurred in 136/338 (39.4%) of participants and hospital discharge in 202/338 (59.8%) of participants (p = 0.130).

Among the reasons for orotracheal intubation, lowered level of consciousness was the major cause (107/345;

31.0%), followed by respiratory causes (94/345; 27.3%). When analyzed by group, both proportions remained similar (p = 0.717). The most frequent medical diagnoses during hospitalization were infection or sepsis (77/345; 22.3%), followed by non-surgical trauma (56/345; 16.2%), and the values were similar in the inter-group analysis. Causes of orotracheal intubation and other medical diagnoses during hospitalization are described in Table 2.

An exploratory analysis was performed to identify differences between the periods of collection regarding the evaluated markers. No differences occurred for age (p = 0.183), sex (p = 0.212), number of deaths (p = 0.720), failed extubation (p = 0.349), and participants who underwent tracheostomy (p = 0.564) distributed according to the year. The percentage of PSV was the same between periods (p = 0.220). However, the number of patients receiving each mode of ventilation was unequal between periods, where a higher rate of SIMV + PSV (111/120; 92.5%) vs. A/C (9/120; 7.5%) occurred in 2015 and a lower rate of SIMV + PSV (9/125; 7.2%) vs. A/C (116/125; 92.8%) occurred in 2017 (p ≤ 0.001). In 2016, the A/C mode of ventilation (69/100;

Table 2 Intubation causes and medical diagnoses of study participants according to the ventilatory strategy for assist-control and synchronized intermittent mandatory ventilation modes

Causes of intubation	Group A (SIMV + PSV)	Group B (A/C)	Total	*p* value
Lowered level of consciousness alone	43 (28.5)	64 (33.0)	107 (31.0)	0.717
Respiratory causes alone	46 (30.5)	48 (24.7)	94 (27.3)	
Cardiopulmonary arrest	22 (14.6)	24 (12.4)	46 (13.3)	
Respiratory causes and lowered level of consciousness	11 (7.3)	12 (6.2)	23 (6.7)	
Polytrauma or trauma	7 (4.6)	10 (5.2)	17 (4.9)	
Others	22 (14.6)	36 (18.6)	58 (16.8)	
Medical diagnosis				
Infection or sepsis	32 (21.2)	45 (23.2)	77 (22.3)	NA
Non-surgical trauma	26 (17.2)	30 (15.5)	56 (16.2)	
No definite diagnosis or diagnosis to clarify	19 (12.6)	27 (13.9)	46 (13.3)	
Neurological or psychiatric disorders	19 (12.6)	21 (10.8)	40 (11.6)	
Cardiovascular diseases	15 (9.9)	20 (10.3)	35 (10.1)	
Respiratory diseases	12 (8.0)	10 (5.2)	22 (6.5)	
Not found	5 (3.3)	10 (5.2)	15 (4.4)	
After cardiorespiratory arrest	9 (7.0)	4 (2.1)	13 (3.8)	
Exogenous Poisoning	4 (2.7)	6 (3.1)	10 (2.9)	
Shock	3 (2.0)	4 (2.1)	7 (2.1)	
Endocrine and metabolic diseases	2 (1.3)	5 (2.6)	7 (2.0)	
Gastrointestinal diseases	1 (0.7)	6 (3.1)	7 (2.0)	

Values expressed in absolute numbers and percentage [*N* (%)]. Alpha = 0.05. Statistical analyses were performed by chi-square test

NA not applicable, *SIMV + PSV* synchronized intermittent mandatory ventilation with pressure support ventilation, *A/C* assist-control ventilation

69%) represented twice the number of intubated participants on SIMV + PSV (31/100; 31%) ($p \leq 0.001$). The difference between numbers of modes of ventilation from 2015 to 2017 probably causes increasing duration of MV during hospitalization [days ($p = 0.010$) and higher percentage of days under hospitalization ($p = 0.041$)], and in contrast, lower scores for SAPS 3 severity scale ($p = 0.007$) (Table 3).

A subgroup analysis was added considering both groups (SIMV + PSV and A/C) in each year. No difference occurred between participants on SIMV + PSV and A/C for all periods for sex, age, participants who underwent tracheostomy, failed extubation and number of deaths ($p \geq 0.05$). However, differences occurred between both groups (SIMV + PSV and A/C) as following ($p < 0.05$): (2015) participants on SIMV + PSV showed increasing length of hospital stay and longer duration of MV when compared to participants on A/C; (2016) participants on SIMV + PSV showed higher percentage of MV duration during hospitalization and PSV in days and percentage, but the same group presented a lower score for SAPS 3 severity scale when compared to participants on A/C; (2017) participants on SIMV + PSV showed increasing length of hospital stay when compared to participants on A/C (Supplement material 1).

A subgroup analysis based on medical diagnoses was conducted for the primary diagnosis, which required initiation of MV and a sufficient number of participants. In this context, the following medical diagnoses were included in our data: (i) respiratory diseases ($N = 22$); (ii) infection or sepsis ($N = 77$); (iii) non-surgical trauma ($N = 56$); (iv) neurological or psychiatric disorders ($N = 40$); (v) cardiovascular diseases ($N = 35$); (vi) no definite diagnosis or diagnosis to clarify ($N = 46$). All *ps* are shown as Supplement Material 2. Participants with medical diagnoses of respiratory symptoms on SIMV + PSV were prone to failed extubation (5/12; 41.7% vs. 0/10) ($p = 0.040$); however, a lower number of deaths occurred among these participants (2/12; 16.7% vs. 7/10; 70%) when compared to participants on A/C ($p = 0.027$) (Table 4). Participants with medical diagnoses of neurological or psychiatric disorders on SIMV + PSV presented a lower number of deaths (4/15; 21.1% vs. 12/21; 57.1%) when compared to participants on A/C ($p = 0.027$) (Table 4). In cases of medical diagnoses of non-surgical trauma, the group of participants on A/C showed higher values for (days) of PSV ($p = 0.025$) (Table 4).

Importantly, a post-hoc analysis was performed to determine the achieved power after data collection and we failed to obtain a sample power equal or above than 0.80 in all statistical tests performed. In this context, our results lack statistical power (type 2 error) and an exploratory analysis was conducted to compare group A (SIMV + PSV) and group B (A/C).

Table 3 General characteristics of study participants according to the year of follow-up

Marker	2015	2016	2017	p value
Number of patients	120 (34.8)	100 (29)	125 (36.2)	NA
Sex				
Male	76 (63.3)	66 (66)	69 (55.2)	0.212
Female	44 (36.7)	34 (34)	56 (44.8)	
Mode of Ventilation				
SIMV + PSV	111 (92.5)	31 (31)	9 (7.2)	< 0.001
A/C	9 (7.5)	69 (60)	116 (92.8)	
Age (years)	53.2 ± 17.4; 56.5 (18.6 to 86.5)	56.7 ± 17.5; 59.7 (19.4 to 92.2)	56.7 ± 16.5; 59.6 (18.3 to 91.5)	0.183
Length of hospital stay (days)	17.9 ± 19.7; 12 (1 to 145)	17.8 ± 13.3; 14.5 (2 to 75)	19.2 ± 14; 16 (2 to 67)	0.159
Duration of mechanical ventilation (days)	7.6 ± 6.9; 5.5 (0.5 to 33.5)	8.3 ± 7.2; 6.3 (0.5 to 30.5)	10.1 ± 8; 8.5 (1 to 44)	0.010
Percentage of duration of mechanical ventilation during hospitalization	51.5 ± 28.6; 44.6 (2.1 to 100)	49.3 ± 25.6; 50 (3.3 to 100)	58.1 ± 26.1; 53.6 (9.4 to 100)	0.041
Pressure support ventilation (days)	2 ± 3.2; 0.5 (0 to 16)	2.9 ± 4.6; 1 (0 to 25)	3.1 ± 4.7; 1 (0 to 26)	0.047
Pressure support ventilation (%)	19.8 ± 23.8; 8.3 (0 to 100)	23.9 ± 25.3; 17 (0 to 93.3)	22.8 ± 23.2; 14.3 (0 to 94.5)	0.220
Severity scale—SAPS 3	57.7 ± 16.6; 58 (16 to 96)	58.2 ± 17.4; 59 (16 to 101)	50.4 ± 19.6; 53 (16 to 99)	0.007
Traqueostomy[a]	28 (23.3)	24 (24.5)	36 (29)	0.564
Failed extubation	17 (14.2)	21 (21)	25 (20)	0.349
Death (outcome)[b]	45 (38.5)	38 (38.8)	53 (43.1)	0.720

Values are expressed in absolute numbers and percentage [N (%)] or mean ± standard deviation of the mean; median (minimum value to maximum value)

NA not applicable, SAPS 3 Simplified Acute Physiology Score III scale, SIMV + PSV synchronized intermittent mandatory ventilation with pressure support ventilation, A/C assist-control ventilation

[a]Three participants did not have the data collected

[b]Data were not obtained in seven medical records due to transfer (5 cases) and not included (2 cases). Alpha = 0.05. Statistical analyses were performed using chi-square and Kruskal–Wallis tests

Table 4 General characteristics of study participants according to the ventilatory strategy for assist-control and synchronized intermittent mandatory ventilation modes grouped by medical diagnoses

Marker	Group A (SIMV + PSV)	Group B (A/C)	Total	p-value
Respiratory diseases				
Failed extubation	5/12 (41.7)	0	5/22 (22.7)	0.040
Death (outcome)[a]	10/12 (16.7)	7/10 (70)	9/22 (40.9)	0.027
Non-surgical trauma				
Pressure support ventilation (days)	1.4 ± 2.3; 0 (0 to 7)	3.9 ± 5.4; 1.8 (0 to 21)	2.8 ± 4.4; 0.5 (0 to 21)	0.025
Neurological and psychiatric disorders				
Death (outcome)[a]	4/19 (21.1)	12/21 (57.1)	16/40 (60)	0.027

Values are expressed in absolute numbers and percentage [N (%)] or mean ± standard deviation of the mean; median (minimum value to maximum value)

SIMV + PSV synchronized intermittent mandatory ventilation with pressure support ventilation, A/C assist-control ventilation

[a]Data were not obtained in seven medical records due to transfer (5 cases) and not included (2 cases). Alpha = 0.05. Statistical analyses were performed using Fisher´s Exact and Mann–Whitney tests

Discussion

The analysis of the scenario of ICUs in Brazil shows that access to modern mechanical ventilators and advanced MV is poor [12]; therefore, it is appropriate to investigate the effectiveness of conventional modes. In the literature, there are few studies comparing SIMV combined with PSV with other conventional mode [13].

In our study, the sample consisted of a homogeneous population, with prevalence of males and mean age similar to the epidemiological data of ICUs in Brazil, where mean ages ranged from 57 to 66 and percentage of males from 52 to 60% [3, 12, 16, 17].

Among the causes of orotracheal intubation and diagnoses, the need for MV due to respiratory diseases [12, 18], diagnoses of sepsis, septic shock [12], pneumonia [8, 12], circulatory system diseases/trauma [17] and neurological disorders [8] were more frequently described in the literature. On the other hand, our study found lowered level of consciousness and infection/sepsis followed by trauma as the main causes of intubation and diagnosis, respectively. Lowered level of consciousness can be interpreted as a neurological disorder, which is described in other studies [8], especially in the elderly population [19], showing similarities between the findings, but lack of agreement with the terminology used. On the other hand, the differences found between the most frequent terms, i.e., neurological disorders and lowered level of consciousness, are probably due to the studies with different populations, medical and surgical patients [12] and regions [18].

ICU mortality remained high, with approximately 34% of deaths in the sample in a study with a larger number of medical patients [8], and also 23% in a mixed population with medical and surgical patients on MV [12]. Another study conducted in São Paulo/Brazil, which included all ICU patients, had a mortality rate of 24.3% [17], which is lower than that found in our sample, i.e., 39% of deaths. Thus, the type of population studied, the distinctions between severity and diagnosis and the use of MV may have been the reasons for the difference in mortality rate. Every additional day without a successful weaning increases the risk of death and may be associated with disease severity [12, 20], evaluated in our study by the SAPS 3 scale, where we obtained a score similar to the results of a recent study, which averaged out to 62 points [8].

Another factor related to the high mortality rate is failed extubation requiring reintubation, which ranged from 29.4% in medical and surgical patients to 31.2% in neurological patients [4, 12]. In predominantly medical patients, failed extubation accounted for 15% of cases [8]. In the present study, a slightly higher number was found, which may be due to disease severity and diagnosis divergence.

The implementation of protocols and organizational guidelines for extubation may positively influence the results regarding failed extubation, which are similarly related to prolonged hospitalization and incidence of MV-associated pneumonia [4, 21]. Tracheostomy may facilitate difficult ventilatory weaning, with a positive impact on mortality [22, 23]. About 25% of participants in this study underwent tracheostomy and the incidence of tracheostomized patients varies widely in the literature (10.4–41%), being higher according to severity and neurological patients [8, 12, 18, 24].

Mean duration of MV was 8 days in the present sample, twice the amount found in another study [16], with medical and surgical patients (mixed ICUs), demonstrating that patients undergoing surgery may stay shorter periods on MV, possibly due to lower disease severity, preoperative care and institutional protocols. The mean length of hospital stay is 17–22 days for patients requiring ventilatory support in mixed populations, similar to the numbers found in our study [16, 18]. In this sense, medical patients received longer MV, but without difference in days of hospitalization compared to surgical patients.

A subgroup analysis was performed using the periods of data collection. In this analysis, there was no difference for age, sex, number of deaths, failed extubation and participants who underwent tracheostomy between periods. In fact, the characterization of the population was similar between periods. In another subgroup analysis by medical diagnoses, it was observed that among patients with respiratory diseases, the group on SIMV + PSV showed higher rates of failed extubation but a lower number of deaths; on the other hand, neurological or psychiatric patients showed lower mortality rate on SIMV + PSV. The better outcomes using each mode of ventilation in the subgroups analysis, mainly using the underlying disease as analysis parameters, show a lower power as statistical measure, considering a small number of individuals in each group. Moreover, for certain diseases, such as moderate acute respiratory distress syndrome, SIMV + PSV can be an adequate ventilation strategy [14].

Currently, there is little evidence on the position of professionals to choose a ventilatory strategy. This decision involves a complex interaction between factors related to the patient, the disease, the institution and the professional [10]. The most commonly used modes are SIMV, volume control ventilation and pressure-control ventilation combined with PSV for weaning [8, 10]. In 2016, there was a change in the ventilation strategy at ICUs, which was approached in this study, regarding the use of A/C pressure and volume instead of SIMV, in order to comply with the Brazilian recommendations for mechanical ventilation (2013) [11].

Other studies show agreement with these strategies, showing a global decline in the use of SIMV for ventilation [10, 12] and weaning as well as an increase in the use of

PSV to perform ventilator weaning [16]. A study from 2018 showed that SIMV is rarely used during ventilator weaning worldwide [9]. The comparison between SIMV and PSV during traditional ventilator weaning demonstrated inferior performance of the SIMV mode, which presents greater respiratory muscle work [25], as it provides inadequate rest to the respiratory muscles [7], higher incidence of asynchronies and prolonged hospitalization and MV [7, 25].

Regarding advanced MV modes, SIMV performance remains inferior in the literature, in studies comparing pressure-regulated volume control ventilation, which presents better respiratory conditions and hemodynamic stability [1]. Thus, advanced MV modes are more often favored than SIMV [1, 26]. Other studies compared SIMV with adaptive support ventilation (ASV) as a weaning method, where ASV had shorter duration of MV compared with SIMV [27, 28], improved medical outcomes, recovery of airway function, decreased respiratory muscle work and more stable chest pressure [29].

However, when we analyze conventional ventilatory strategies, considering the tools available in clinical practice and the current Brazilian scenario, we can find divergent outcomes in relation to SIMV, when compared with A/C as the main modes of ventilation associated with PSV for weaning. Contrary to our expectations, the present study found similarities in duration of MV, length of hospital stay, failed extubation rates and outcomes in the comparison of such modes. The result may have been influenced by the limitations of the study, i.e., the study had a retrospective design and small sample size, might show a potential selection bias, and was performed in only one ICU; therefore it could not be reproducible in other contexts.

Nevertheless, in a study with trauma patients, SIMV showed no association with prolonged MV or mortality, although asynchronies were present [15]. In patients with acute respiratory distress syndrome, similar results were obtained, with SIMV + PSV showing improved oxygenation, but without decreased mortality rate, incidence of delirium, use of analgesics, and especially without differences in duration of MV and length of hospital stay [14]. In another comparison of SIMV with A/C and weaning performed with PSV or SIMV, no differences were found regarding mortality, reintubation, tracheostomies and duration of MV [13]. In the aforementioned study, disease severity may have favored SIMV [12], which is not the case in our study. Our study did not show significant differences between groups in disease severity, assessed by the SAPS 3 scale. These results suggest the possibility of exploring the use of SIMV beyond its today´s scope. Ultimately, our study did not provide information about the use of paralysis or intensity of sedation (number of agents, dosing, and/or duration). These markers could possibly influence the outcomes of interest if an imbalance had occurred between the cohorts, but the same protocol for sedation was used during follow-up period. Following an assessment of the patient´s readiness to extubate, the daily sedation interruption was performed in all years of data collection.

In the present study, some limitations can be reported: (i) one center was evaluated; (ii) the study is retrospective and evaluated medical records completed by several professionals at the University Hospital; (iii) the sample had low statistical power and it was not possible to perform the statistical correction of the data for factors associated with the outcomes; (iv) the gold standard for assessing the effectiveness of interventions is the randomized clinical trial. Observational studies are susceptible to selection, measurement and confounding bias.

Therefore, the conclusions of this study are conservative and include the uncertainty related to study limitations and risk of bias. In short, although there are guidelines to discontinue the use of SIMV, studies that demonstrate the superiority of A/C are scarce. The studies that compared both modes of ventilation and that demonstrate the best performance of A/C did not use SIMV + PSV and the studies that use PSV do not describe differences between the two modes of ventilation.

MV has been approached in recent studies in order to establish better strategies for its use in clinical practice. It is necessary to investigate the clinical situations where each ventilation mode would be indicated to optimize MV. As a medical application, we encourage questioning and investigation, maintenance of continuing education and practice based on evidence, adequacy of clinical management strategies and the search for better results with the tools available to the multidisciplinary team.

Conclusion

In conclusion, SIMV + PSV as a mode of ventilation showed similar statistical results to A/C, when comparing duration of MV, length of hospital stay, the need for tracheostomy, failed extubation and mortality rates. The results of the study are susceptible to type II error, since post-hoc power analyses did not show an appropriate power to detect differences between the two study arms. In brief, our data are a qualitative report with pre-post design which showed no major changes in outcomes with adoption of A/C as the primary mode of ventilation in our medical ICU.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Statement of human and animal rights This is an observational and retrospective study, approved by the Research Ethics Committee of São Francisco University (CAEE—submission register: #97953518.2.0000.5514; institutional review board—#3.139.823) and the study was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Informed consent For this type of study, formal consent is not required.

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