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# Impact of a multidisciplinary checklist on the duration of invasive mechanical ventilation and length of ICU stay

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## ABSTRACT

**Objective:** To assess the impact that implementing a checklist during daily multidisciplinary rounds has on the duration of invasive mechanical ventilation (IMV) and length of ICU stay. **Methods:** This was a non-randomized clinical trial in which the pre-intervention and post-intervention duration of IMV and length of ICU stay were evaluated in a total of 466 patients, including historical controls, treated in three ICUs of a hospital in the city of Caxias do Sul, Brazil. We evaluated 235 and 231 patients in the pre-intervention and post-intervention periods, respectively. The following variables were **studied:** age; gender; cause of hospitalization; diagnosis on admission; comorbidities; the Simplified Acute Physiology Score 3; the Sequential Organ Failure Assessment score; days in the ICU; days on IMV; reintubation; readmission; in-hospital mortality; and ICU mortality. **Results:** After the implementation of the checklist, the median (interquartile range) for days in the ICU and for days on IMV decreased from 8 (4-17) to 5 (3-11) and from 5 (1-12) to 2 (< 1-7), respectively, and the differences were significant (p ≤ 0.001 for both). **Conclusions:** The implementation of the checklist during daily multidisciplinary rounds was associated with a reduction in the duration of IMV and length of ICU stay among the patients in our sample.

**Keywords:** Checklist; Respiration, artificial; Length of stay; Intensive care units.

## INTRODUCTION

The duration of invasive mechanical ventilation (IMV) and length of ICU stay can be considered at least partial indicators of quality of care. It has been reported that 5-20% of ICU patients require mechanical ventilation, which is required for more than 7 days in 25%.[1-4]

Longer duration of IMV is associated with increased mortality, longer ICU/hospital stays, and substantially increased health care costs. Therefore, protective mechanical ventilation strategies are essential for early ventilator weaning, i.e., as soon as patients are stable and show signs of recovery.[5-9]

Among critically ill patients, the average ICU length of stay ranges from 2 days to 13 days depending on patient profile and case severity.[10] This wide variation can be explained by the proportion of postoperative patients admitted for shorter stays. Among adult patients on IMV, the average ICU length of stay ranges from 7.2 days to 13.7 days.[4]

In a multicenter study conducted in Brazil, Azevedo et al.[11] showed that patients receiving IMV had an average ICU length of stay of 10 days, with high in-hospital mortality (42%). Nassar Junior et al.[3] showed similar results, reporting an in-hospital mortality of 43.3% among patients on IMV.

In intensive care settings, the complexity of the environment, as well as ineffective communication among health care professionals, together with the fact that professionals are under enormous pressure, can lead to errors of omission during daily rounds and, consequently, negative outcomes.[12-14]

Several studies have examined the use of checklists during daily multidisciplinary rounds, showing that the implementation of checklists improves clinical outcomes, as well as reducing the duration of IMV and length of ICU stay.[12] In addition, checklists improve the quality of multidisciplinary care processes by increasing error detection, improving patient care, enforcing safety standards, and promoting patient-centered care.[13-16] Although populations and outcomes have varied across studies, the implementation of a checklist during daily multidisciplinary rounds appears to be highly beneficial to patients. However, in a study conducted in Brazil,[16] checklists were found to have no impact on the mortality of critically ill patients, having no effect in reducing the duration of IMV or the length of ICU stay.

Given the conflicting results found in the literature, the objective of the present study was to assess the impact that implementing a checklist during daily multidisciplinary rounds has on the duration of IMV and length of ICU stay.

## METHODS

This was a non-randomized clinical trial involving 466 patients, including historical controls, treated between

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February of 2015 and July of 2016 in three ICUs in a hospital located in the city of Caxias do Sul, Brazil.

The inclusion criteria were as follows: being ≥ 18 years of age, having been on IMV, and having stayed in the ICU for at least 48 h. The exclusion criteria were as follows: patient medical records missing data on initial diagnosis or primary outcome; patients receiving exclusive palliative care; and patients with a diagnosis of brain death.

The content of the intervention (the checklist) was developed on the basis of the needs expressed by the multidisciplinary ICU team and is shown in Chart 1. The checklist was tailored to the local context and consisted of five items (analgesia and sedation; IMV; prophylaxis; invasive devices; and nutritional status) addressing safety, clinical management, and treatment goals for the next 24 h.

In July of 2015, a 30-day pilot study of 90 patients was conducted to evaluate the applicability of the checklist at the bedside. The study examined the following: team adaptation to the checklist; checklist completion time; clarity of checklist items; and checklist appropriateness to the local context (item review and revision). At the end of the study period, the final version of the checklist was approved for use during daily multidisciplinary rounds.

No data were collected in the first 6 months of checklist use (from August of 2015 to January of 2016), in order to allow checklist use to become routine in the ICUs and avoid outcome bias.

Data collection was conducted in two phases, electronic medical records being used for both phases. For patients admitted to the ICU prior to the intervention, data were retrospectively collected between February and June of 2015. For patients admitted to the ICU after the intervention, data were collected between February and July of 2016.

The checklist was performed daily during early morning multidisciplinary rounds, the multidisciplinary team consisting of an intensivist, a nurse, a physical therapist, a pharmacist, and a nutritionist, as well as of students and health professionals in training in the ICUs. Rounds lasted 10 min on average per patient, being performed at the bedside with the use of a laptop computer. The intensivist read the checklist

**Chart 1.** Checklist used in the present study.

| CHECKLIST ROUND MULTIPROFISSIONAL | | |
|---|---|---|
| Adequate analgesia and sedation? | | |
| ( ) Yes | ( ) No | ( ) Not applicable |
| Reduction/interruption? | | |
| ( ) Yes | ( ) No | ( ) Not applicable |
| Appropriate/lung-protective ventilation? | | |
| ( ) Yes | ( ) No | ( ) Not applicable |
| SBT? | | |
| ( ) Yes | ( ) No | ( ) Not applicable |
| Mobilization? | | |
| ( ) Yes | ( ) No | ( ) Not applicable |
| Appropriate prophylaxis (DVT, pressure sores, gastric ulcer, VAP) ? | | |
| ( ) Yes | ( ) No | ( ) Not applicable |
| Discontinuation of invasive devices? | | |
| ( ) Yes. Which?___________________________ | ( ) No | ( ) Not applicable |
| Discontinuation of antibiotics? | | |
| ( ) Yes. Which?___________________________ | ( ) No | ( ) Not applicable |
| Adequate caloric intake? | | |
| ( ) Yes | ( ) No | ( ) Not applicable |
| Continue with current diet? | | |
| ( ) Yes. How long for?______________________ | ( ) No | ( ) Not applicable |
| GOALS OF THE DAY | | |
| ________________________________________ | | |
| ________________________________________ | | |
| ________________________________________ | | |
| ________________________________________ | | |
| SBT: spontaneous breathing trial; DVT: deep vein thrombosis; and VAP: ventilator-associated pneumonia. | | |

aloud and the remaining team members responded, making suggestions regarding interventions.

Neither investigator was directly involved in patient care. The health care team was the same in both phases of the study. None of the health care professionals were aware of the study; the checklist was simply introduced into daily ICU practice as a new protocol, thus minimizing information bias.

The sample size was calculated with WINPEPI, version 11.43 (http://www.brixtonhealth.com/pepi4windows.html), on the basis of a pilot study of 40 patients (20 patients in each study period). A sample size of at least 438 was estimated to be required for a level of significance of 5%, a power of 90%, and a minimum effect size of 0.31 standard deviations for the two outcomes (duration of IMV and length of ICU stay), which was defined as the smallest difference between the means for the pre- and post-intervention groups in the pilot study divided by the standard deviation.

With regard to the duration of IMV, the pilot study showed a mean duration of 7 days prior to the intervention and a mean duration of 3.9 days after the intervention, a post-intervention reduction of 3.1 ± 10 days being assumed. With regard to the length of ICU stay, the pilot study showed a mean length of stay of 16 days prior to the intervention and a mean length of stay of 7 days after the intervention, a post-intervention reduction of 9 ± 17 days being assumed.

For descriptive statistics, categorical variables were expressed as absolute and relative frequencies. Continuous variables were expressed as means and standard deviations or as medians and interquartile ranges, depending on the distribution of the variables.

For group comparisons, the following tests were used: the Student's t-test, for continuous variables with normal distribution; Pearson's chi-square test or Fisher's exact test, for nominal categorical variables; and the Mann-Whitney test, for continuous variables with non-normal distribution.

Backward stepwise multiple linear regression was used in order to identify factors independently associated with the duration of IMV and length of ICU stay. All of the variables showing $p < 0.20$ in the univariate analysis were included in the multivariate model, although only those showing $p < 0.10$ remained in the final model. Outcomes were log-transformed for parametric analysis. Differences were considered significant at $p < 0.05$.

The research project was approved by the Scientific Committee and Research Ethics Committee of the Pontifical Catholic University of Rio Grande do Sul (Ruling no. 1,355,805), located in the city of Porto Alegre, Brazil. Because the study used secondary data, the requirement for informed consent was waived.

## RESULTS

During the study periods, 489 patients received IMV in the ICUs. Of those, 466 met the inclusion criteria (235 in the pre-intervention group and 231 in the post-intervention group). As can be seen in Figure 1, 23 patients were excluded, the reasons being as follows: brain death, in 12, exclusive palliative care, in 8, and missing data (no initial diagnosis or primary outcome), in 3.

The general characteristics of the patients are shown in Table 1. Male patients predominated in both groups. There was no significant difference between the pre- and post-intervention groups regarding disease severity as assessed by the Simplified Acute Physiology Score 3 (SAPS 3). The patients in the post-intervention group were significantly older than those in the pre-intervention group.

Although neurological disease was the most common reason for ICU admission in the pre- and post-intervention groups, the number of patients admitted to the ICU for neurological care was significantly lower in the latter group. Hypertension and smoking were the most prevalent comorbidities in both groups.

Patient outcomes are shown in Table 2. The implementation of the checklist resulted in significant reductions in the duration of IMV and length of ICU stay.

Factors independently associated with the duration of IMV and length of ICU stay are shown in Table 3. After linear regression adjustment, the intervention itself was the only variable that remained significantly associated with a reduction in the length of ICU stay. Age, admission for trauma, a diagnosis of respiratory disease on admission, SAPS 3, and reintubation within 48 h were significantly associated with longer ICU stays.

The intervention itself and a diagnosis of renal/urological disease were associated with a shorter duration of IMV ($p \leq 0.001$). Admission for trauma, a diagnosis of respiratory disease on admission, the Sequential Organ Failure Assessment score on admission, and reintubation within 48 h were significantly associated with a longer duration of IMV ($p \leq 0.001$, $p = 0.014$, $p \leq 0.001$, and $p \leq 0.002$, respectively).

## DISCUSSION

In the present study, the implementation of a checklist during daily multidisciplinary rounds was found to be associated with a reduction in the duration of IMV and length of ICU stay.

Although studies examining the use of checklists have shown conflicting results, the findings indicate that checklists improve adherence to care processes, communication among health care professionals, and clinical outcomes.[16-22]

In a prospective multicenter study conducted in Brazil and examining the impact of checklists on mortality,[16] the duration of IMV and length of ICU stay were found to be shorter in the intervention group than in the control group; however, the difference was not significant. The population in that study was similar to the current population in terms of mean age, male predominance,

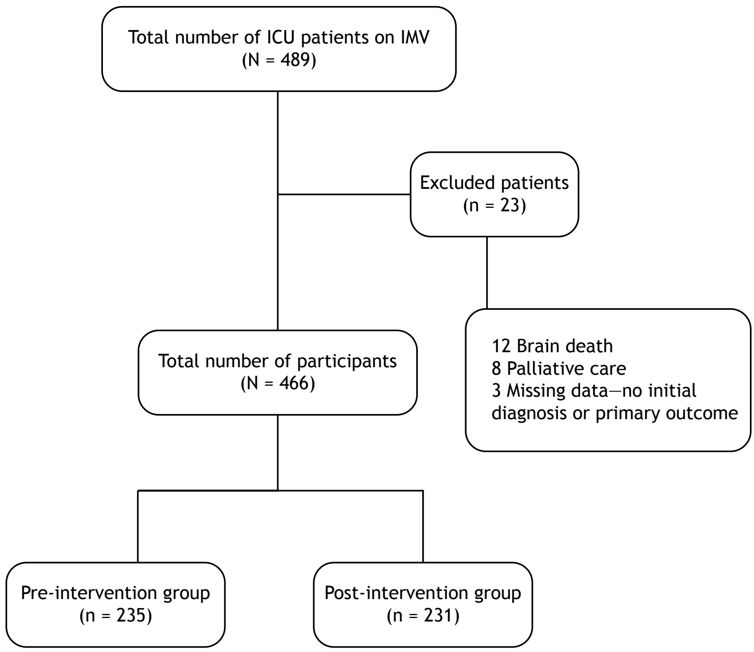


**Figure 1.** Flow chart of patient recruitment. IMV: invasive mechanical ventilation.

and disease severity as assessed by the SAPS 3; however, the results were different.[16] This might be due to the following: differences in study objective and design between the two studies; differences in intervention duration between the two studies; differences in the profiles of the institutions participating in the studies; the fact that the health care team was blinded to the outcomes of our study; the fact that the checklist used in the present study was tailored to the local context; and the fact that the present study included only patients receiving IMV. The conclusions should be interpreted with caution because of the many methodological differences.[22] However, despite the differences, both studies reinforce the importance of a multidisciplinary team and a daily checklist in the ICU.

Differences in results might be due to other differences. In studies including mostly postoperative patients, most of whom require a shorter duration of IMV and are extubated at the end of the procedure or shortly after arrival in the ICU,[8] the results obtained with the use of a checklist might not be significant, because postoperative care is the primary reason for ICU admission.

There was a predominance of male patients in the present study, and the disease profiles and general characteristics of the participants are similar to those of those in previous studies conducted in Brazil and describing the profile of critically ill ICU patients.[23,24]

The median duration of IMV and the median length of ICU stay were lower in the present study than in a study conducted by Azevedo et al.[11] This is expected to a certain extent because of the differences in profile and disease severity between the two populations, as well as because the present study included only patients receiving IMV.

The participation of a multidisciplinary team in the development and implementation of a checklist can lead to better results than those obtained with the introduction of a new tool in an established routine, as recommended elsewhere.[16] Future studies should examine the specific role that a multidisciplinary team plays in the yield of a checklist.

In the present study, data were collected after 6 months of checklist use, so as to allow health care team members to become familiar with the new protocol. Implementation of a new tool or protocol ideally requires strategies to overcome organizational and behavioral barriers to change, meaning that it takes time to implement a new tool/protocol and demonstrate its clinical impact, as reported in previous studies.[12,25,26]

Multidisciplinary team involvement in the implementation of local quality management strategies is important because team members are aware of the strengths and weaknesses of the facility, identifying opportunities for improvement.[27,28] Joint management appears to play a fundamental role in establishing effective organizational processes and protocols.[29,30]

In a single-center study conducted in Sweden over the course of 6 years and including 5,950 patients, the authors evaluated the effects of a quality improvement program on the quality of ICU care.[31] Restructuring the ICU workforce into multidisciplinary teams was found to contribute to the improvement of clinical performance. There were reductions of 24%, 43%, and 52% in long-term mortality, length of ICU stay, and duration of IMV, respectively.

**Table 1.** General characteristics of the study sample (N = 466).[a]

| Variable | Group | | p |
|---|---|---|---|
| | Pre-intervention (n = 235) | Post-intervention (n = 231) | |
| Age, years | 50.6 ± 19.5 | 55.6 ± 18.4 | 0.004 |
| Age group, years | | | 0.011 |
| < 30 | 44 (18.7)* | 25 (10.8) | |
| 30-49 | 62 (26.4) | 56 (24.2) | |
| 50-59 | 49 (20.9) | 40 (17.3) | |
| ≥ 60 | 80 (34.0) | 110 (47.6)* | |
| Sex | | | 0.139 |
| Female | 83 (35.3) | 98 (42.4) | |
| Male | 152 (64.7) | 133 (57.6) | |
| Reason for ICU admission | | | 0.202 |
| Medical condition | 112 (47.6) | 117 (50.6) | |
| Surgical condition | 69 (29.4) | 76 (32.9) | |
| Trauma | 54 (23.0) | 38 (16.5) | |
| Diagnosis on admission | | | 0.001 |
| Neurological disease | 101 (43.0)* | 92 (39.8) | |
| Cardiovascular disease | 39 (16.6) | 27 (11.7) | |
| Hemodynamic instability | 26 (11.1) | 36 (15.6) | |
| Respiratory disease | 23 (9.8) | 16 (6.9) | |
| External causes | 17 (7.2)* | 7 (3.0) | |
| Gastric/abdominal disease | 8 (3.4) | 32 (13.9)* | |
| Cancer | 8 (3.3) | 5 (2.2) | |
| Renal/urological disease | 7 (3.0) | 12 (5.2) | |
| Other | 6 (2.6) | 4 (1.7) | |
| Comorbidities | | | |
| Hypertension | 87 (37.0) | 95 (41.1) | 0.416 |
| Smoking | 59 (25.1) | 63 (27.3) | 0.670 |
| Alcoholism | 44 (18.7) | 36 (15.6) | 0.438 |
| Diabetes | 35 (14.9) | 42 (18.2) | 0.406 |
| Heart disease | 21 (8.9) | 31 (13.4) | 0.165 |
| COPD/asthma | 18 (7.7) | 15 (6.5) | 0.757 |
| Neurological disease | 18 (7.7) | 5 (2.2) | 0.012 |
| Drug addiction | 12 (5.1) | 5 (2.2) | 0.148 |
| Dyslipidemia | 6 (2.6) | 8 (3.5) | 0.761 |
| Cancer | 3 (1.3) | 2 (0.9) | 1.000 |
| Kidney disease | 7 (3.0) | 1 (0.4) | 0.068 |
| SAPS 3 | 50.8 ± 15.7 | 52.8 ± 15.1 | 0.163 |
| SOFA score on admission | 6 [3-9] | 4 [1-7] | 0.036 |
| SOFA score 48 h after admission | 4 [1-8] | 4 [1-7] | 0.494 |

SAPS 3: Simplified Acute Physiology Score 3; and SOFA: Sequential Organ Failure Assessment. [a]Values expressed as n (%), mean ± SD, or median [interquartile range]. *Statistically significant association as assessed by analysis of adjusted residuals at a significance level of 5%.

One of the contributions of the present study was the examination of the possible impact that a checklist tailored to the local context has on the duration of IMV and length of ICU stay. The results suggest that multidisciplinary team involvement in the development and implementation of checklists leads to better results. However, further studies are needed in order to confirm that.

The risk of information bias was minimized by the fact that data were collected from electronic medical records by individuals who were not involved in patient care, as well as by the fact that none of the health care professionals using the checklist were aware of the study.

The present study confirms the findings of previous studies[16-22] and provides the impetus for future studies in different contexts, as well as for future validation studies.

Limitations of the present study include the use of historical data, the lack of validation of the checklist, the lack of randomization, and the issue

**Table 2.** Patient outcomes, by group.[a]

| Variable | Group | | p |
|---|---|---|---|
| | Pre-intervention (n = 235) | Post-intervention (n = 231) | |
| Length of hospital stay, days | | | |
| Prior to ICU admission | 2 [< 1-6] | 1 [< 1-6] | 0.371 |
| ICU stay | 8 [4-17] | 5 [3-11] | < 0.001 |
| After ICU discharge | 5 [< 1-12] | 2 [< 1-7] | 0.095 |
| Duration of invasive mechanical ventilation, days | 5 [1-12] | 2 [< 1-7] | < 0.001 |
| Reintubation within 48 h | 11 (4.7) | 6 (2.6) | 0.341 |
| Readmission within 48 h | 4 (1.7) | 3 (1.3) | 1.000 |
| ICU mortality | 57 (24.3) | 59 (25.5) | 0.831 |
| In-hospital mortality | 73 (31.1) | 76 (32.9) | 0.745 |

[a]Values expressed as n (%) or median [interquartile range].

**Table 3.** Backward stepwise multiple linear regression for factors associated with the duration of invasive mechanical ventilation and length of ICU stay.

| Variable | β | p |
|---|---|---|
| Length of ICU stay* | | |
| Post-intervention | −0.182 | < 0.001 |
| Age | 0.114 | 0.023 |
| Admission for trauma | 0.187 | < 0.001 |
| Diagnosis of respiratory disease on admission | 0.099 | 0.023 |
| SAPS 3 | 0.164 | < 0.001 |
| Reintubation within 48 h | 0.176 | < 0.001 |
| Duration of mechanical ventilation** | | |
| Post-intervention | −0.111 | 0.002 |
| Admission for trauma | 0.164 | < 0.001 |
| Diagnosis of respiratory disease on admission | 0.094 | 0.014 |
| Diagnosis of renal/urological disease on admission | −0.144 | < 0.001 |
| SOFA score on admission | 0.561 | < 0.001 |
| Reintubation within 48 h | 0.110 | 0.002 |

SAPS 3: Simplified Acute Physiology Score 3; and SOFA: Sequential Organ Failure Assessment. *Variables in the multivariate model: pre-intervention, post-intervention, age, reason for ICU admission, diagnosis on admission (external causes, neurological disease, heart disease, respiratory disease, cancer, renal/urological disease, hemodynamic instability, or metabolic disease), infections (community-acquired or nosocomial infections), foci of infection (nervous system, lung, urinary tract, bloodstream), SAPS 3, sepsis, septic shock, SOFA score, and reintubation. **Variables in the multivariate model: post-intervention, evaluation period, age, reason for ICU admission, diagnosis on admission (external causes, neurological disease, heart disease, respiratory disease, cancer, renal/urological disease, hemodynamic instability or metabolic disease), SAPS 3, SOFA score, and reintubation within 48 h.

of external validity (i.e., the generalizability of the study findings). However, our study has high internal validity because the participating ICUs are referral ICUs for 48 municipalities in the Brazilian state of Rio Grande do Sul.

In summary, the implementation of a checklist during daily multidisciplinary rounds was associated with a reduction in the duration of IMV and length of ICU stay in the study population. Multicenter randomized controlled studies are needed in order to confirm these findings.

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