

## Clinical and Functional Outcomes of Tracheostomized Patients in Ventilation Weaning in a Neurological ICU

### Desfechos Clínicos e Funcionais de Pacientes Traqueostomizados em Desmame Ventilatório em UTI Neurológica

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#### Abstract

Neurocritical patients require prolonged invasive mechanical ventilation (MV) and need for tracheostomy for ventilatory weaning. The aim of this study was to compare clinical and functional outcomes of tracheostomized patients who evolved with success or failure in ventilatory weaning in a neurological ICU. A retrospective survey was carried out between January and December 2022 in a neurological ICU, evaluating the clinical outcomes age, sex, medical diagnosis that motivated hospitalization, comorbidities reported by patients, days of ICU hospitalization, days of MV stay, success or failure rates in ventilatory weaning, and the outcome of functional mobility, assessed by the ICU mobility scale (IMS). A total of 82 patients were included, 79% in the success group and 21% in the failure group of ventilatory weaning. The most prevalent diagnosis was stroke in the success (37%) and failure (41%) groups. The most prevalent comorbidity was arterial hypertension in the weaning success (57%) and weaning failure (59%) groups. The success group remained weaned for a significantly longer time ( $p=0.02$ ), presented significantly greater functionality ( $p=0.0002$ ) at discharge from the ICU than the weaning failure group, and presented a significant increase ( $p<0.0001$ ) in functionality between admission and discharge from the ICU. This study found a high rate of success in ventilatory weaning of tracheostomized neurological patients, prevalence of stroke and arterial hypertension, longer time for ventilatory weaning, better functionality at discharge, and increased functionality during hospitalization in patients who were successfully weaned from ventilatory care.

**Keywords:** Intensive Care Unit. Tracheostomy. Mechanical Ventilation. Neurocritical Patient. Ventilatory Weaning.

#### Resumo

Pacientes neurocríticos necessitam de tempo prolongado de ventilação mecânica (VM) invasiva e necessidade de traqueostomia para desmame ventilatório. O objetivo deste estudo foi comparar desfechos clínicos e funcionais de pacientes traqueostomizados que evoluíram com sucesso ou falha no desmame ventilatório em UTI neurológica. Foi realizada uma pesquisa retrospectiva, entre janeiro a dezembro de 2022, em uma UTI neurológica, avaliando os desfechos clínicos idade, sexo, diagnóstico médico que motivou a internação, comorbidades referidas pelos pacientes, dias de internação na UTI, dias de permanência em VM, taxas de sucesso ou falha no desmame ventilatório e o desfecho mobilidade funcional, avaliado pela escala *ICU mobility scale* (IMS). Foram incluídos 82 pacientes, 79% no grupo sucesso e 21% no grupo falha do desmame ventilatório. O diagnóstico mais prevalente foi o acidente vascular cerebral nos grupos sucesso (37%) e falha do desmame (41%). A comorbidade mais prevalente foi a hipertensão arterial nos grupos sucesso (57%) e falha do desmame (59%). O grupo sucesso permaneceu tempo significativamente maior ( $p=0,02$ ) em desmame, apresentou funcionalidade significativamente maior ( $p=0,0002$ ) na alta da UTI que o grupo falha do desmame ventilatório e apresentou incremento significativo ( $p<0,0001$ ) da funcionalidade entre admissão e alta da UTI. Este estudo encontrou alta taxa de sucesso no desmame ventilatório de pacientes neurológicos traqueostomizados, prevalência de acidente vascular cerebral e hipertensão arterial, maior tempo para o desmame ventilatório, melhor funcionalidade na alta e incremento da funcionalidade durante a internação nos pacientes que obtiveram sucesso no desmame ventilatório.

**Palavras-chave:** Unidade de Terapia Intensiva. Traqueostomia. Ventilação Mecânica. Paciente Neurocrítico. Desmame Ventilatório.

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#### 1 Introduction

Neurological intensive care units (NICU) are intended for neurocritical patients, providing intensive care for patients with various pathologies, such as hemorrhagic or ischemic stroke, traumatic brain injury (TBI) or spinal cord injury,

subarachnoid hemorrhages, infections in the central nervous system, among others<sup>1,2</sup>.

Most patients admitted to the NICU have significant respiratory problems and are unable to maintain effective spontaneous ventilation, thus requiring invasive ventilatory

support<sup>3,4</sup>. Ineffective coughing and swallowing, inability to maintain a patent airway, and reduced level of consciousness are common reasons for prolonged mechanical ventilation (MV) and the need for tracheostomy (TQT) in NICU patients<sup>5,6</sup>. TQT rates are around 15% in general critically ill patients and 35% in patients with acute brain injuries admitted to the NICU<sup>6</sup>.

In patients with severe neurological injuries, TQT may be beneficial by ensuring airway protection, reducing the need for analgesia and sedation, allowing faster weaning from MV, facilitating early mobilization progress, reducing complications related to hospitalization, and providing early discharge from the NICU<sup>7-9</sup>. However, the literature is contradictory, as some evidence indicates that TQT in neurocritical patients may be associated with worse outcomes such as risk of subcutaneous emphysema, increased infectious conditions, increased length of NICU and hospital stay, and increased morbidity and mortality<sup>10</sup>. Thus, a multidisciplinary approach, including physical therapists and speech therapists, may allow good results in neurocritical patients<sup>10</sup>.

In this context, analyzing factors that may interfere with the success or failure of ventilatory weaning in neurocritical patients undergoing TQT can help health professionals in monitoring and early identification to design strategies that minimize the risk of failure. Thus, the objective of the present study was to compare clinical and functional outcomes of tracheostomized patients who evolved with success or failure in ventilatory weaning in the NICU.

2 Material and Methods

This is a retrospective study, which was carried out at the Neurological Intensive Care Unit of Hospital de Base, in the city of São José do Rio Preto, SP, Brazil, with data referring to January to December 2022. The data were collected from clinical records, via the MVPEP® system, of patients and from Google Drive® spreadsheets of the physiotherapy team of the Neurological ICU of Hospital de Base.

Data from patients aged 18 years or older who had been on MV for more than 24 hours in the ICU, who failed weaning/extubation, and who underwent TQT were included in the study. Medical records of patients with known neuromuscular disease, as well as those with incomplete or imprecise data on the duration of ventilation before admission to the ICU, or who had restrictions or suspension of therapeutic measures during their stay in the ICU were excluded from the study.

Data collection was carried out from July to August 2023. The primary clinical outcome was the success and failure rate of ventilatory weaning in tracheostomized patients in the unit, and the secondary outcomes were the clinical and functional outcomes of patients in the unit. Tracheostomized patients were divided into a success group (SG) and a failure group (FG) of ventilatory weaning.

The secondary clinical outcomes collected were age, sex, pathology that led to hospitalization, presence of

comorbidities, length of stay in days on MV, length of stay in days in the ICU, days on ventilatory weaning after TQT and the functional outcome, which was considered the level of functional mobility at discharge, measured by the ICU Mobility Scale (IMS)<sup>11</sup> translated and validated into Portuguese<sup>12</sup>, in tracheostomized patients.

The ICU mobility scale has a single domain and a score that varies between 0 and 10. A score of zero expresses low mobility and maximum functional dependence, translated by patients who do not perform active muscle contractions of the limbs and only perform passive exercises by the physiotherapist in bed. A score of 10 expresses high mobility and complete functional independence, translated by patients who perform independent walking, without assistance<sup>12</sup>.

The work followed the ethical principles established in Resolution nº 466/2012 of the National Health Council and is part of the project entitled “Clinical outcomes of patients undergoing invasive mechanical ventilation in a neurosurgical ICU”, which was submitted to the Research Ethics Committee of the Rio Preto School of Medicine (FAMERP) and approved under opinion nº 4,062,514. A waiver of the informed consent form was requested and authorized by the ethics committee, given the documentary methodological design of the study.

The data were tabulated in Microsoft Excel® spreadsheets, and descriptive statistics were applied, presenting the data as means, standard deviations or medians, interquartile ranges, percentages and absolute numbers. The Kolmogorov-Smirnov test was applied to analyze the normality of the data. Inferential statistical analysis was performed to compare the outcomes in the SG and FG of ventilatory weaning using the unpaired Student’s t-test or Mann-Whitney test to compare continuous variables and Fisher’s exact test or  $\alpha$ -squared test to compare categorical variables. The Statistical Package for Social Sciences (SPSS) program was used, and p-values  $\leq 0.05$  will be considered statistically significant.

3 Results and Discussion

The study included 82 patients undergoing TQT, 79% (n=65) in the weaning SG and 21% (n=17) in the ventilatory weaning FG. There was a prevalence of males (63%) in the SG and females (59%) in the weaning FG, the most prevalent diagnosis was stroke in the SG (37%) and weaning FG (41%) and arterial hypertension in the SG (57%) and ventilatory weaning FG (59%) was the most prevalent comorbidity (Table 1).

Table 1 - Sociodemographic and clinical characteristics of patients in the ventilatory weaning success and failure groups

| Variable    | Success Group                  | Failure Group                 | p-value |
|-------------|--------------------------------|-------------------------------|---------|
| Sex (M/F)   | M: 63% (n=41)<br>F: 37% (n=24) | M: 41% (n=7)<br>F: 59% (n=10) | 0.16*   |
| Age (years) | 57.9±16.8                      | 66.4±18.4                     | 0.07**  |
| Diagnosis   |                                |                               |         |

|                             |            |             |       |
|-----------------------------|------------|-------------|-------|
| Stroke                      | 37% (n=24) | 41% (n=7)   | 0.68* |
| TBI                         | 17% (n=11) | 18% (n=3)   | 1.00* |
| T u m o r<br>resection      | 15% (n=10) | 12% (n=2)   | 1.00* |
| Other                       | 31% (n=20) | 29% (n=5)   | 1.00* |
| Comorbidit-<br>eis          |            |             |       |
| SAH                         | 57% (n=37) | 59% (n=10)  | 1.00* |
| D i a b e t e s<br>mellitus | 26% (n=17) | 23,5% (n=4) | 1.00* |
| Obesity                     | 8% (n=5)   | 0           | 0.19* |
| Alcoholism                  | 14% (n=9)  | 18% (n=3)   | 0.70* |
| Smoking                     | 20% (n=13) | 18% (n=3)   | 1.00* |

M: masculine; F: female; TBI: traumatic brain injury; SAH: systemic arterial hypertension. \*Fisher's exact test; \*\*unpaired t-test.

Source: research data.

The diagnoses classified as other in Table 1 in the SG included drainage of cerebral hematomas, reduction in the level of consciousness to be clarified, spinal arthrodesis, cases of meningitis and hydrocephalus, and cases of refractory seizures. For the FG of ventilatory weaning, these diagnoses included drainage of cerebral hematomas, cerebral aneurysms, and spinal arthrodesis.

Regarding clinical outcomes, it was found that the SG remained weaned for a significantly longer median time ( $p=0.02$ ) than the FG in ventilatory weaning (Table 2).

**Table 2** - Comparison of clinical outcomes of patients in the ventilatory weaning success and failure groups

| Variable            | Success Group | Failure Group | p-value      |
|---------------------|---------------|---------------|--------------|
| MV time (days)      | 11 [3-36]     | 12 [6-75]     | 0.21*        |
| Weaning time (days) | 3 [1-10]      | 2 [1-5]       | <b>0.02*</b> |
| ICU stay (days)     | 18.8±7.5      | 19.5±16.4     | 0.79**       |

MV: mechanical ventilation; ICU: intensive care unit. \*Mann-Whitney test. \*\*unpaired t-test.

Source: research data.

Regarding functional outcomes, it was found that the SG presented significantly higher median functionality ( $p=0.0002$ ) at discharge from the ICU than the ventilator weaning FG (Table 3).

**Table 3** - Comparison of functional outcomes of patients in the ventilator weaning success and failure groups

| Variable  | Success Group | Failure Group | p-value*      |
|-----------|---------------|---------------|---------------|
| Admission | 0 [0-5]       | 0 [0-1]       | 0.67          |
| Discharge | 2 [0-9]       | 0 [0-8]       | <b>0.0002</b> |

\*Mann-Whitney test

Source: research data.

It was also observed that the SG showed a significant increase ( $p<0.0001$ ) in functionality between admission and discharge from the ICU (Table 4).

**Table 4** - Comparison of functional outcomes between admission and discharge in the successful and failed ventilatory weaning groups

| Group         | Admission | Discharge | p-value*          |
|---------------|-----------|-----------|-------------------|
| Success Group | 0 [0-5]   | 2 [0-9]   | <b>&lt;0.0001</b> |
| Failure Group | 0 [0-1]   | 0 [0-8]   | 0.18              |

\*Mann-Whitney test

Source: research data.

In this study, the primary clinical outcome was the success and failure rate of ventilatory weaning. It was found that 79% of patients successfully weaned from ventilatory weaning (SG) and 21% failed (FG). Among the secondary outcomes, there was a predominance of males in SG and females in FG, stroke as the most prevalent diagnosis and hypertension as the most prevalent comorbidity in groups, longer ventilatory weaning time, better functionality at discharge from the NICU, and increased functionality between admission and discharge from the NICU in SG.

A recent study<sup>13</sup> that included 158 patients on MV, with 75% in the SG and 25% in the FG of ventilatory weaning, showed a predominance of males, a more prevalent diagnosis of TBI in the SG and brain tumor resection in the FG. This finding was similar to the present study regarding the prevalence of males in the SG. Such results can be explained by genetic factors, since males have greater musculoskeletal mass, which favors the ventilatory weaning process. On the other hand, the aforementioned study differed from the present study in relation to the admission diagnosis, as it found a higher incidence of stroke in the SG and FG of weaning. This divergence can be explained by epidemiological changes resulting from the inherent comorbidities of the groups studied.

In the present study, it was found that 79% of the patients included were successfully weaned from ventilation after TQT. In addition, the SG remained significantly longer in weaning than the FG after ventilatory weaning. A recent study<sup>14</sup> analyzed the relationship between the cross-sectional area of the rectus femoris and diaphragmatic excursion with successful weaning from MV in 81 chronic critical patients with TQT and found a prevalence of males (56%), median age of 67 years, the main reason for admission was sepsis (69%), and 55% of patients were successfully weaned from ventilation. These data are contradictory to those of the present study, which showed a higher ventilatory weaning success rate. Such differences can be explained by the causes that led patients to ICU admission. According to the literature, septic patients are more severe due to systemic involvement resulting from generalized infection.

Petrolina-Mateus et al.<sup>15</sup> compared the level of ventilatory dependence and length of hospital stay between responsive and unresponsive tracheostomized neurological patients and found that responsive patients had a higher level of ventilatory independence at hospital discharge and remained hospitalized for a shorter period of time. These findings are also contradictory to the present study regarding length of hospital stay, but they are not plausible for comparison, since the characteristics used to determine the outcome of ventilatory weaning were the level of consciousness, a variable not used in the present study.

The SETPOINT2 randomized clinical trial compared early TQT ( $\leq 5$  days of intubation) versus standard TQT ( $\geq 10$  days of intubation) in 382 stroke patients undergoing MV and found that an early TQT strategy did not significantly improve the survival rate without severe disability at six months<sup>5</sup>. A recent narrative review<sup>16</sup> on MV weaning in neurocritical patients revealed the paucity of data in the literature on the topic in patients with brain injury. The study describes the general principles of weaning in three main topics related to MV weaning in patients with brain injury: (1) sedation protocol, (2) weaning and extubation protocol and criteria, (3) criteria, timing, and technique for tracheostomy. The authors conclude that goal-directed analgesia and sedation appear beneficial in brain-injured patients, while daily interruption of sedation is debated; the weaning protocol can be adapted to these patients, assuming that they can be extubated with a lower level of consciousness than recommended for other patients, and based on certain criteria, professionals can select patients who will benefit from TQT<sup>16</sup>.

Another secondary clinical outcome analyzed in this study was the level of functional mobility at discharge of tracheostomized patients, and the results showed better functionality at discharge from the NICU and an increase in functionality between admission and discharge from the NICU in the SG. A recent Italian study<sup>17</sup> described the differences in the decannulation rate and clinical outcomes of tracheostomized patients admitted to a NICU after the inclusion of a group of specialized physiotherapists. The authors showed that a multidisciplinary approach, including a physiotherapist, dedicated to the management of tracheostomy, decannulation and early mobilization in the NICU is safe, feasible and appears to improve the number of decannulated critically ill patients<sup>17</sup>.

Smailes et al.<sup>18</sup> compared the clinical and functional outcomes of patients with severe burns admitted to the ICU and submitted to early or late TQT and observed that early TQT was associated with earlier active exercises, fewer days of ventilation, shorter hospital stay, and better functional independence at hospital discharge. Despite differences in the populations studied and at the time of functionality assessment, the findings of these authors are similar to those found in the present study regarding the improvement in functionality after TQT in the SG of ventilatory weaning, which can be

justified by the ease of handling both the artificial airway and the evolution of positioning and achievement of postural landmarks such as orthostatic, sitting out of bed, and walking.

Sutt et al.<sup>19</sup> assessed whether the timing of TQT, early or late, had an impact on length of hospital stay, morbidity, mortality, and functional recovery, using the ICU mobility scale, in 276 patients admitted to the ICU for cardiorespiratory problems. The authors found that early TQT was associated with better functional recovery results, such as performing exercises out of bed 6.2 days earlier (CI = -8.4 to -4 days). The results of this study are similar to those of current research on the increase in functionality after TQT, even considering methodological differences such as underlying diseases and comparison groups between studies.

Another recent study<sup>20</sup> sought to identify significant factors for the time to decannulation in 324 individuals with TQT after TBI and found that a change in swallowing ability, improvement in cognitive level and functional rehabilitation are significant factors in reducing the time to decannulation. Although these data are not comparable to those of the present study, they reinforce the importance of focusing on improving functionality after TQT to accelerate the process of ventilatory weaning and decannulation and favor the patient's return to society.

This research presented some limitations such as the retrospective observational design of the study, which does not allow the association between cause and effect and the inclusion of a single center in the study. In addition, the lack of stratification of the time of TQT performance, early or late and its relationship with the outcomes of ventilatory weaning can also be pointed out as a limitation of the study.

## 4 Conclusion

This study found a high success rate in ventilatory weaning of tracheostomized neurological patients, prevalence of stroke and arterial hypertension, longer time for ventilatory weaning, better functionality at discharge and increased functionality during hospitalization in patients who were successfully weaned from ventilatory care.

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