

Cibelle Andrade Lima<sup>1</sup>, Tiago Branco Siqueira<sup>1</sup>, Érica da Fonseca Travassos<sup>1</sup>, Catarina Maria Gomes Macedo<sup>1</sup>, Andrezza Lemos Bezerra<sup>2</sup>, Marçal Durval Siqueira Paiva Júnior<sup>3</sup>, Flávio Maciel Dias Andrade<sup>4</sup>, Eduardo Eriko Tenório França<sup>5</sup>

1. General Intensive Care Unit of Hospital Agamenon Magalhães – HAM – Recife (PE), Brazil.

2. General Intensive Care Unit of Hospital Agamenon Magalhães; Physiotherapy Course at Faculdade Pernambucana de Saúde - Recife (PE), Brazil.

3. General Intensive Care Unit of Hospital Agamenon Magalhães; Intensive Care Unit of Hospital Dom Helder - Recife (PE), Brazil.

4. Physiotherapy Course of Universidade Católica de Pernambuco e Faculdade Integrada do Recife – Recife (PE), Brazil

5. Residency Program in Intensive Care Physiotherapy of Hospital Agamenon Magalhães – HAM – Recife (PE), Brazil; Course of Physiotherapy of Universidade Católica de Pernambuco - Recife (PE), Brazil.

Study developed at Hospital Agamenon Magalhães – HAM – Recife (PE), Brazil.

**Conflicts of interest:** None

Submitted on August 5, 2010  
Accepted on December 23, 2010

**Corresponding author:**

Eduardo Eriko Tenório de França  
Hospital Agamenon Magalhães  
Estrada do Arraial - Casa Amarela, s/n  
Zip Code: 50000-000 - Recife (PE),  
Brazil.  
Email: edueriko@ig.com.br

## Influence of peripheral muscle strength on the decannulation success rate

*Influência da força da musculatura periférica no sucesso da decanulação*

### ABSTRACT

**Introduction:** Tracheostomy is probably the most common surgical procedure in critically ill patients and is generally performed to facilitate mechanical ventilation weaning. Evidence-based guidelines have confirmed the benefits of tracheostomy weaning protocols and of the physiotherapists engagement in this process; however, no consensus decannulation criteria are currently available. Therefore, this study aimed to evaluate the influence of peripheral muscle strength and other indicators on decannulation success.

**Methods:** This was an observational retrospective study that analyzed the medical records of patients admitted to the medical and surgical intensive care unit of Hospital Agamenon Magalhães between March 2007 and August 2009. Respiratory and peripheral muscle strengths were evaluated in decannulated patients.

**Results:** Overall, 1,541 patients were evaluated, 143 of which had been tracheostomized, and only 57 of which

had been decannulated. Forty-six patients had a satisfactory decannulation outcome, while 11 had decannulation failure, requiring the return to an artificial airway within 2 weeks. The calculated Medical Research Council peripheral muscle strength score was significantly lower for the failure group than for the successful decannulation group ( $28.33 \pm 15.31$  vs.  $41.11 \pm 11.52$ ;  $P = 0.04$ ). Scores above or equal 26 had 94.4% sensitivity and 50.0% specificity for the decannulation outcome, with an area under the ROC curve of 0.7593. In addition, white blood cell counts were higher in decannulation failure group patients ( $14,070 \pm 3,073$  vs.  $10,520 \pm 3,402$  cells/ $\mu$ L;  $P = 0.00$ ).

**Conclusion:** This study has shown that peripheral muscle strength and blood leucocyte counts evaluated on the day of decannulation may influence the tracheostomy decannulation success rate.

**Keywords:** Tracheostomy; Decannulation; Weaning; Mechanical ventilation

### INTRODUCTION

Tracheostomy is probably the most frequent surgical procedure performed in critically ill patients. Approximately 10% of critically ill patients requiring mechanical ventilation (MV) support undergo tracheostomy, the main advantage of which is to allow better patient mobility and easy prolonged MV weaning.<sup>(1-3)</sup>

Tracheostomy has several advantages versus orotracheal intubation, including shorter MV weaning time, lower airflow resistance, less dead

space, less movement inside the trachea, patient comfort, and more effective deglutition.<sup>(4)</sup> However, recent studies have shown that prolonged tracheostomy may lead to late complications, such as tracheal stenosis, bleeding, fistulae, infections, hemorrhage and bronchoaspiration.<sup>(2,4)</sup> Additionally, the mortality of tracheostomized patients discharged from the intensive care unit (ICU) to the ward is higher. Therefore, decannulation is a fundamental step in the rehabilitation of critically ill patients.<sup>(2,4,5)</sup>

Recommendations confirm the benefit of MV weaning protocols for tracheostomized patients and the relevance of physiotherapists' engagement in this process. However, few studies are available proposing decannulation criteria. The decannulation decision is still based on subjective evaluations rather than on standardized protocols.<sup>(1,6)</sup>

Usually, the following are considered criteria for decannulation: consciousness level, appropriate oxygenation and mechanical ventilation, spontaneous breathing without MV, lack of airways obstruction, controlled secretion status, and appropriate deglutition. Other factors predictive of decannulation success include MV time, cough effectiveness (represented by the peak expiratory flow) and the ability of the respiratory muscle to provide satisfactory maximal expiratory pressure (PE<sub>max</sub>).<sup>(2,7,8)</sup>

Therefore, considering the lack of parameters known to predict decannulation success, this study aimed to identify possible factors associated with decannulation success.

## METHODS

This was an observational retrospective evaluation study involving the analysis of medical records and including all decannulated patients from a general ICU of a high-complexity reference hospital, which is part of the public Recife – Pernambuco (Brazil's) healthcare network (Hospital Agamenon Magalhães – HAM), who were admitted from March 1, 2007, to August 8, 2009. This study was approved by the institution's Ethics Committee.

Routine decannulation criteria included the following: clearance of the respiratory failure cause, clinical stability, Glasgow scale rating above 9, lack of tracheal or glottic stenosis, preserved deglutition, and PE<sub>max</sub> above 40 cmH<sub>2</sub>O, reflecting effective cough.

Personal information, underlying disease, comorbidities, length of ICU stay, MV days before

decanulation, orotracheal tube days, tracheostomy days, spontaneous breathing days before decannulation, number of extubation failures and spontaneous breathing tests failures, antibiotics use, and decannulation success or failure were collected.

Data on respiratory muscle (maximal inspiratory pressure - P<sub>I</sub>max, P<sub>E</sub>max and rapid shallow breathing index - RSBI) and peripheral muscle strength (Medical Research Council [MRC] score),<sup>(6)</sup> white blood cell counts and arterial gas on the decannulation day (pH, PaCO<sub>2</sub>, PaO<sub>2</sub> and oxygenation rate – OR) were also collected.

The MRC peripheral muscle evaluation score was calculated for alert patients. This score rated the muscle strength between 0 (total palsy) and 5 (normal strength) for specific voluntary bilateral movements (Table 1). The total score ranged between 0 (complete tetraparesis) to 60 (normal muscle strength).<sup>(6)</sup>

**Table 1 – Medical Research Council (MRC) Score**

| Evaluated movements   |
|---|
| ■ Shoulder abduction  |
| ■ Elbow flexion   |
| ■ Wrist extension   |
| ■ Hip flexion   |
| ■ Knee extension  |
| ■ Ankle dorsal flexion  |
| Muscle strength degrees   |
| ■ 0 = No movement is observed                                   |
| ■ 1 = Visible contraction, no segment movement                  |
| ■ 2 = Active movement upon resistance of gravity removed        |
| ■ 3 = Active movement, against gravity                          |
| ■ 4 = Active movement against gravity and examiners' resistance |
| ■ 5 = Normal strength   |

Consists of six bilaterally evaluated movements, and each movement muscle force was rated between 0 (total palsy) and 5 (normal muscle strength). Total scores ranged between 0 (complete tetraparesis) and 60 (normal muscle strength). Source: Adapted from De Jonghe et al. (2005).<sup>(6)</sup>

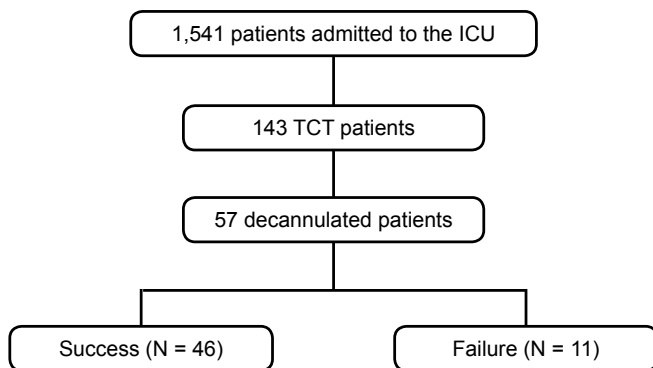
Decannulation success was defined as lack of respiratory symptoms leading to recannulation or reintubation within 2 weeks following the decannulation.<sup>(7)</sup>

The normality of the study variables was tested with the Kolmogorov-Smirnov test. The influence of the analyzed factors on decannulation success or failure was evaluated with Fisher's exact test for categorical variables, in addition to Student's t test for independent samples, and the non-parametric Mann-Whitney test for continuous variables. All analyses used a 5% significance level and were performed

using GraphPad Prism version 4.0, Stata 10.1, and Microsoft Office Excel 2007.

## RESULTS

During the evaluation period, 1,541 distinct diagnosis patients were admitted to the general ICU of which 143 were tracheostomized; however, only 57 patients met the criteria and were decannulated during their general ICU stay, and 46 were successfully decannulated (81%) (Figure 1).



ICU – intensive care unit; TCT - tracheostomy.

**Figure 1 - Included patients disposition.**

Fifty-seven patients were evaluated of which 37 were female. The diabetes mellitus (DM) prevalence, sepsis prevalence, use of antibiotics, leucocytosis status, phonoaudiology evaluation, extubation failure, spontaneous breathing attempt (SBA) failure and peripheral muscle strength evaluation data for these 57 patients are displayed in Table 2. The comparison of the decannulation success group patients with the failure group patients showed significantly higher DM and/or sepsis prevalences and more cases of leucocytosis in the decannulation failure group.

Table 3 compares the decannulation success and failure groups with respect to the length of ICU stay; ventilatory support time; artificial airway time; ventilatory support-free time; pH, PaCO<sub>2</sub>, PaO<sub>2</sub> and OR profile; white blood cell count; PImax and PEmax values; RSBI; and MRC score, with significantly higher leucocyte counts and less peripheral strength in the decannulation failure group ( $P < 0.01$  and  $P < 0.05$ , respectively).

Figure 2 displays the MRC versus the decannulation outcome ROC curve, with 94.4% sensitivity and 50.0% specificity for MRC values greater than or equal to 26, with an area under the ROC curve of 0.7593.

**Table 2 – Sample characterization**

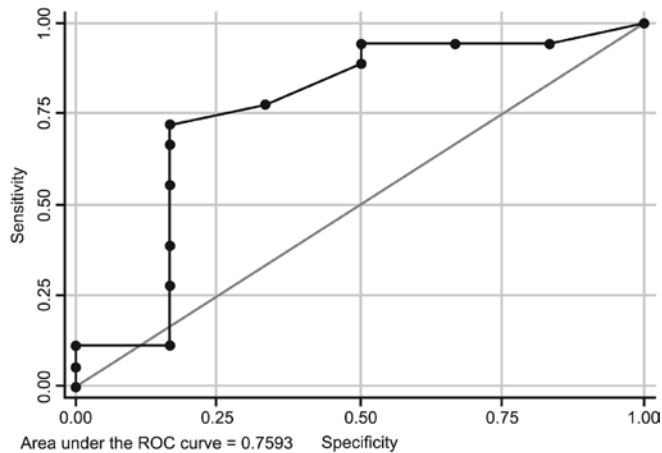
|                           | Success<br>(N = 46) | Failure<br>(N = 11) |
|---------------------------|---------------------|---------------------|
| Age (years)               | 51.12 ± 20.57       | 54.00 ± 18.22       |
| Female                    | 29 (63)             | 8 (73)              |
| DM / Sepsis               | 9 (20)              | 4 (36)*             |
| Antibiotics use           | 21 (46)             | 7 (64)              |
| Leucocytosis              | 11 (24)             | 11 (100)*           |
| Phonoaudiology evaluation | 27 (59)             | 9 (82)              |
| Extubation failure        | 6 (13)              | 4 (36)              |
| SBA failure ≥ 3           | 12 (26)             | 4 (36)              |
| MRC ≥ 41                  | 12 (26)             | 1 (9)               |

DM – diabetes mellitus; SRA – spontaneous breathing attempt; MRC – Medical Research Council. Results expressed as mean ± standard deviation or number (%). \*  $P < 0.01$ ; Fisher's exact test.

**Table 3 – Decannulation success predictive factors**

|                            | Success<br>(N = 46) | Failure<br>(N = 11) | p<br>value* |
|----------------------------|---------------------|---------------------|-------------|
| T <sub>ICU</sub> (days)    | 44.00 ± 25.64       | 43.36 ± 21.09       | 0.94        |
| T <sub>MV</sub> (days)     | 35.79 ± 24.36       | 36.64 ± 21.80       | 0.82        |
| T <sub>OTT</sub> (days)    | 14.50 ± 4.71        | 15.45 ± 2.77        | 0.52        |
| T <sub>TCT</sub> (days)    | 27.11 ± 25.04       | 29.00 ± 22.60       | 0.27        |
| T <sub>SB</sub> (days)     | 5.86 ± 4.90         | 5.54 ± 3.35         | 0.84        |
| pH                         | 7.44 ± 0.05         | 7.46 ± 0.05         | 0.43        |
| PaCO <sub>2</sub> (mmHg)   | 41.85 ± 10.46       | 34.88 ± 8.16        | 0.10        |
| PaO <sub>2</sub> (mmHg)    | 106.10 ± 28.84      | 98.28 ± 32.53       | 0.53        |
| OR                         | 371.60 ± 122.20     | 357.40 ± 92.72      | 0.77        |
| WBC (cél/μL)               | 10520 ± 3402        | 14070 ± 3073        | 0.00        |
| PImax (cmH <sub>2</sub> O) | 61.45 ± 22.68       | 59.00 ± 16.09       | 0.75        |
| PEmax (cmH <sub>2</sub> O) | 77.21 ± 27.92       | 73.20 ± 27.64       | 0.69        |
| RSBI (ipm/L)               | 68.80 ± 28.79       | 73.40 ± 38.94       | 0.84        |
| MRC                        | 41.11 ± 11.52       | 28.33 ± 15.31       | 0.04        |

T<sub>ICU</sub> – time at the intensive care unit; T<sub>MV</sub> – mechanical ventilation time; T<sub>OTT</sub> – time with orotracheal tube; T<sub>TCT</sub> – time with tracheostomy; T<sub>SB</sub> – time with spontaneous breathing; pH – hydrogen-ion potential; PaCO<sub>2</sub> – arterial blood partial carbon dioxide pressure; PaO<sub>2</sub> – arterial blood partial oxygen pressure; OR – oxygenation rate; PImax – maximal inspiratory pressure; PEmax – maximal expiratory pressure; RSBI – rapid shallow breathing index; MRC – Medical Research Council. Results expressed as mean ± standard deviation. The PImax values are expressed in modulus. Student-t and Mann-Whitney.



**Figure 2 – Medical Research Council (MRC) score and decannulation outcome ROC curve**

## DISCUSSION

No decannulation decision-making recommendations are currently available in the literature; however, some trials suggest different tracheal decannulation success predictive factors.<sup>(8)</sup>

In this study, the current parameters suggested in the literature were adopted; however, we observed a 19% decannulation failure rate. Similar to our results, Mendes et al. had a 20% failure rate when using P<sub>I</sub>max, P<sub>E</sub>max, vital capacity and peak expiratory flow criteria; these two last variables were also analyzed in our study.<sup>(8)</sup> Aiming to reduce this population decannulation failure rate, this study analyzed other factors possibly correlated with tracheal decannulation success.

In our study, both the success and failure groups had no differences with respect to MV time; length of ICU stay; orotracheal tube, tracheostomy and spontaneous breathing times; and arterial gas evaluation on the decannulation day, showing that these variables were not effective tracheostomy decannulation success predictors. These criteria were not considered in previous studies; however, Ceriana et al. established that only patients spontaneously breathing for at least 5 days with stable arterial gasometry and PaCO<sub>2</sub> below 60 mmHg would be decannulated, with a low 3% failure rate.<sup>(1)</sup> In our study, both the success and failure groups had more than 5 spontaneous breathing days, stable arterial gasometry, and PCO<sub>2</sub> levels lower than 60 mmHg.

The MV times were 35.79 and 36.54 days for success and failure patients, respectively. Studies such as that by Jubran et al. and Levine et al. have

shown that respiratory muscle strength is MV time-dependent, i.e., ventilator-related injuries impair the strength of the inspiratory muscles and render MV weaning difficult.<sup>(9-11)</sup>

Inspiratory muscle strength and appropriate ventilation work load indices, such as P<sub>I</sub>max and RSBI, are supposed to predict decannulation success. However, in our study, the mean values of these indices were similar for both groups, proving them to be ineffective decannulation success predictors.

Mendes et al. conducted a retrospective study to evaluate the MV and decannulation phases and also failed to identify any P<sub>I</sub>max differences between the groups, although all decannulated patients had a P<sub>I</sub>max above 30 cmH<sub>2</sub>O.<sup>(8)</sup> Our study's similarity between the P<sub>I</sub>max and RSBI results may have been influenced by the routine muscle training completed by our tracheostomized patients.

Regarding white blood cell counts, Bach and Saporito reported that decannulation patients should have an antibiotic-free normal leucogram, but this is neither a consensus criterion nor has this criterion been used in other studies.<sup>(7)</sup> Our findings showed that antibiotic use was unable to predict decannulation success or failure. For leucogram readings, however, the results were significant, showing that 100% of the failure group patients had leucocytosis versus only 24% in the decannulation success group; additionally, the white blood cell count on the day of decannulation was significantly higher in the failure group. Although not directly reflecting an active infective process, the leucocyte count is indicative of ongoing and resolving infective and inflammatory processes and is used for disease phasing guidance.<sup>(12)</sup>

Another relevant finding in this study was the relationship between peripheral muscle strength, as evaluated using the MRC score, and decannulation success. Immobilization and skeletal muscle weakness are the most common and relevant ICU complications, especially in prolonged MV patients, such as tracheostomized patients. The literature reports that peripheral muscle strength loss is correlated with reduced respiratory muscle strength and MV weaning failure. It was also shown that an MRC score  $\geq 41$  could be predictive of MV weaning success; however, in our study, this value was not predictive of decannulation success.<sup>(13-16)</sup>

Our results point to the MRC score as a probable decannulation success predictor, as shown by its higher mean in the successful group.<sup>(17)</sup> An MRC  $\geq 26$

had 94.4% sensitivity and 50% specificity, representing the best categorization of patients with respect to outcome (success or failure) in our sample. Given that this method is reliable, we could assure that a direct correlation between peripheral muscle strength and decannulation success was found in our findings.<sup>(16)</sup>

However, additional evaluation is warranted, with larger longitudinal trials and sample sizes, to evaluate the selected variables' predictive value and to identify values above which the decannulation success rate is significant.

## CONCLUSION

We may conclude that, for the studied population, peripheral muscle strength influenced the decannulation success rate, as did the white blood cell count on the day of the procedure.

## ACKNOWLEDGMENTS

We would like to acknowledge the support of all of the Intensive Care Unit of the Hospital Agamenon Magalhães staff, especially the physiotherapists and intensive physiotherapy residents who supported us in the writing of this manuscript. This manuscript is published in memory of Prof. Jáder Carneiro Júnior, a great professional.

## RESUMO

**Introdução:** A traqueostomia é provavelmente o procedimento cirúrgico mais comum realizado em pacientes críticos

objetivando facilitar o desmame do suporte ventilatório. Diretrizes baseadas em evidências têm confirmado o benefício de protocolos de desmame da traqueostomia e a participação dos fisioterapeutas neste processo, porém não existe consenso quanto aos critérios para decanulação. Portanto, o objetivo do estudo é avaliar a influência da força muscular periférica e outros índices sobre o sucesso na decanulação.

**Métodos:** Análise retrospectiva por meio de levantamento de prontuário de pacientes internados na unidade de terapia intensiva do Hospital Agamenon Magalhães no período de março de 2007 a agosto de 2009.

**Método:** Este é um estudo observacional, retrospectivo, dos prontuários dos pacientes internados na unidade de terapia intensiva clínico-cirúrgica do Hospital Agamenon Magalhães no período de março de 2007 a agosto de 2009. Foi avaliada a força muscular respiratória e periférica dos pacientes decanulados nesse período.

**Resultados:** Foram avaliados 1.541 pacientes, dos quais, 143 realizaram a traqueostomia, mas apenas 57 pacientes preencheram os critérios de inclusão para serem decanulados, sendo que destes 46 evoluíram com sucesso e 11 com insucesso, considerado a necessidade de retorno a via aérea artificial no período de duas semanas. A força muscular periférica obtida através do score do *Medical Research Council* (MRC) foi significativamente menor no grupo insucesso comparada ao sucesso ( $28,33 \pm 15,31$  vs  $41,11 \pm 11,52$ ;  $p = 0,04$ ). Valores de MRC  $\geq 26$  apresentaram uma sensibilidade de 94,4% e uma especificidade de 50,0% em relação ao desfecho da decanulação, com uma área sob a curva ROC de 0,7593. Já os leucócitos foram maiores no grupo insucesso ( $14070 \pm 3073$  vs  $10520 \pm 3402$  células/ $\mu\text{L}$ ;  $p = 0,00$ ).

**Conclusão:** O estudo mostrou que a força muscular periférica e a contagem dos leucócitos no dia da decanulação influenciaram no sucesso de remoção do traqueostomo.

**Descritores:** Traqueostomia; Decanulação; Desmame; Ventilação mecânica

## REFERÊNCIAS

1. Ceriana P, Carlucci A, Navalesi P, Rampulla C, Delmastro M, Piaggi G, et al. Weaning from tracheotomy in long-term mechanically ventilated patients: feasibility of a decisional flowchart and clinical outcome. *Intensive Care Med.* 2003;29(5):845-8.
2. Stelfox HT, Crimi C, Berra L, Noto A, Schmidt U, Bigatello LM, Hess D. Determinants of tracheostomy decannulation: an international survey. *Crit Care.* 2008;12(1):R26.
3. Veelo DP, Schultz MJ, Phoa KY, Dongelmans DA, Binnekade JM, Spronk PE. Management of tracheostomy: a survey of Dutch intensive care units. *Respir Care.* 2008;53(12):1709-15.
4. Martinez GH, Fernandez R, Casado MS, Cuena R, Lopez-Reina P, Zamora S, Luzon E. Tracheostomy tube in place at intensive care unit discharge is associated with increased ward mortality. *Respir Care.* 2009;54(12):1644-52.
5. Hsu CL, Chen KY, Chang CH, Jerng JS, Yu CJ, Yang PC. Timing of tracheostomy as a determinant of weaning success in critically ill patients: a retrospective study. *Crit Care.* 2005;9(1):R46-52.
6. De Jonghe B, Sharshar T, Lefaucheur JP, Outin H. Critical illness neuromyopathy. *Clin Pulm Med.* 2005;12(2):90-6.
7. Bach JR, Saporito LR. Criteria for extubation and tracheostomy tube removal for patients with ventilatory

- failure. A different approach to weaning. *Chest*. 1996;110(6):1566-71.
8. Mendes TAB, Cavalheiro LV, Arevalo RT, Sonoght R. Estudo preliminar sobre a proposta de um fluxograma de decanulação em traqueostomia com atuação interdisciplinar. *Einstein (São Paulo)*. 2008;6(1):1-6.
  9. Heffner JE. Tracheostomy decannulation: marathons and finish lines. *Crit Care*. 2008;12(2):128.
  10. Jubran A. Critical illness and mechanical ventilation: effects on the diaphragm. *Respir Care*. 2006;51(9):1054-61; discussion 1062-4.
  11. Levine S, Nguyen T, Taylor N, Friscia ME, Budak MT, Rothenberg P, et al. Rapid disuse atrophy of diaphragm fibers in mechanically ventilated humans. *N Engl J Med*. 2008;358(13):1327-35.
  12. Andriolo A. *Guia de medicina laboratorial*. Barueri: Manole; 2005.
  13. Vassilakopoulos T. Ventilator-induced diaphragm dysfunction: the clinical relevance of animal models. *Intensive Care Med*. 2008;34(1):7-16.
  14. Chiang LL, Wang LY, Wu CP, Wu HD, Wu YT. Effects of physical training on functional status in patients with prolonged mechanical ventilation. *Phys Ther*. 2006;86(9):1271-81.
  15. De Jonghe B, Bastuji-Garin S, Durand MC, Malissin I, Rodrigues P, Cerf C, Outin H, Sharshar T; Groupe de Réflexion et d'Etude des Neuromyopathies en Réanimation. Respiratory weakness is associated with limb weakness and delayed weaning in critical illness. *Crit Care Med*. 2007;35(9):2007-15.
  16. Chambers MA, Moylan JS, Reid MB. Physical inactivity and muscle weakness in the critically ill. *Crit Care Med*. 2009;37(10 Suppl):S337-46. Review.
  17. Schweickert WD, Hall J. ICU-acquired weakness. *Chest*. 2007;131(5):1541-9.