Validation of a new WIND classification compared to ICC classification for weaning outcome

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Abstract

Background: Although the WIND (Weaning according to a New Definition) classification based on duration of ventilation after the first separation attempt has been proposed, this new classification has not been tested in clinical practice. The objective of this cohort study was to evaluate the clinical relevance of WIND classification and its association with hospital mortality compared to the International Consensus Conference (ICC) classification.

Methods: All consecutive medical ICU patients who were mechanically ventilated for more than 24 h between July 2010 and September 2013 were prospectively registered. Patients were classified into simple, difficult, or prolonged weaning group according to ICC classification and Groups 1, 2, 3, or no weaning (NW) according to WIND classification.

Results: During the study period, a total of 1600 patients were eligible. These patients were classified by the WIND classification as follows: Group NW = 580 (36.3%), Group 1 = 617 (38.6%), Group 2 = 186 (11.6%), and Group 3 = 217 (13.6%). However, only 735 (45.9%) patients were classified by ICC classification as follows: simple weaning = 503 (68.4%), difficult weaning = 145 (19.7%), and prolonged weaning = 87 (11.8%). Clinical outcomes were significantly different across weaning groups by ICC classification and WIND classification. However, there were no statistical differences in successful weaning rate (96.6% vs. 95.2%) or hospital mortality (22.5% vs. 25.5%) between simple and difficult weaning groups by the ICC. Conversely, there were statistically significant differences in successful weaning rate (98.5% vs. 76.9%) and hospital mortality (21.2% vs. 33.9%) between Group 1 and Group 2 by WIND.

Conclusions: The WIND classification could be a better tool for predicting weaning outcomes than the ICC classification.

Keywords: Mechanical ventilation, Ventilator weaning, Treatment outcome, Classification

Introduction

Weaning from mechanical ventilation (MV) is a complex process involving daily assessment of readiness to wean and spontaneous breathing trial (SBT) to extubation [1]. The weaning process comprises at least 40% of the total duration of MV [2], and prolonged weaning is associated with higher mortality [3, 4]. A good understanding of the weaning process will reduce the duration of MV, lead to successful extubation, and eventually reduce the mortality rate and length of stay (LOS) in the intensive care unit (ICU) [1, 5].

In 2007, an International Consensus Conference (ICC) on weaning from MV proposed a classification into three different groups (simple, difficult, and prolonged weaning) according to the number, duration, and results of SBTs as well as extubation outcomes to simply classify
and deeply understand the weaning process [1]. However, ICC classification had some problems when applied in clinical practice: (a) it does not apply to patients without a weaning trial (unplanned extubation, death, or transfer out), (b) patients with tracheostomy tube before weaning trials are difficult to classify with ICC, and (c) ICC classification is based only on the successful results of SBT. Therefore, approximately half of mechanically ventilated patients could not be classified by the ICC classification [3, 4, 6, 7]. To overcome these limitations, the WIND (Weaning according to a New Definition) Study Group and the REVA (Réseau Européen de Recherche en Ventilation Artificielle) Network proposed a new classification using four different groups (Groups 1, 2, 3, and no weaning [NW]) [8]. However, WIND classification has not yet been fully validated and has not been sufficiently compared with ICC classification. Therefore, the objective of this cohort study was to evaluate the clinical relevance of WIND classification and its association with hospital mortality compared to ICC classification.

**Methods**

**Study population**

All consecutive patients admitted to the medical ICU and requiring MV for more than 24 h between July 2010 and September 2013 were prospectively registered at Samsung Medical Center, a 1989-bed tertiary referral hospital with tertiary-level ICU, in Seoul, South Korea [3, 9, 10]. If a patient was re-admitted to the ICU for MV support during the same hospital admission, only the first weaning episode was included in analysis. Multiple ICU visits during different hospital admissions were enrolled separately. Patients who were transferred from other hospitals after more than 48 h of intubation or were successfully treated by noninvasive ventilation (NIV) were excluded. The Institutional Review Board of Samsung Medical Center approved this study and allowed review and publication of information from patient records. Informed consent was waived because of the study’s observational nature.

**Standardized weaning process**

Since 2010, the medical ICU of our hospital has utilized a specific protocol-based weaning program according to the recommendations by Boles et al. [1]. Details of our weaning program were described in previous reports [3, 9, 10] and an additional file provided. In short, respiratory care practitioners (RCP), who are registered nurses specializing in respiratory care, screened patients daily for weaning readiness and conducted SBTs according to the protocol. When a patient passed the SBT, extubation proceeded. If a patient failed the SBT, MV was resumed, and the team reviewed possible reversible etiologies for the failure. Again, when a patient proved ready for weaning, the SBT was repeated the following day.

**Weaning classification by ICC and WIND**

Patients were classified into simple, difficult, or prolonged weaning groups according to ICC classification [1] and Groups 1, 2, 3, or NW according to WIND classification [8]. The three weaning groups by ICC classification were defined as follows: simple weaning, patients who proceed from initiation of weaning to successful extubation (no need to reinstitute ventilator support within 48 h of extubation) on the first attempt without difficulty; difficult weaning, patients who failed initial weaning and required up to three SBTs or as long as 7 days from the first SBT to achieve successful extubation; or prolonged weaning, patients who required more than three SBTs or > 7 days of weaning after the first SBT. To apply the ICC classification, unclassifiable patients were excluded as follows: patients with tracheostomy prior to MV; patients who died, underwent tracheostomy, transferred out, or had unplanned extubation before weaning trial; and patients with unclassifiable weaning after SBT who died or were transferred to another hospital after failure of the first SBT and before the third SBT or 7 days (Fig. 1). The four weaning groups by WIND classification were defined as follows: Group NW, patients who never experienced any separation attempt (SA); Group 1, the first SA resulted in termination of the weaning process within 1 day (successful separation or early death); Group 2, weaning was completed after more than 1 day but in less than 1 week after the first SA (successful separation or death); and Group 3, weaning was not terminated by 7 days after the first SA (by successful separation or death). In WIND classification, SA is defined as SBT or extubation directly performed without SBT (including unplanned extubation) for intubated patients and as ≥ 24 h with spontaneous ventilation through tracheostomy without any mechanical ventilation for tracheostomized patients.

**Weaning outcomes**

To analyze differences in weaning outcomes among groups according to ICC and WIND classifications, clinical outcomes of MV days, ventilator-free days, tracheostomy rate, successful weaning rate, ICU mortality, LOS in ICU, hospital mortality, and LOS in hospital were investigated. Ventilator-free days were calculated as the number of days without invasive ventilation to day 28. Nonsurvivors were considered as patients with 0 ventilator-free days. Because there is no applicable definition for tracheostomized patients in ICC classification, successful weaning was defined according to WIND definitions as follows: for intubated patients,
extubation without death or reintubation within the next 7 days whether postextubation NIV was used or not or ICU discharge without invasive MV within 7 days, whichever comes first; for tracheostomized patients, spontaneous ventilation through tracheostomy without any MV for 7 consecutive days or discharged with spontaneous breathing, whichever comes first. The date of successful weaning was counted to the actual day of extubation or spontaneous ventilation through tracheostomy after the patient had completed 7 days without reintubation or any MV through tracheostomy (or was alive and discharged earlier).

Statistical analysis
The data are presented as medians and interquartile ranges (IQR) for continuous variables and as numbers and percentages for categorical variables. The Jonckheere–Terpstra test for continuous variables [11] and the Mantel–Haenszel test for categorical variables [12] were used to analyze trends of baseline characteristics and outcomes across weaning groups. The Mann–Whitney U test was used for continuous variables, and Pearson's Chi-square test was used for categorical variables to identify statistical differences of main weaning outcomes between weaning groups according to the ICC and WIND classifications, respectively. All tests were two-tailed, and a P value < 0.05 was considered significant. The data were analyzed using PASW Statistics 18 (SPSS Inc., Chicago, IL, USA).

Results
Application of ICC and WIND classifications to the same cohort
During the study period, a total of 1600 patients were eligible after excluding patients who transferred from other hospitals after more than 48 h of intubation (n = 53) or underwent successful NIV (n = 76) (Fig. 1). All eligible patients were classified by the WIND classification as follows: Group NW = 580 (36.3%), Group 1 = 617 (39%), Group 2 = 186 (12%), and Group 3 = 217 (14%). However, only 735 (45.9%) patients could be classified by the ICC classification as follows: simple weaning = 503 (31.4%), difficult weaning = 145 (9.1%), and prolonged weaning = 87 (5.4%).
Baseline characteristics of the total cohort are presented in Table 1. Median age was 65 years, and 68.0% of patients were male. The most common comorbidity was malignant disease (59.5%), and the most common cause of respiratory failure was pneumonia (33.4%), followed by extrapulmonary sepsis (21.6%) and acute respiratory distress syndrome (9.8%).

Comparison of baseline characteristics among groups according to ICC and WIND classifications
Agreement of weaning results between ICC and WIND classifications is presented in Table 2. Although most patients in the simple weaning (462/503, 91.8%) or prolonged weaning groups (76/87, 87.4%) were classified as Group 1 or 3, respectively, only 59.3% (86/145) of patients in the difficult weaning group by ICC classification were classified as Group 2 by WIND classification. Of 865 patients whose weaning results could not be classified by ICC, 285 were classifiable to Group 1 (n = 109), 2 (n = 68), or 3 (n = 108) by WIND.

In a comparison of baseline characteristics among weaning groups, there were statistically significant trends with more underlying malignancy and neurologic disorders, longer interval between hospital admission and ICU admission, more pneumonia as a cause of respiratory failure, less pulmonary edema as a cause of respiratory failure, and longer interval between hospital admission and intubation across the ICC classification from simple to prolonged weaning groups (Table 3). In addition to this trend, except for neurologic disorders, there were statistically significant trends with more respiratory disorders and less gastrointestinal and genitourinary disorders as underlying diseases across the WIND classification from Group 1 to Group 3.

Clinical outcomes among groups according to ICC and WIND classifications
Clinical outcomes of the total cohort are listed in Table 4. Median interval between intubation and first SA was 3 days (IQR, 2–6 days), and median MV requirement was 5 days (IQR, 2–11 days). Tracheostomy was needed in 416/1580 (26.3%) patients after a median of 11 days (IQR, 6–15 days) of intubation. The successful weaning rate was 51.5%, and ICU and hospital mortality were 41.0% and 53.0%, respectively.

All of these clinical outcomes showed statistically significant trends across the ICC and WIND classifications (Table 5). However, there were no statistical differences in successful weaning rate (96.6% vs. 95.2%, P = 0.416), ICU mortality (5.4% vs. 5.5%, P = 0.944), and hospital mortality (22.5% vs. 25.5%, P = 0.443) between simple and difficult weaning groups by ICC (Fig. 2). Conversely, there were statistically significant differences in successful weaning rate (98.5% vs. 76.9%, P < 0.001), ICU mortality (3.6% vs. 16.7%, P < 0.001), and hospital mortality (21.2% vs. 33.9%, P < 0.001) between Group 1 and Group 2 by WIND. By the WIND classification, only the LOS between Group 1 and Group 2 had no statistically significant difference (median 25 days [IQR 15–51 days] versus median 29 days [IQR 16–52 days], P = 0.300).

Discussion
To the best of our knowledge, this is the first validation study of WIND classification compared to ICC classification. Our study demonstrates that the WIND classification.
classification could be operational for every patient under MV and better discriminates clinical outcomes by weaning group compared to ICC classification.

In this study, only 46% of patients receiving invasive MV were classifiable by ICC. However, WIND classification was applicable to all patients, even in
tracheostomized patients and patients not receiving the SBT. Our results are similar to those of the original study that proposed WIND classification, which classified only 1330/2709 (51%) patients by ICC and all patients by WIND [8]. In previous studies related to ICC classification, 40–60% of mechanically ventilated patients were excluded from studies because they died, had a tracheostomy, transferred to another hospital, had unplanned extubation before they were ready to wean or during weaning, or did not use SBT to wean [3, 4, 6, 7]. However, all patients could adopt the WIND classification because (a) the starting point of weaning in WIND classification was defined as SA including methods other than SBT, even unplanned extubation, (b) WIND classification provided clear criteria for the starting point of weaning and successful weaning in both intubated and tracheostomized patients, and (c) the WIND classification is based on duration of ventilation between the first SA and the end of weaning, regardless of the results, such as successful separation or death.

Although most previous studies have shown that prolonged weaning increases ICU and hospital mortality rates, there are no statistical differences between simple and difficult weaning [3, 4, 6, 7, 13]. As with previous studies, ICU and hospital mortality and successful weaning rates between simple and difficult weaning groups by ICC classification showed no differences in the present study. However, WIND classification had stepwise differences in Groups 1–3 for these weaning outcomes. In Table 4, successful weaning was noted in 18.5% (160/865) of the unclassifiable patients by ICC. In addition, their ICU survival rate was 32.0%, which was higher than that of Group NW (11.9%). Because these patients were

### Table 4 Clinical outcomes of total cohort, excluded patients by ICC classification, and Group NW by WIND classification

| Variables | Total (n = 1600) | ICC Excluded (n = 865) | WIND Group NW (n = 580) |
|-----------|----------------|-----------------------|-------------------------|
| Interval between intubation and the first SA, days | 3 (2–6) | 4 (2–10) | – |
| SOFA score at the day of first SA | 5 (3–8) | 7 (5–9) | – |
| MV days | 5 (2–11) | 6 (2–15) | 5 (2–11) |
| Ventilator-free days | 2 (0–24) | 0 (0–0) | 0 |
| Tracheostomy | 436 (27.3) | 277 (32.0) | 101 (17.4) |
| No | 1164 (72.8) | 568 (65.7) | 479 (82.6) |
| Before MV | 20 (1.3) | 20 (2.3) | 6 (1.0) |
| Between MV and first SA | 219 (13.7) | 219 (25.3) | 95 (16.4) |
| Between first SA and extubation | 151 (9.4) | 54 (6.2) | – |
| After the first extubation | 46 (2.9) | 4 (0.5) | – |
| Interval between intubation and tracheostomy, days | 11 (6–15) | 9 (5–14) | 10 (7–14) |
| Successful weaning from MV | 824 (51.5) | 160 (18.5) | 0 |
| ICU mortality | 656 (41.0) | 588 (68.0) | 511 (88.1) |
| LOS in ICU, days | 7 (4–15) | 8 (3–17) | 6 (2–13) |
| Hospital mortality | 848 (53.0) | 643 (74.3) | 520 (89.7) |
| LOS in hospital, days | 24 (13–46) | 20 (9–43) | 15 (5–30) |
| Type of discharge | | | |
| Home | 422 (26.4) | 44 (5.1) | 0 |
| Other hospital | 219 (13.7) | 90 (10.4) | 5 (0.9) |
| Other ICU | 24 (1.5) | 20 (2.3) | 10 (1.7) |
| Hospice | 87 (5.4) | 68 (7.9) | 45 (7.8) |
| Death | 848 (53.0) | 643 (74.3) | 520 (89.7) |

ICC, International Consensus Conference; NW, no weaning; WIND, Weaning according to a New Definition; SA, separation attempt; SOFA, Sequential Organ Failure Assessment; MV, mechanical ventilation; ICU, intensive care unit; LOS, length of stay.

a Excluded patients who had no SA from MV. Therefore, total patients, excluded patients by ICC, and Group NW by WIND numbered 1020, 285, and 0, respectively.

b Ventilator-free days are defined as 28 minus the total number of days with invasive MV. Nonsurvivors were considered as having 0 ventilator-free days.

c Excluded patients with no tracheostomy or tracheostomy prior to mechanical ventilation.

d Successful weaning is defined as in the WIND Study (intubated patients: extubation without death or reintubation within 7 days after extubation [whether postextubation noninvasive ventilation was used or not] or ICU discharge without invasive mechanical ventilation within 7 days, whichever comes first. Tracheostomized patients: spontaneous ventilation through tracheostomy without any mechanical ventilation during 7 consecutive days or ICU discharge with spontaneous breathing, whichever comes first).
classified as Groups 1–3 by WIND, the WIND classification seems to show greater differences in weaning outcomes between groups than does the ICC classification.

Although this study provides new information on weaning outcome based on new definitions that allow classification of all mechanically ventilated patients, our study has some limitations that should be considered. First, given its observational nature in a single tertiary referral hospital, there could be a selection bias that might have influenced the significance of our results. However, the data were collected prospectively between July 2010 and September 2013 from all consecutive patients who were admitted to the medical ICU and mechanically ventilated for more than 24 h. The patients were screened daily for weaning readiness according to a protocol-based weaning program [3, 9]. Thus, our cohort is more likely to reflect the patients encountered in routine ICU practice, and our findings are therefore readily applicable in similar settings. Second, our cohort was weaned from MV according to a protocol-based program with SBT using a T-piece. In addition, tracheostomy was performed in a quarter of patients, which is higher than the rate of 11–15% in an international multicenter study [14]. Although SBT using a T-piece is a general method of withdrawal from MV [4] and tracheostomy may improve aspects of care of patients on MV [15], our findings have limitations in their generalizability to other groups that underwent methods such as SBT using low pressure support, continuous positive airway pressure, gradual reduction in support using pressure support

Table 5  Clinical outcomes according to ICC and WIND classifications

| Variables                        | ICC classification | WIND classification | P for trend |
|----------------------------------|--------------------|---------------------|------------|
|                                  | Simple (n = 503)   | Difficult (n = 145) | P for trend |
| Interval between intubation and the first SA, days | 3 (2–5) | 3 (2–6) | 4 (2–7) | 0.002 | 3 (2–5) | 3 (2–6) | 4 (2–9) | <0.001 |
| SOFA score at the day of first SA | 5 (3–7) | 6 (3–8) | 5 (4–8) | <0.001 | 5 (3–7) | 6 (4–8) | 7 (5–9) | <0.001 |
| MV days                          | 3 (2–6) | 7 (4–10) | 19 (12–28) | <0.001 | 3 (2–5) | 7 (5–10) | 21 (14–35) | <0.001 |
| Ventilator-free days<sup>a</sup> | 25 (22–26) | 21 (18–24) | 0 (0–13) | <0.001 | 25 (23–26) | 19 (0–23) | 0 (0–5) | <0.001 |
| Tracheostomy                     | 40 (8.0) | 37 (25.5) | 62 (71.3) | <0.001 | 109 (17.7) | 64 (34.4) | 162 (74.7) | <0.001 |
| No                               | 463 (92.0) | 108 (74.5) | 25 (28.7) | – | 508 (82.3) | 122 (65.6) | 55 (25.3) | – |
| Before MV                        | – | – | – | – | 10 (1.6) | 3 (1.6) | 1 (0.5) | – |
| Between MV and first SA          | – | – | – | – | 63 (10.2) | 21 (11.3) | 40 (18.4) | – |
| Between first SA and extubation  | 12 (2.4) | 25 (17.2) | 60 (69.0) | – | 0 | 32 (17.2) | 119 (54.8) | – |
| After the first extubation        | 28 (5.6) | 12 (8.3) | 2 (2.3) | – | 36 (5.8) | 8 (4.3) | 2 (0.9) | – |
| Interval between intubation and tracheostomy, days<sup>b</sup> | 18 (13–33) | 12 (5–19) | 11 (9–15) | <0.001 | 10 (2–17) | 7 (4–12) | 12 (9–15) | <0.001 |
| Successful weaning from MV<sup>c</sup> | 486 (96.6) | 138 (95.2) | 40 (46.0) | <0.001 | 608 (98.5) | 143 (76.9) | 73 (33.6) | <0.001 |
| ICU mortality                     | 27 (5.4) | 8 (5.5) | 33 (37.9) | <0.001 | 22 (3.6) | 31 (16.7) | 92 (42.4) | <0.001 |
| LOS in ICU, days                 | 6 (3–9) | 10 (6–14) | 21 (14–30) | <0.001 | 6 (4–9) | 10 (7–14) | 24 (17–35) | <0.001 |
| Hospital mortality               | 113 (22.5) | 37 (25.5) | 55 (63.2) | <0.001 | 131 (21.2) | 63 (33.9) | 134 (61.8) | <0.001 |
| LOS in hospital, days            | 24 (14–45) | 31 (19–57) | 40 (27–74) | <0.001 | 25 (15–51) | 29 (16–52) | 45 (29–78) | <0.001 |
| Type of discharge                |                       |                      |          | |
| Home                             | 296 (58.8) | 72 (49.7) | 10 (11.5) | – | 343 (55.6) | 62 (33.3) | 17 (7.8) | – |
| Other hospital                   | 82 (16.3) | 30 (20.7) | 17 (19.5) | – | 129 (20.9) | 45 (24.2) | 40 (18.4) | – |
| Other ICU                        | 0 | 1 (0.7) | 3 (3.4) | – | 0 | 4 (2.2) | 10 (4.6) | – |
| Hospice                          | 12 (2.4) | 5 (3.4) | 2 (2.3) | – | 14 (2.3) | 12 (6.5) | 16 (7.4) | – |
| Death                            | 113 (22.5) | 37 (25.5) | 55 (63.2) | – | 131 (21.2) | 63 (33.9) | 134 (61.8) | – |

ICC International Consensus Conference, WIND Weaning according to a New Definition, SA separation attempt, SOFA Sequential Organ Failure Assessment, MV mechanical ventilation, ICU intensive care unit, LOS length of stay

<sup>a</sup> Ventilator-free days are defined as 28 minus the total number of days with invasive MV. Nonsurvivors were considered as having 0 ventilator-free days

<sup>b</sup> Excluded patients with no tracheostomy and tracheostomy prior to mechanical ventilation

<sup>c</sup> Successful weaning is defined as in the WIND Study (Intubated patients: extubation without death or reintubation within 7 days after extubation [whether postextubation noninvasive ventilation was used or not] or ICU discharge without invasive mechanical ventilation within 7 days, whichever comes first. Tracheostomized patients: spontaneous ventilation through tracheostomy without any mechanical ventilation during 7 consecutive days or ICU discharge with spontaneous breathing, whichever comes first)
Fig. 2 Comparisons of weaning outcomes between groups according to ICC and WIND classifications. Data are presented as medians and interquartile ranges for continuous variables and as percentages for categorical variables. P values between groups are < 0.001 except where otherwise noted. ICC International Consensus Conference, WIND Weaning according to a New Definition, MV mechanical ventilation, ICU intensive care unit, LOS length of stay, G1 Group 1, G2 Group 2, G3 Group 3, S simple weaning group, D difficult weaning group, P prolonged weaning group
mode, or synchronized intermittent mandatory ventilation, and that has lower rate of tracheostomy.

Conclusion
In conclusion, WIND classification could be a better tool for predicting weaning outcomes than ICC classification because WIND classification is applicable to all mechanically ventilated patients and has higher discriminatory power for weaning outcomes.

Additional file

Additional file 1. Standardized weaning process.

Abbreviations
ICC: International Consensus Conference; ICU: intensive care unit; IQR: interquartile range; LOS: length of stay; MV: mechanical ventilation; NIV: noninvasive ventilation; NW: no weaning; RCP: respiratory care practitioners; REVA: Réseau Européen de Recherche en Ventilation Artificielle; SA: separation attempt; SBT: spontaneous breathing trial; WIND: Weaning according to a New Definition.

Authors’ contributions
BHJ, KYL, and KJ conceived and designed the study; BHJ, KYL, JN, MGK, SJN, GYS, and KJ analyzed and interpreted the data; BHJ, KYL, and KJ drafted the manuscript. All authors read and approved the final manuscript.

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Competing interests
The authors declare that they have no competing interests.

Availability of data and materials
All data generated or analyzed during the present study are included in this published article.

Consent for publication
Not applicable.

Ethics approval and consent to participate
The Institutional Review Board of Samsung Medical Center approved this study and waived the requirement for informed consent because of the observational nature of the study.

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References
1. Boles JM, Bion J, Connors A, Herridge M, Marsh B, Melot C, et al. Weaning from mechanical ventilation. Eur Respir J. 2007;29:1033–56.
2. Esteban A, Ferguson ND, Meade MO, Frutos-Vivar F, Apezteguia C, Brochard L, et al. Evolution of mechanical ventilation in response to clinical research. Am J Respir Crit Care Med. 2008;177:170–7.
3. Jeong BH, Ko MG, Nam J, Yoo H, Chung CR, Suh GY, et al. Differences in clinical outcomes according to weaning classifications in medical intensive care units. PLoS ONE. 2015;10:e0122810.
4. Penuelas O, Frutos-Vivar F, Fernandez C, Anzueto A, Epstein SK, Apezteguia C, et al. Characteristics and outcomes of ventilated patients according to time to liberation from mechanical ventilation. Am J Respir Crit Care Med. 2011;184:430–7.
5. Blackwood B, Alderdice F, Burns K, Cardwell C, Lavery G, O’Halloran P. Use of weaning protocols for reducing duration of mechanical ventilation in critically ill adult patients: cochrane systematic review and meta-analysis. BMJ. 2011;342:c7237.
6. Funk GC, Anders S, Breyer MK, Burghuber OC, Edelmann G, Heindl W, et al. Incidence and outcome of weaning from mechanical ventilation according to new categories. Eur Respir J. 2010;35:88–94.
7. Pu L, Zhu B, Jiang L, Du B, Zhu X, Li A, et al. Weaning critically ill patients from mechanical ventilation: a prospective cohort study. J Crit Care. 2015;30(862):e7–13.
8. Beduneau G, Pharm T, Schortgen F, Piquilloud L, Zogheib E, Jonas M, et al. Epidemiology of Weaning Outcome according to a New Definition. The WIND Study. Am J Respir Crit Care Med. 2017;195:772–83.
9. Jeon K, Jeong BH, Ko MG, Nam J, Yoo H, Chung CR, et al. Impact of delirium on weaning from mechanical ventilation in medical patients. Respirology. 2016;21:315–20.
10. Jeong BH, Nam J, Ko MG, Chung CR, Suh GY, Jeon K. Impact of limb weakness on extubation failure after planned extubation in medical patients. Respirology. 2018;23:842–50.
11. Bewick V, Cheek L, Ball J. Statistics review 10: further nonparametric methods. Crit Care. 2004;8:196–9.
12. Bewick V, Cheek L, Ball J. Statistics review 8: qualitative data: tests of association. Crit Care. 2004;8:46–53.
13. Tonneller A, Tonneller JM, Nowak E, Gut-Gobert C, Prat G, Renaudt A, et al. Clinical relevance of classification according to weaning difficulty. Respir Care. 2011;56:583–90.
14. Esteban A, Frutos-Vivar F, Muriel A, Ferguson ND, Penuelas O, Abraira V, et al. Evolution of mortality over time in patients receiving mechanical ventilation. Am J Respir Crit Care Med. 2013;188:220–30.
15. Nieszkowska A, Combes A, Luyt CE, Kolbi H, Trouillet JL, Gibert C, et al. Impact of tracheotomy on sedative administration, sedation level, and comfort of mechanically ventilated intensive care unit patients. Crit Care Med. 2005;33:2527–33.