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WHAT'S NEW IN INTENSIVE CARE

How to optimize extubation?

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Extubation failure, defined as the inability to sustain spontaneous breathing after removal of the artificial airway and need for reintubation within 24–72 h or up to 7 days, is associated with high morbidity and mortality, as well as long term disability [1]. Many studies have attempted to identify risk factors for extubation failure in order to prevent it. Nevertheless, the incidence of extubation failure in intensive care units (ICUs) remains quite high in the literature, between 10% within 48 h [1] and 15% within 7 days [2].

Two main causes of extubation failure can be identified [1]: weaning failure, the patient's unreadiness to breathe without respiratory assistance, or airway failure, the patient's unreadiness to breathe without an artificial airway.

The aim of this paper is to provide an update on strategies to optimize extubation, before and after extubation procedure (Fig. 1).

Anticipate the cause of extubation failure before extubation

The FREE-REA study [1] identified risk factors for airway failure vs weaning failure among cases of extubation failure in a large multicenter, prospective cohort of extubated medical and surgical critically ill patients. Potentially actionable risk factors were identified: absence of strong cough associated with both airway failure and weaning failure, copious secretions associated with airway failure and Sequential Organ Failure Assessment (SOFA) score ≥ 8 associated with weaning failure.

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To anticipate weaning failure, the first established method is to perform a spontaneous breathing trial (SBT) [3]. The most common modes of SBT are pressure support ventilation (PSV) and T-piece ventilation. In a recent randomized trial of patients receiving mechanical ventilation [3], a 30-min PSV-SBT resulted in a significantly higher rate of successful extubation than a 2-h T-piece SBT, without significantly increasing reintubation. The higher rate was related to more patients being extubated after the PSV-SBT, suggesting that a less demanding SBT better allows critically ill patients to demonstrate their ability to sustain breathing. It is worth noting that a 2 h T-piece SBT represents a very long time, and might overestimate the inspiratory effort post-extubation. A trial recently published by Thille et al. [2] selecting patients at high-risk of extubation failure found no difference regarding the number of ventilator-free days at day 28 between PSV and T-piece trials of one hour. In patients with obesity [4], it was shown that either a T-piece or a PSV 0 and positive end-expiratory pressure (PEEP) 0 cmH_2O test are the trials that are the most representative of the post-extubation inspiratory effort. Studies are ongoing to identify which SBT best mimics the post-extubation inspiratory effort for selected groups of patients.

Using high-flow nasal oxygen (HFNO) during T-piece SBT may help by providing warm and humidified oxygen. In a single-center, pilot randomized controlled trial [5], rates of reintubation within 7 days after extubation were 16% in T-piece with standard oxygen and 3.9% in SBT with HFNO ($P=0.05$). It is also important to let the patient rest after a SBT [6], by reconnecting the patient to the ventilator during a 1-h rest [2].

A second very important point is to perform a careful hemodynamic assessment. Extubation on vasopressors was controversial until a recent study [7] that suggested that extubation on low-dose vasopressors ($\leqslant 0.1$ µg/kg/min) could be safe and associated with a lower mortality and a shorter ICU length of stay. On the contrary,

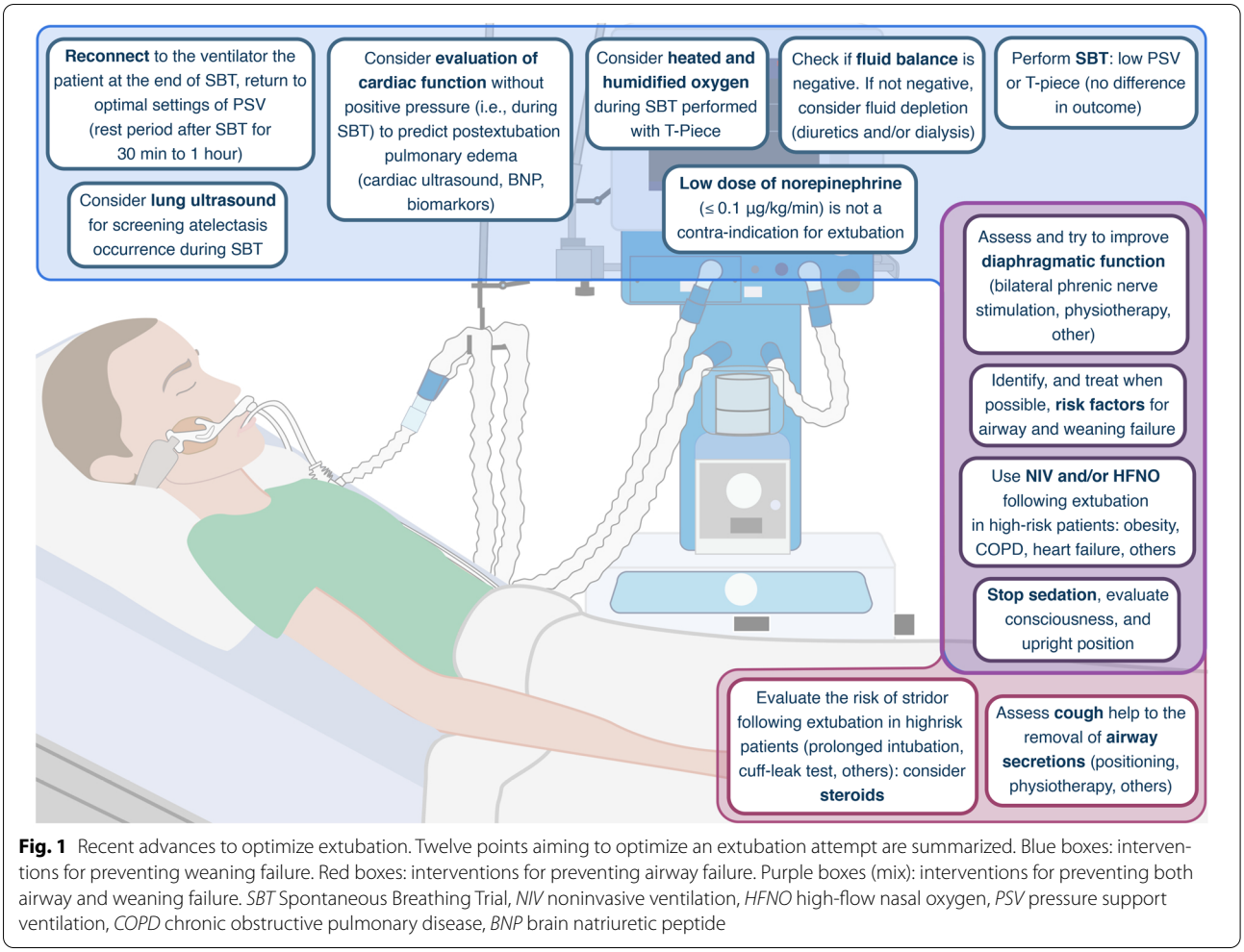

Fig. 1 Recent advances to optimize extubation. Twelve points aiming to optimize an extubation attempt are summarized. Blue boxes: interventions for preventing weaning failure. Red boxes: interventions for preventing airway failure. Purple boxes (mix): interventions for preventing both airway and weaning failure. *SBT* Spontaneous Breathing Trial, *NIV* noninvasive ventilation, *HFNO* high-flow nasal oxygen, *PSV* pressure support ventilation, *COPD* chronic obstructive pulmonary disease, *BNP* brain natriuretic peptide

extubation on high-dose vasopressors (>0.1 µg/kg/min) [7] was associated with a greater hazard of reintubation compared with extubation after vasopressor discontinuation. Allowing the use of low-dose vasopressors might help to obtain a negative fluid balance, and low filling pressures, to avoid overload after extubation and removal of the positive pressure ventilation. High-risk patients who failed SBT due to weaning pulmonary edema exhibited echocardiographic findings consistent with left ventricular overload together with excessive cumulated fluid balance [8]. Echocardiography-guided therapy helped attending physicians to successfully extubate patients who previously failed SBT due to weaning pulmonary edema [8].

Echocardiography can be combined with diaphragm and lung ultrasound to further optimize the positive and negative predictive values of extubation failure tests. A recent study [9] assessed the effectiveness of bilateral phrenic nerve stimulation and did not show an increase of the proportion of successful weaning from mechanical ventilation compared with the standard of care. However, it resulted in substantial improvements in inspiratory pressure generation capacity without major safety issues, suggesting that diaphragm pacing could mitigate diaphragm dysfunction in patients who are difficult to wean from mechanical ventilation [9].

To anticipate airway failure before extubation, cough expiratory peak-flow and the evaluation of the amount of secretions are also important to identify patients at risk to develop airway failure. Steroids were found to be effective in preventing stridor and reintubation only in a high-risk population, as determined by the cuff-leak test, and when given at least four hours before extubation [10].

After extubation: still anticipate

A recent meta-analysis [11] revealed that preventive noninvasive ventilation (NIV) and HFNO reduced reintubation in critically ill adults, compared to conventional

oxygen therapy. Sensitivity analyses showed that the magnitude of the effect was highest in patients with increased baseline risk of reintubation [11].

An effective clearing of the airways requires a balance between production and removal of respiratory secretions that can be reduced by respiratory muscle weakness and upper airway dysfunction. In this setting, physiotherapy through cough augmentation techniques seems of great importance following extubation, even if the level of proof remains low.

Specific populations

Some specific populations are at very high-risk of extubation failure.

In patients with chronic obstructive pulmonary disease and heart failure, NIV is a therapeutic of choice in order to prevent extubation failure and was found to be superior to HFNO [12].

In patients with obesity, NIV seems especially effective to prevent reintubation [13] and a current trial focused on this specific population is ongoing [14].

In patients with brain injury, specific risk factors for extubation failure have been identified in brain-injured patients: absence of cough, absence of deglutition (swallowing attempts), absence of gag reflex, and altered neurologic status (low Coma Recovery Scale-Revised visual subscale, absence of visual pursuit, Glasgow coma score lower than 10) [15].

Future studies are needed to individualize periextubation care, combining the use of clinical assessment (cough, fluid balance, secretions amount, deglutition, neurologic status), SBTs, ultrasounds and biomarkers, adapted to specific group of patients, to accurately predict extubation failure.

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Declarations

Conflicts of interest

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References

1. Jaber S, Quintard H, Cinotti R, Asehnoune K, Arnal JM, Guitton C, Paugam-Burtz C, Abback P, Mekontso Dessap A, Lakhal K, Lasocki S, Plantefeve G, Claud B, Pottecher J, Corne P, Ichai C, Hajjej Z, Molinari N, Chanques G, Papazian L, Azoulay E, De Jong A (2018) Risk factors and outcomes for airway failure versus non-airway failure in the intensive care unit: a multicenter observational study of 1514 extubation procedures. Crit Care 22:236
2. Thille AW, Gacouin A, Coudroy R, Ehrmann S, Quenot JP, Nay MA, Guitton C, Contou D, Labro G, Reignier J, Pradel G, Beduneau G, Dangers L, Saccheri C, Prat G, Lacave G, Sedillot N, Terzi N, La Combe B, Mira JP, Romen A, Azais MA, Rouzé A, Devaquet J, Delbove A, Dres M, Bourenne J, Lautrette A, de Keizer J, Ragot S, Frat JP (2022) Spontaneous-breathing trials with pressure-support ventilation or a T-piece. N Engl J Med 2:2
3. Subirà C, Hernández G, Vázquez A, Rodríguez-García R, González-Castro A, García C, Rubio O, Ventura L, López A, de la Torre MC, Keough E, Arauzo V, Hermosa C, Sánchez C, Tizón A, Tenza E, Laborda C, Cabañes S, Lacueva V, Del Mar FM, Arnau A, Fernández R (2019) Effect of pressure support vs t-piece ventilation strategies during spontaneous breathing trials on successful extubation among patients receiving mechanical ventilation: a randomized clinical trial. JAMA 321:2175–2182
4. Mahul M, Jung B, Galia F, Molinari N, de Jong A, Coisel Y, Vaschetto R, Matecki S, Chanques G, Brochard L, Jaber S (2016) Spontaneous breathing trial and post-extubation work of breathing in morbidly obese critically ill patients. Crit Care 20:346
5. Fossat G, Nay MA, Jacquier S, Desmalles E, Boulain T (2021) High-flow oxygen during spontaneous breathing trial for patients at high risk of weaning failure. Intensive Care Med 47:916–917
6. Fernandez MM, Gonzalez-Castro A, Magret M, Bouza MT, Ibanez M, Garcia C, Balerdi B, Mas A, Arauzo V, Anon JM, Ruiz F, Ferreres J, Tomas R, Alabert M, Tizon AI, Altaba S, Llamas N, Fernandez R (2017) Reconnection to mechanical ventilation for 1 h after a successful spontaneous breathing trial reduces reintubation in critically ill patients: a multicenter randomized controlled trial. Intensive Care Med 43:1660–1667
7. Zarrabian B, Wunsch H, Stelfox HT, Iwashyna TJ, Gershengorn HB (2022) Liberation from invasive mechanical ventilation with continued receipt of vasopressor infusions. Am J Respir Crit Care Med 205:1053–1063
8. Goudelin M, Champy P, Amiel JB, Evrard B, Fedou AL, Daix T, François B, Vignon P (2020) Left ventricular overloading identified by critical care echocardiography is key in weaning-induced pulmonary edema. Intensive Care Med 46:1371–1381
9. Dres M, de Abreu MG, Merdji H, Müller-Redetzky H, Dellweg D, Randerath WJ, Mortaza S, Jung B, Bruells C, Moerer O, Scharffenberg M, Jaber S, Besset S, Bitter T, Geise A, Heine A, Malfertheiner MV, Kortgen A, Benzaquen J, Nelson T, Uhrig A, Moenig O, Meziani F, Demoule A, Similowski T (2022) Randomized clinical study of temporary transvenous phrenic nerve stimulation in difficult-to-wean patients. Am J Respir Crit Care Med 205:1169–1178
10. Jaber S, Jung B, Chanques G, Bonnet F, Marret E (2009) Effects of steroids on reintubation and post-extubation stridor in adults: meta-analysis of randomised controlled trials. Crit Care 13:R49
11. Fernando SM, Tran A, Sadeghirad B, Burns KEA, Fan E, Brodie D, Munshi L, Goligher EC, Cook DJ, Fowler RA, Herridge MS, Cardinal P, Jaber S, Møller MH, Thille AW, Ferguson ND, Slutsky AS, Brochard LJ, Seely AJE, Rochwerg B (2022) Noninvasive respiratory support following extubation in critically ill adults: a systematic review and network meta-analysis. Intensive Care Med 48:137–147
12. Hernández G, Paredes I, Moran F, Buj M, Colinas L, Rodríguez ML, Velasco A, Rodríguez P, Pérez-Pedrero MJ, Suarez-Sipmann F, Canabal A, Cuena R, Blanch L, Roca O (2022) Effect of postextubation noninvasive ventilation with active humidification vs high-flow nasal cannula on reintubation in patients at very high risk for extubation failure: a randomized trial. Intensive Care Med 2:1–9
13. Thille AW, Coudroy R, Nay MA, Gacouin A, Decavèle M, Sonneville R, Beloncle F, Girault C, Dangers L, Lautrette A, Levrat Q, Rouzé A, Vivier E, Lascarrou JB, Ricard JD, Mekontso-Dessap A, Barberet G, Lebert C, Ehrmann S, Massri A, Bourenne J, Pradel G, Bailly P, Terzi N, Dellamonica J, Lacave G, Robert R, Frat JP, Ragot S (2022) Beneficial effects of noninvasive ventilation

after extubation in obese or overweight patients: a post hoc analysis of a randomized clinical trial. Am J Respir Crit Care Med 205:440–449
14. De Jong A, Huguet H, Molinari N, Jaber S (2022) Non-invasive ventilation versus oxygen therapy after extubation in patients with obesity in intensive care units: the multicentre randomised EXTUB-OBESE study protocol. BMJ Open 12:e052712
15. Cinotti R, Mijangos JC, Pelosi P, Haenggi M, Gurjar M, Schultz MJ, Kaye C, Godoy DA, Alvarez P, Ioakeimidou A, Ueno Y, Badenes R, Suei Elbuzidi AA, Piagnerelli M, Elhadi M, Reza ST, Azab MA, McCredie V, Stevens RD, Digitale JC, Fong N, Asehnoune K (2022) Extubation in neurocritical care patients: the ENIO international prospective study. Intensive Care Med 48:1539–1550