Predictors for the removal of the tracheostomy tube

Predictores para la retirada de la cánula de traqueostomía

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ABSTRACT

It is essential to prioritize the decannulation of tracheostomized patients. A successful procedure could avoid prolonged hospital stay. Accordingly, there could be a reduction in mortality. Removing the tracheotomy cannula is a very controversial issue, because there are different types of strategies and approaches to do so. The prolonged use of the cannula must be avoided, since it entails different complications such as tracheal malacia, tracheal stenosis, tracheoesophageal fistula, and functionally altered swallowing and phonation; thus, it is very important to be able to know exactly which are the variables that need to be measured before a patient is decannulated. Several published studies disagree on which are the best indicators that should be observed to be successful. So, the objective of this review was to analyze which are the most effective target variables when performing the decannulation.

Key words: Tracheostomy; Decannulation; Intensive care Unit

RESUMEN

Es imprescindible poder priorizar la decanulación de los pacientes traqueostomizados. El éxito en el procedimiento podría evitar estadías hospitalarias prolongadas y, por consiguiente, llegar a disminuir la mortalidad. La retirada de la cánula de traqueostomía es un tema muy controversial, dado que, para lograrla, existen diferentes tipos de abordajes y estrategias. Teniendo en cuenta que su uso prolongado debe ser evitado, ya que conlleva a diferentes complicaciones, como traqueomalacia, estenosis traqueal, fistula traqueo-esofágica, alteraciones funcionales en la deglución y la fonación, es de suma importancia poder conocer con exactitud cuáles son las variables que mensurar para que el paciente pueda ser decanulado. Diversos trabajos publicados difieren en cuáles son los mejores indicadores que deben ser observados para lograr el éxito. Por lo tanto, el objetivo de la presente revisión es analizar cuáles son las variables objetivables con mayor eficacia al momento de llevar a cabo la decanulación.

Palabras clave: Traqueostomía; Decanulación; Unidad de cuidados intensivos

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INTRODUCTION

The tracheostomy (TQT) is one of the most commonly used procedures at the Intensive Care Unit (ICU) in patients with prolonged invasive mechanical ventilation (PIMV).[1, 2] It is performed in 34% of patients with invasive mechanical ventilatory support (IMVS) for more than 48 hours.[3] It is also indicated in patients with poor secretion management, with alterations in the upper airway, extubation failure, and prolonged mechanical ventilation.[4]

It is essential to prioritize the decannulation of tracheostomized patients, because if the procedure is successful, prolonged hospital stay (with greater predisposition to infections) could be avoided; thus, mortality could be reduced. Various publications analyze if the success or failure of decannulation are determining factors of patients' survival. In a multicenter study about tracheostomized patients carried out in Argentina, Díaz Ballve et al found that mortality was higher in patients who couldn't decannulate. Among patients who couldn't be decannulated, after 90 days, only 64% were alive, whereas those who could be decannulated reached 94.1% survival.[5] Scrigna et al observed in an analysis of 181 patients with TQT that having been decannulated was a protective factor for mortality during hospitalization.[6] On the other hand, Rapela et al analyzed patients with chronic obstructive pulmonary disease (COPD), tracheostomized under PIMV, and observed that most patients who couldn't be weaned from IMVS (47.5%) were either referred to a higher complexity health center or died (78.9%).[7] Another multicenter study conducted in Germany which observed 831 tracheostomized patients with a diagnosis of neurological origin upon hospital admission found that 93.5% of the 62 patients that died hadn't been able to be decannulated.[8]

We should also consider that, due to the facts previously described, delayed decannulation could increase public health costs.[9]

Removing a TQT cannula is a very controversial issue, because there are different types of strategies and approaches to do so, according to the published bibiliography.[4] Knowing that the prolonged use of the cannula must be avoided, because it entails different complications such as tracheal malacia, tracheal stenosis, tracheoesophageal fistula, and functionally altered swallowing and phonation,[10-13] it is very important to be able to know exactly which are the variables that need to be taken into account for a patient to be successfully decannulated.

Various published studies disagree on which are the best indicators that should be observed to achieve a successful removal of the tracheostomy cannula.[5, 14, 15] So, the objective of this review was to analyze which are the most effective target variables when performing the decannulation.

MATERIALS AND METHODS

Bibliographic search

Bibliographic search was performed in the following databases: LILACS, PUBMED, MEDLINE and SciELO, using the following keywords: tracheostomy, decannulation, termination of tracheostomy, swallowing disorders and decannulation predictors during the period between 2010 and 2020. The other studies were obtained through recommendation of specialists, and so the selection was completed according to the criterion and objective of the study.
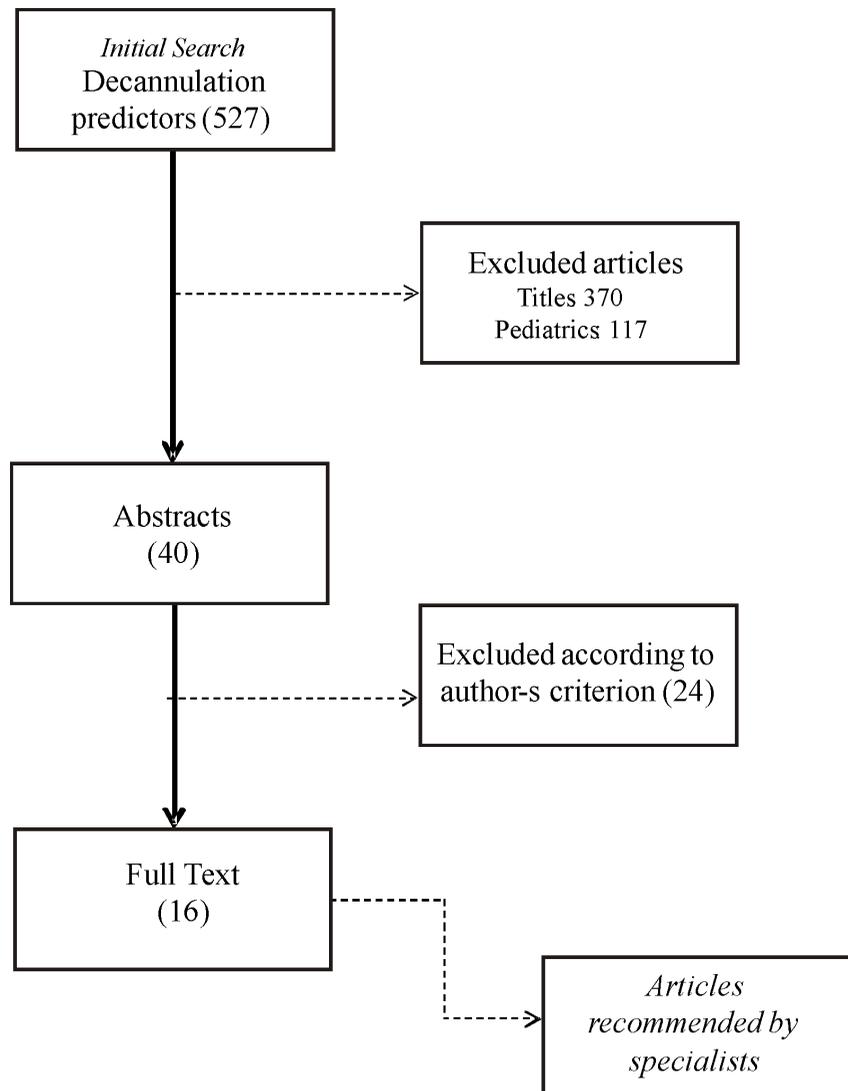
We excluded articles about pediatric patients and those in which the title did not match the objective of the work.

Different decannulation predictive indicators (of both failure and success) were evaluated:

- **Age:** expressed in years.
- **Sex:** female and male.
- **Comorbidities:** history of admission to the Intensive Care Unit or mechanical ventilation weaning and rehabilitation center (MVWRC).
- **Level of consciousness:** state of consciousness before decannulation.
- **Structural alterations of the airway:** anatomical alterations produced during the patient's stay with an artificial airway.
- **Alteration in swallowing or management of secretion pooling :** alterations produced as a consequence of treatment.
- **Duration of mechanical ventilation:** number of days with invasive mechanical ventilation.
- **Effectiveness of cough and muscle strength:** evaluated before decannulation.

Development

The objective of the decannulation process is to remove the artificial airway. Generally, it is based on a protocol that varies according to the attending institution. 31%-44% of tracheostomized patients are decannulated, with a percentage of recannulation of 3%-4% according to published information.[1, 6, 16, 17, 18] Taking into account the low percentage of success and complications associated with decannulation failure (alteration of consciousness, poor management of secretions, impossibility to wean from invasive mechanical ventilatory support, weakness

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Flow diagram about bibliographic search

of respiratory muscles and structural alterations of the airway), decannulation becomes an extremely important topic of study, since multiple variables involved in the process have to be analyzed. These variables are represented in Figure 1.

Age

According to the bibliography, the mean age of patients who require a tracheostomy cannula ranges from 55 to 70 years.[5, 19-22] Distefano et al observed that 40% of decannulated patients from a total of 50 had a mean age of 66 years, whereas Scrigna et al obtained a median of 63 and 66 years of success and failure, respectively, with 44% of success in decannulation.[6, 23]

Thomas and Schneider observed that successfully decannulated patients had a mean age of less than 70 years.[22, 24] In turn, Díaz Ballve et al found in their univariate analysis that advanced age (more than 70 years) was a predictive factor independently associated with decannulation failure.[5] In the same way, Budweiser et al found that having a median of age of 72 years is predictive of recannulation.[25] It is worth mentioning that, whereas the mean age of the observed populations of tracheostomized patients from the studies published by Luo and Berney was 44 and 47 years, those patients had been admitted due to multiple trauma, which was one of the possible causes of a reduction in the age range.[26, 27] Age is possibly a
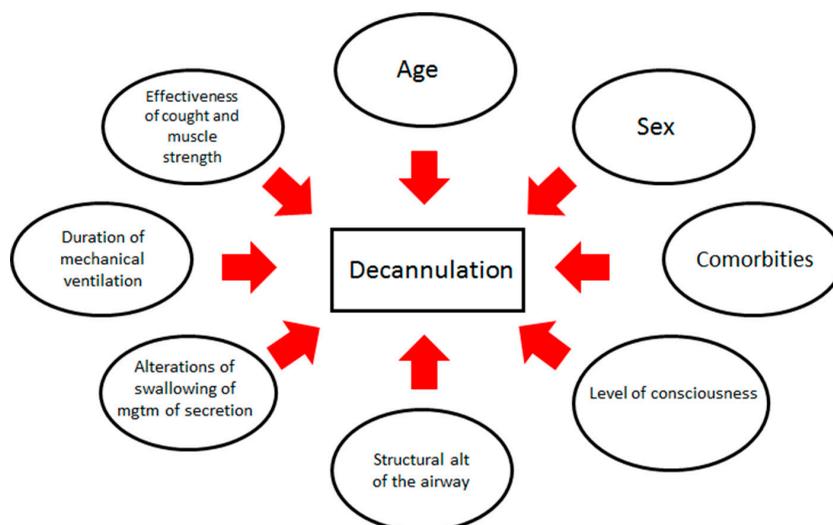
Figure 1. Analyzed variables that interfere with decannulation.

factor to be highlighted when we talk about the possibility to decannulate. Old patients generally show varied medical records and comorbidities on admission to the Intensive Care Unit (ICU), thus complicating the decannulation process, which is even more difficult in cases of Intensive Care Unit-acquired weakness.

Sex

In almost all the analyzed bibliography, males were predominant in both the group of patients who couldn't decannulate and also in the failure group that required recannulation. Scrigna et al provide support for this finding in their multivariate analysis, in which they found that the male sex is a risk factor independently associated with decannulation failure.[5, 6, 14, 15, 19, 20, 23] However, Tawfik et al found, in their search for risk factors associated with decannulation following laryngotracheal reconstruction, that female patients with tracheostomy cannula were predominant. Moreover, most patients who didn't have success in decannulation were females (62.2%). This author didn't analyze the reason for such predominance, but observed that almost 60% of the sample had a history of gastroesophageal reflux (GER). This could be the cause of tracheal stenosis by mucosal injury and consequent requirement of airway reconstruction. GER is one of the causes of failure in post-surgical decannulation.[28] Taking this finding into consideration, it is necessary to remember that females predominate in patients with history of GER.[29] The

latter author found that decannulation failed in a great percentage of female patients, but females were predominant in that sample, clearly showing that male patients are the ones who definitely entail more risks of failure in the decannulation process, according to the bibliography.

Comorbidities

There is strong predominance of patients with history of cardiovascular disease, followed by toxic-metabolic history, among patients with TQT admitted to the ICU or the MVWRC.[5, 6, 30] On the other hand, Stelfox observed in his two studies published for two consecutive years about tracheostomized patients, that subjects with terminal renal disease were less succesful in decannulation compared to patients with chronic respiratory failure.[31, 32]

Hernández et al compared two groups: one consisted of patients with TQT with predominance of neurologic history and difficulty in managing secretions; in the other one, there were patients with TQT under PIMV with predominant history of COPD, diabetes mellitus, respiratory diseases, arterial hypertension, and a similar APACHE II average score of 18 and 19, respectively, where no significant difference was found between both groups as regards the percentage of decannulation success, which was 90% and 85% of the total number of patients.[21]

It is worth mentioning that, in the multivariate analysis of Scrigna et al, the presence of respiratory history was associated with decannulation failure,

taking into account the fact that in the cohort of their study, the neurologic history was predominant.[6]

Comorbidities could possibly have a major role in the course of the patient's hospitalization. If the patient also has an extensive history, treatment complexity becomes even more evident. Patients with respiratory and neurologic history are the ones who have greater difficulty in weaning from mechanical ventilation and also in the decannulation process. The reason for this may be the physiopathology of these comorbidities, which pose a big challenge to treating professionals in order to reach treatment success.

Level of consciousness

There is lack of consensus in the bibliography about which level of consciousness is necessary to begin the decannulation protocol. This is a such a controversial issue that many authors decided not to include in the decannulation protocol those patients who can't provide minimum active cooperation with a value of more than 8 in the Glasgow Coma Scale (GCS).[12, 19, 21, 33, 34] Villalba et al state that the level of consciousness can be a determining factor of the process of decannulation if it interferes with the protection of the airway.[4] However, Stelfox et al came to the conclusion (through a survey) that, whereas the level of consciousness was one of the determining factors of decannulation success, it wasn't an indispensable requirement, so it was considered a secondary variable. The main variables that were studied were tolerance to occlusion and cough effectiveness.[32]

Choate et al believe the state of consciousness is a predictor of decannulation,[35] whereas Bellon et al conducted a study that analyzed the relationship between the chronic alteration of the state of consciousness and decannulation, using the coma recovery scale-revised (CRS-R) as a measurement tool, and observed that of the 33% of patients who were able to decannulate and had chronic alteration of the state of consciousness, 40% had unresponsive wakefulness (GCS < 8) the moment the TQT cannula was being removed.[30] The Glasgow scale is not recommended for the population of patients with chronic alteration of the state of consciousness.[30]

Structural alterations of the airway

Both the placement and prolonged presence of an artificial airway (AAW) cause the patient to be at risk of having structural lesions such as stenosis, granulomas and tracheal malacia.[10] One of the most prevalent structural complications present when performing a fibrobronchoscopy before decannulation were granulomas.[36, 37] A large percentage of patients with granulomas had a mild lesion of the airway that did not exceed the 50% occlusion of the tracheal tube, so, according to Rumbak et al, in patients with a good general condition, it would not prevent a successful decannulation. They also observed that a lesion is clinically important if it functionally obstructs more than 50% of the tracheal tube, because if the trachea has an approximate diameter of 1.6 cm to 1.8 cm, an 8 mm lesion (the most common internal diameter of TQT cannulas) wouldn't offer strong resistance to tolerate spontaneous ventilation.[38]

On the other hand, some authors consider stenosis as one of the most severe complications. Even though stenosis has a 3%-12% prevalence in patients with TQT, it could prevent decannulation given its difficult surgical resolution or possible progression, if it occludes more than 50% of the tracheal tube.[36] It's important to mention that Planells et al, just like Epstein et al, found an association between advanced age and the development of tracheal stenosis. Also, the number of days with an artificial airway proved to be a significant variable for the development of these complications, with a median of 84.5 days [IQR, interquartile range of 49-135.5] .[10, 38]

Mathur et al observed that age and number of days with TQT were associated with the presence of structural complications and the difficulty to achieve decannulation; but they didn't find any significant correlation between the failure of the procedure and the findings of the fibrobronchoscopy; thus, they came to the conclusion that this tool must be used as part of the decannulation and not as a determining factor of the process.[39] On the contrary, Enrichi et al consider the endoscopic evaluation of the airway as a determinant of the successful removal of the tracheostomy cannula.[40]

To conclude, we must highlight the fact that, whereas tolerance to the occlusion of the tracheostomy cannula not only depends on the permeability of the airway, several authors thought of it as a variable of success in the process of decannulation. Enrichi et al found that the combination of an adequate permeability of the airway evaluated through an endoscopy, and a positive result in

the blockage testing of the tracheostomy cannula resulted in a sensitivity of 94.1% and a specificity of 94.7% for decannulation. We have to mention that separate studies of these variables showed lower percentages of sensitivity and specificity.[40]

Therefore, the fibrobronchoscopy and the evaluation of the TQT cannula occlusion would be the most useful tools to get close to decannulation success. The most prejudicial lesion is stenosis, which occludes more than 50% of the tracheal tube, preventing decannulation and probably requiring a surgical resolution, laser therapy or an endoscopic procedure.

Alteration in swallowing and management of secretion pooling

Some authors consider that swallowing solid, semisolid or liquid food is not determinant of decannulation,[32, 34] whereas other researchers think it is necessary to formally and thoroughly study this function for the purpose of achieving a successful artificial airway removal.[12]

At present, the use of the *Blue Dye Test* as a predictor of decannulation success is being questioned because, despite the fact that it is highly sensitive, it has low specificity; thus, it may show false negative results.[41] However, Enrichi et al conducted a study on patients with acquired brain injury in a post-acute center where they analyzed different variables used in an experimental decannulation protocol and came to the conclusion that the *Blue Dye Test* together with other factors, such as occlusion of the TQT cannula, endoscopic evaluation of airway permeability, and the instrumental swallowing assessment should be used as a decannulation prediction tool. When considered individually, the variables showed high levels of reliability, but when they were all combined, increased sensitivity (100%) and specificity (82%) were found the moment decannulation was achieved.[40]

Fernández Carmona et al, in a study of 2012 describe multiple conditions produced by the use of this device and focus on oropharyngeal dysphagia in patients with TQT. They develop an algorithm that has to be followed for the difficult treatment of this condition and recommend the use of video fluoroscopy, fibroscopy and isotopic transit as a tool for the study of patients with suspected dysphagia. In patients without this suspicion, the approach includes methylene blue staining (clearing its low specificity) and multiple coadjuvant strategies for

the evaluation of this situation in order to remove the patient's ventilatory support.[42]

Tracheostomized patients diagnosed with COPD have a complex approach, because, apart from having an artificial airway, there is asynchrony between ventilation and swallowing. This asynchrony is inherent to the disease and gets worse with the exacerbation of the underlying disease.[43-45] Microaspirations, together with the presence of gastroesophageal reflux between 17%-78%, with risk of aspiring gastric content, cause these patients to have greater difficulty in weaning from mechanical ventilation and a low decannulation rate,[6, 7] resulting in prolonged use of the tracheostomy and higher risk of suffering exacerbations that increase mortality.[46]

In view of the above, the swallowing tests would be useful tools for any situation in which, for some reason (patient's disease on admission to the ICU, history, prolonged treatment of invasive mechanical ventilation), there is any suspicion of saliva bronchoaspiration. We should also explain that oral feeding isn't an essential requirement for decannulation, since there are other routes through which food can be supplied that allow for the removal of the ventilatory support.

Duration of mechanical ventilation

The study of Sansone et al, with an analyzed sample of 437 patients, showed that the duration of mechanical ventilation didn't have a significant effect on successful weaning and long-term survival, but would probably have a dangerous and counterproductive effect in relation to the decannulation rate, because it increases the hospital length of stay.[47] In the same way, several authors were able to show that the PMV intervenes in the failed removal of the tracheostomy cannula through different factors. These studies were conducted in heterogeneous populations, strengthening this concept.[19, 21, 26]

The complications related to PMV entail indirect negative effects on decannulation. Heidler et al suggest that the absence of physiological airflow through the upper airway causes sensory damage due to lack of stimulation of the chemoreceptors and pressure in the laryngeal mucosa which, together with the tracheal tube cuff pressure for prolonged periods of time caused by the difficulty in weaning from IMVS, extend the duration of the artificial airway and complicate decannulation.[8]

According to what has been mentioned, the use of IMVS for prolonged periods of time complicates decannulation but not long-term survival. We can analyze the possibility that maybe the cause of decannulation failure isn't the PMV itself, but the critical state or the patient's comorbidities that prevent the weaning process.

Effective cough and muscle strength

Back in 1996, Bach showed that in patients with respiratory failure produced by different causes and etiologies, the peak cough flow (PCF) was one of the most important predictive factors (together with vital capacity) for decannulation, which obtained a reference value that had to exceed 160 L/min.[48]

Fluctuating levels of consciousness shouldn't be conditioning factors of decannulation,[30] however, a study carried out in Hong Kong analyzed if the induced peak cough flow (iPCF) in neurosurgical patients with alteration of consciousness was a predictor of decannulation success. The results of the study showed that 66% of a total of 32 patients were successfully decannulated, 2% required recannulation, and 28% couldn't be decannulated according to the study's criteria. Also, the multivariate analysis showed that, a value $\geq$ 29 L/min of iPCF is independently associated with decannulation success.[49]

On the other hand, in order to confirm cough effectiveness, Ceriana et al used the maximum expiratory pressure (MEP) with a cut-off point of 40 cmH_2O and obtained 80% success in decannulation.[34]. Then, Hernández et al observed that, for a patient to be decannulated, he/she shouldn't exceed two secretion aspirations, with an interval of 8 h between each, and also the quality of those aspirations had to be considered .[21].

The surveys conducted by Stelfox among health professionals addressed this problem, where cough effectiveness and secretion management, together with other variables (patient's state of consciousness and tolerance to occlusion) were the most important factors for patient decannulation.[31, 32]

There is an extensive bibliography of published writing supporting the fact that cough strength and good secretion management are predictors of decannulation success[19, 26, 36, 50, 51] However, Enrichi et al found that, in tracheostomized patients with acute brain injury, both voluntary and reflex cough are important variables to be evaluated, but they are not determinant of decannulation. In this work, the cough evaluation showed high sensitivity (85%) but low specificity (31.5%) with a low positive predictive value.[40]

With regard to the aforementioned, Choate et al found that retention of secretions and the impossibility to remove them were the main complications involved in decannulation failure. As a result of that study, 4.8% (39 of 823 patients) had decannulation failure, 60% of which failed due to poor secretion management.[35]

Regarding the evaluation of muscle strength and cough, probably the MEP and peak cough flow are the main variables to consider when decannulating a patient. They are consistent with good secretion management; thus, we could think that with numbers exceeding the lower limit described by the bibliography we would more effectively get closer to decannulation.

CONCLUSION

Tolerance to the occlusion of the TQT cannula for more than 24 h and a peak cough flow $\geq$ 160 L/min are the most determining variables of decannulation success. Alterations in swallowing, in the state of consciousness and anatomical alterations of the airway are still controversial when evaluating the decannulation process. On the other hand, advanced age, male sex and tracheal stenosis with a tube reduction of more than 50% are the most common risk factors associated with decannulation failure.

When predictor variables of success or failure in the process of decannulation with the most scientific evidence are those that can be observed when evaluating the patient, it would possibly be easier to recognize if that procedure can be used or not, and if it can't be used, to acknowledge the cause that prevents it.

Most analyzed studies are conducted in relatively short follow-up period. Long-term follow-up would allow us to know even better the impact of decannulation in patients.

It is very important to know new variables that could predict success or failure in decannulation.

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