

Unplanned extubations in Intensive Care Unit: evidences for risk factors. A literature review

Chiara Cosentino¹, Mattia Fama², Chiara Foà¹, Giorgia Bromuri³, Serena Giannini⁴, Marco Saraceno⁵, Angela Spagnoletta⁶, Mbemo Tenkue⁷, Elena Trevisi⁸, Leopoldo Sarli¹

¹Department of Medicine and Surgery, University of Parma, Italy; ²Neonatology and Neonatal Intensive Care Unit, Filippo del Ponte Hospital, Varese, Italy; ³High Intensity Care, Cardiothoracic Vascular Unit, Polyclinic S.Orsola Malpighi, Bologna, Italy; ⁴Emergency Room, Infermi Hospital, Rimini, Italy; ⁵General Medicine Unit, Ponte San Pietro Clinic, Bergamo, Italy; ⁶Cardiology & Cardiological Intensive Care Unit, Local Health and Social Care Centre Pavia, Pavia, Italy; ⁷Freelance Nurse, France; ⁸Cardiology & Cardiological Intensive Care Unit, Local Health and Social Care Centre Piacenza, Piacenza, Italy

Abstract. *Background and aim:* Unplanned extubations (UE) are getting more and more relevant in Critical Care, becoming a quality and care safeness outcome. This happens because after an UE the patient can face some complications concerning the airway management, respiratory and hemodynamic problems, lengthen in the hospital stay and in the mechanical ventilation time. The aim of this review is identify and classify the factors that could increase UE risk. *Methodology:* A systematic review of scientific articles was performed consulting the databases PubMed, Cinahl, Medline, EBSCOhost and Google Scholar. Articles from 2006 to 2011 were included. Pediatric Care settings were excluded. *Results:* 21 articles were selected. From the results emerged that risk factors associated to the patient are widely controversial. Yet restlessness, a low level of sedation and a high level of consciousness seem to be highly related to UE. Organizational risk factors, as workload, nurse:patient ratio, and the use of interdisciplinary protocols seem to play an important role in UE. *Conclusion:* According the current literature, the research on UE still has to handle a wide uncertainty. There is the need for more studies developing conclusive evidences on the role of different risk factors. Anyway, literature highlights the importance of the nurse and of the healthcare system organization in reducing UE incidence.

Key words: unplanned extubation, risk factors, nurse, Intensive Care Unit, night shift

Introduction

Unplanned extubation (UE) is one of the major complications which may occur to patients experiencing invasive mechanical ventilation in Intensive Care Units (ICU; 1).

This phenomenon includes Accidental Extubation (AE), caused involuntarily by health professionals during their bedside activities (2, 3) and Self-Extubation (SE): the deliberate removal of the endotracheal tube by the patient himself (3-5).

The incidence of the UE did not change over the years with a range from 3% to 16% in intubated

patients before 2000 (2, 6) and a range from 2% in 2011 (7) and 4.2%-10% in a study of 2012 (8). Among these, the SEs seem to happen more frequently (9, 10).

The impact of the UE is expressed as the number of UE for 100 ventilated patients or as the number of UE for 100 days of mechanical ventilation (8). The latter measure allows to compare different studies because it provides a time standardization: in fact, the different intubation duration between patients is difficult to compare (9). Although it is a relatively rare event - the UE has an occurrence rate of 0.1-3.6 events for 100 days of intubation (8) - the UE may be accompanied by serious complications and adverse outcomes

as laryngeal trauma of the vocal cords, difficult intubation, hypoxemia, esophageal intubation, sustained respiratory distress, multiple tries to laryngoscopy, difficult laryngoscopy, respiratory insufficiency, respiratory arrest, immediate vomiting with possible suction, ventricular tachycardia, hypotension, hypertension, arrhythmia (8) and laryngeal edema (9). The rate of hospital mortality of patients experiencing UE can vary from 10% to 25% and is even higher for patients who need reintubation (7). In addition, UE can cause increased mortality when there: an increase of the respiratory frequency before UE, uremia, liver cirrhosis, and before the weaning beginning (11). Re intubations vary between 1.8% and 88% of the cases of UE (8) and most of the times follow AE more than SE (8).

In addition to increasing healthcare expenditure, the UE increase the time of mechanical ventilation by lengthening the mean time of stay in ICU and then the total hospitalisation (8, 12).

Over the years several strategies have been proposed to reduce the risk of UE as the introduction in ICUs of the ABCDE Bundle (Awakening and Breathing Coordination, Delirium Monitoring and Management, and Early Mobility). This approach aims to an early rehabilitation of the patient through interventions such as the daily interruption of sedation, the reduction of all avoidable delays in weaning, the delirium prevention, and the person's early mobilization (3). Although on the one hand, this protocol seems not to add the further risk of UE, on the other hand, there is not even a reduction in the rate of UE.

In critical conditions in adults, most of the UE can be avoidable, provided a proper identification of risk factors and the use of effective prevention strategies (9).

Consequently, there is a need to take a step back, trying to identify with greater clarity in the literature the factors - patient-related, clinical condition related, and healthcare system related -, can pose the patient at higher risk.

Aim

The aim of this systematic literature review is to identify and classify the factors that, according to na-

tional and international literature, could increase UE risk.

Methodology

This literature review was conducted in Italy in 2016-2017 through a systematic and critical analysis of scientific articles.

The analysed articles came from online databases including PubMed, Cinahl, Medline, EBSCOhost platform and search engines such as Google Scholar.

Inclusion criteria for the articles were: Italian and English language, published between 2006 and 2017, full-text availability. Articles concerning UE in pediatric patients were excluded. The key words that were used are set forth in Table 1

After a first analysis, we selected articles considered relevant on the basis of the publication date, type of patients, interventions, measured outcomes, and results.

In total 21 articles were therefore included in the review.

Results

Based on the available literature, we identified several risk factors linked to patients, operators, the therapeutic choices and the healthcare system logistics.

We lastly selected 21 studies: 6 reviews, 6 case-control studies, 1 prospective cohort study, 7 observational studies and 1 experimental study.

The risk factors were selected and divided into intrinsic factors associated with the patient, level of consciousness and level of sedation, use of benzodiazepines, weaning from ventilation, endotracheal tube fixation, physical restraint, ICU staff.

Each risk factor and the studies considering it as influent or not are reported in Table 2.

Intrinsic risk factors associated with the patient

Patients' age and sex are always taken into consideration when assessing UE risk in the literature. However, their influence is still unclear and doubtful.

Table 1. Search strings and keywords

Search number	Found articles	Selected Articles	Keywords	Limits	Database
1	46	6	Extubation	2011-2016 Humans Full text	PubMed
2	162	7	Unplanned Extubation	2006-2016 Humans Full text	PubMed
3	70	3	Estubazioni non pianificate	2006 -2016	Google Scholar
4	110	2	Estubazione e Percezione rischio e infermieri	2011-2016	Google Scholar
5	416	2	Unplanned Extubation (AND) Nurse Characteristic (AND) Year of Experience	2010-2016	Google Scholar
6	882	2	Ramsey Sedation Scale (AND) Unplanned Extubation	2006-2016	Google Scholar
7	134	2	Airways Extubation (AND) Intensive Care Unit	2006-2016	PubMed
8	10	5	Night shift (AND) Nurse (AND) Care in night (AND) risk	Newborn	Cinahl, PubMed, Medline
9	356	1	Airway Extubation(AND) Adverse effects	Full text 2011-2016	Pubmed e CINAHL
10	264	8	Unplanned extubation (AND) risk factors	Full text 2006-2010	Pubmed e CINAHL
11	36	2	Uplanned extubation (AND) adverse effects	Full text 2006-2010	Pubmed e CINAHL
12	67	3	Endotracheal tube AND discomfort	Pediatric Intensive Care Unit	PUBMED, MedLine, CINAHL
13	1830	2	ICU patient, safety, critical care, nursing staff, unplanned extubation	2006-2016	Google Scholar
14	7	1	Sedation in intensive care unit AND clinical risk management AND self-extubation in intensive care unit	Newborn	PUBMED, CINAHL, MedLine
15	4	1	Duty shifts (AND) intensive care unit staff	Newborn	PUBMED, CINAHL

Only one study (13) found a higher incidence of UE in patients aged between 46 and 75. Literature does not highlight differences of incidence related to contexts (intensive care unit versus surgery), and there are many contradictions on the influence of sex, the Body Mass Index (BMI) and the age over 65 years (3).

Latest reviews (3, 8, 14), did not consider sex as a risk factor. However, case-control and retrospective

studies identified the male sex as a risk factor for the UE (7, 9, 15). The BMI, instead, does not seem to be a relevant risk factor except for one single study (7).

Also, the presence of nosocomial infections is identified in the literature as a risk factor (9, 13, 14, 16). Also, the presence of chronic obstructive pulmonary disease (COPD) is considered a relevant risk factor for the UE in three studies (8, 10, 17).

Table 2. Summary of risk factors and articles

Risk factors found in literature	Risk factor	Not a risk factor or not considered
Age	2 articles: (Chuang et al., 2015), (McNett et al., 2015).	19 articles: (da Silva & Fonseca 2012), (Bambi et al., 2015), (Kiekkas et al., 2012), (Chao et al., 2017), (Chien-Ming et al., 2017), (EunOk et al., 2017), (Lee et al., 2015), (de Groot et al., 2011), (Chang et al., 2008), (Chang et al., 2011), (Jarachovic et al., 2011), (Boulain et al., 1998), (Curry et al 2008), (kavitha et al., 2014), (Moons et al., 2008), (Singh et al., 2013), (Tanions et al., 2010), (Tanions et al., 2014), (Buckley et al 2016).
Sex (male)	5 articles: (da Silva & Fonseca 2012), (de Groot et al., 2011), (kavitha et al., 2014), (McNett et al., 2015), (Chien-Ming et al., 2017).	16 articles: (Bambi et al., 2015), (Kiekkas et al., 2012), (Chao et al., 2017), (EunOk et al., 2017), (Lee et al., 2015), (Chang et al., 2008), (Chang et al., 2011), (Chuang et al., 2015), (Jarachovic et al., 2011), (Boulain et al., 1998), (Curry et al 2008), (Moons et al., 2008), (Singh et al., 2013), (Tanions et al., 2010), (Tanions et al., 2014), (Buckley et al 2016).
BMI	1 articolo: (McNett et al., 2015).	20 articles: (da Silva & Fonseca 2012), (Bambi et al., 2015), (Kiekkas et al., 2012), (Chao et al., 2017), (Chien-Ming et al., 2017), (EunOk et al., 2017), (Lee et al., 2015), (de Groot et al., 2011), (Chang et al., 2008), (Chang et al., 2011), (Chuang et al., 2015), (Jarachovic et al., 2011), (Boulain et al., 1998), (Curry et al 2008), (kavitha et al., 2014), (Moons et al., 2008), (Singh et al., 2013), (Tanions et al., 2010), (Tanions et al., 2014) (Buckley et al 2016).
Nosocomial infections	2 articles: (Chuang et al., 2015), (McNett et al., 2015).	19 articles: (da Silva & Fonseca 2012), (Bambi et al., 2015), (Kiekkas et al., 2012), (Chao et al., 2017), (Chien-Ming et al., 2017), (EunOk et al., 2017), (Lee et al., 2015), (de Groot et al., 2011), (Chang et al., 2008), (Chang et al., 2011), (Jarachovic et al., 2011), (Boulain et al., 1998), (Curry et al 2008), (kavitha et al., 2014), (Moons et al., 2008), (Singh et al., 2013), (Tanions et al., 2010), (Tanions et al., 2014) (Buckley et al 2016).
COPD	3 articles: (da Silva & Fonseca 2012), (kavitha et al., 2014), (McNett et al., 2015).	18 articles: (Bambi et al., 2015), (Kiekkas et al., 2012), (Chao et al., 2017), (Chien-Ming et al., 2017), (EunOk et al., 2017), (Lee et al., 2015), (de Groot et al., 2011), (Chang et al., 2008), (Chang et al., 2011), (Chuang et al., 2015), (Jarachovic et al., 2011), (Boulain et al., 1998), (Curry et al 2008), (Moons et al., 2008), (Singh et al., 2013), (Tanions et al., 2010), (Tanions et al., 2014) (Buckley et al 2016).
Orotracheal intubation	4 articles: (Bambi et al., 2015), (Boulain et al., 1998), (kavitha et al., 2014), (McNett et al., 2015).	(da Silva & Fonseca 2012), (Kiekkas et al., 2012), (Chao et al., 2017), (Chien-Ming et al., 2017), (EunOk et al., 2017), (Lee et al., 2015), (de Groot et al., 2011), (Chang et al., 2008), (Chang et al., 2011), (Chuang et al., 2015), (Jarachovic et al., 2011), (Curry et al 2008), (Moons et al., 2008), (Singh et al., 2013), (Tanions et al., 2010), (Tanions et al., 2014) (Buckley et al 2016).

(continued)

Table 2 continued. Summary of risk factors and articles

Risk factors found in literature	Risk factor	Not a risk factor or not considered
Lower level of sedation/restlessness	21 articles: (da Silva & Fonseca 2012), (Bambi et al., 2015), (Kiekkas et al., 2012), (McNett et al., 2015), (Chao et al., 2017), (Chien-Ming et al., 2017), (EunOk et al., 2017), (Lee et al., 2015), (de Groot et al., 2011), (Chang et al., 2008), (Chang et al., 2011), (Chuang et al., 2015), (Jarachovic et al., 2011), (Boulain et al., 1998), (Curry et al 2008), (kavitha et al., 2014), (Moons et al., 2008), (Singh et al., 2013), (Tanions et al., 2010), (Tanions et al., 2014) (Buckley et al 2016).	0 articles
Weaning from ventilation	6 articles: (da Silva & Fonseca 2012), (Jarachovic et al., 2011), (McNett et al., 2015), (EunOk et al., 2017), (Chao et al., 2017), (Lee et al., 2015).	15 articles: (Bambi et al., 2015), (Kiekkas et al., 2012), (Chien-Ming et al., 2017), (de Groot et al., 2011), (Chang et al., 2008), (Chang et al., 2011), (Chuang et al., 2015), (Boulain et al., 1998), (Curry et al 2008), (kavitha et al., 2014), (Moons et al., 2008), (Singh et al., 2013), (Tanions et al., 2010), (Tanions et al., 2014) (Buckley et al 2016).
Midazolam use	3 articles: (Bambi et al., 2015), (de Groot et al., 2011), (McNett et al., 2015).	18 articles: (da Silva & Fonseca 2012), (Kiekkas et al., 2012), (Chao et al., 2017), (Chien-Ming et al., 2017), (EunOk et al., 2017), (Lee et al., 2015), (Chang et al., 2008), (Chang et al., 2011), (Chuang et al., 2015), (Jarachovic et al., 2011), (Boulain et al., 1998), (Curry et al 2008), (kavitha et al., 2014), (Moons et al., 2008), (Singh et al., 2013), (Tanions et al., 2010), (Tanions et al., 2014) (Buckley et al 2016).
Nurse:patient ratio >1:3	4 articles: (Boulain et al., 1998), (kavitha et al., 2014), (Kiekkas et al., 2012), (Tanions et al., 2010).	17 articles: (da Silva & Fonseca 2012), (Bambi et al., 2015), (McNett et al., 2015), (Chao et al., 2017), (Chien-Ming et al., 2017), (EunOk et al., 2017), (Lee et al., 2015), (de Groot et al., 2011), (Chang et al., 2008), (Chang et al., 2011), (Chuang et al., 2015), (Jarachovic et al., 2011), (Curry et al 2008), (Moons et al., 2008), (Singh et al., 2013), (Tanions et al., 2014) (Buckley et al 2016).
Nurses care	2 articles: (kavitha et al., 2014), (Tanions et al., 2014).	19 articles: (da Silva & Fonseca 2012), (Bambi et al., 2015), (Kiekkas et al., 2012), (McNett et al., 2015), (Chao et al., 2017), (Chien-Ming et al., 2017), (EunOk et al., 2017), (Lee et al., 2015), (de Groot et al., 2011), (Chang et al., 2008), (Chang et al., 2011), (Chuang et al., 2015), (Jarachovic et al., 2011), (Boulain et al., 1998), (Curry et al 2008), (Moons et al., 2008), (Singh et al., 2013), (Tanions et al., 2010), (Buckley et al 2016).
Nurses' experience <5 years	5 articles: (Bambi et al., 2015), (Chang et al., 2011), (kavitha et al., 2014), (Kiekkas et al., 2012), (EunOk et al., 2017).	16 articles: (da Silva & Fonseca 2012), (McNett et al., 2015), (Chao et al., 2017), (Chien-Ming et al., 2017), (Lee et al., 2015), (de Groot et al., 2011), (Chang et al., 2008), (Chuang et al., 2015), (Jarachovic et al., 2011), (Boulain et al., 1998), (Curry et al 2008), (Moons et al., 2008), (Singh et al., 2013), (Tanions et al., 2010), (Tanions et al., 2014), (Buckley et al 2016).

(continued)

Table 2 continued. Summary of risk factors and articles

Risk factors found in literature	Risk factor	Not a risk factor or not considered
Night shift	6 articles: (Bambi et al., 2015), (Chang et al., 2011), (kavitha et al., 2014), (McNett et al., 2015), (Tanions et al., 2014), (EunOk et al., 2017).	15 articles: (da Silva & Fonseca 2012), (Kiekkas et al., 2012), (Chao et al., 2017), (Chien-Ming et al., 2017), (Lee et al., 2015), (de Groot et al., 2011), (Chang et al., 2008), (Chuang et al., 2015), (Jarachovic et al., 2011), (Boulain et al., 1998), (Curry et al 2008), (Moons et al., 2008), (Singh et al., 2013), (Tanions et al., 2010), (Buckley et al 2016).
Endotracheal tube fixation	9 articles: (Bambi et al., 2015), (Boulain et al., 1998), (Jarachovic et al., 2011), (Kiekkas et al., 2012), (McNett et al., 2015), (Tanions et al., 2010), (Buckley et al 2016), (Chao et al., 2017), (Lee et al., 2015).	12 articles: (da Silva & Fonseca 2012), (Chien-Ming et al., 2017), (EunOk et al., 2017), (de Groot et al., 2011), (Chang et al., 2008), (Chang et al., 2011), (Chuang et al., 2015), (Curry et al 2008), (kavitha et al., 2014), (Moons et al., 2008), (Singh et al., 2013), (Tanions et al., 2014).
Physical restraints	9 articles: (Bambi et al., 2015), (Chang et al., 2011), (Chuang et al., 2015), (Curry et al 2008), (da Silva & Fonseca 2012), (Jarachovic et al., 2011), (kavitha et al., 2014), (McNett et al., 2015), (Chao et al., 2017).	12 articles: (Kiekkas et al., 2012), (Chien-Ming et al., 2017), (EunOk et al., 2017), (de Groot et al., 2011), (Lee et al., 2015), (Chang et al., 2008), (Boulain et al., 1998), (Moons et al., 2008), (Singh et al., 2013), (Tanions et al., 2010), (Tanions et al., 2014) (Buckley et al 2016).
APACHE II score ≥ 17	7 articles: (Bambi et al., 2015), (Chang et al., 2011), (Chuang et al., 2015), (da Silva & Fonseca 2012), (McNett et al., 2015), (EunOk et al., 2017), (Chien-Ming et al., 2017).	14 articles: (Kiekkas et al., 2012), (Chao et al., 2017), (Lee et al., 2015), (de Groot et al., 2011), (Chang et al., 2008), (Jarachovic et al., 2011), (Boulain et al., 1998), (Curry et al 2008), (Kavitha et al., 2014), (Moons et al., 2008), (Singh et al., 2013), (Tanions et al., 2010), (Tanions et al., 2014), (Buckley et al 2016).

Level of consciousness and level of sedation

The increased level of consciousness is an evident risk factor for the UE. All of the 21 studies considered in this review agreed on its influence on the risk of UE. In particular, these studies considered as central: the presence of restlessness, increased consciousness and/or insufficient sedation (8).

A case-control study (16) has detected that the incidence rate of the UE is associated with a Glasgow Coma Scale (GCS) score greater than or equal to 9. The GCS scale is widely used in ICUs and has been developed to facilitate the assessment and classification of the severity of the brain dysfunction. It is widely used as a prognostic indicator for patients with a state of altered consciousness that have undergone traumatic events. It assesses eye opening, verbal responses, and motor skills. Traditionally, the result of

the GCS is classified as mild (14-15), moderate (9-13) or serious (3-8) impairment (18).

Another study (15) showed that SE episodes occur when the patient has a low level of sedation and therefore a low score of Ramsey Sedation Scale (RSS), an instrument used to properly evaluate the level of consciousness during sedation in ICU (19). The RSS evaluates the response to sedation, the presence of motor activity and the presence of restlessness. The RSS identifies 6 levels of sedation: the minimal sedation falls in levels 1 and 2, while the moderate sedation and profound fall in levels greater than or equal to 3.

Still, in this study (15), authors found that UE occurred when the level of sedation was lower, with an RSS score equal to 2.42 and that patients who were later re-intubated had an RSS score equal to 2.85.

A 2014 retrospective study (20), compared patients who were sedated through three different meth-

ods. In the first method was not used any sedation, but only analgesics and opioids for pain management using morphine or fentanyl according to necessity. The second method used is intermittent boluses of sedatives (midazolam) and opioid analgesics (fentanyl). The third method included a continue sedation with a daily interruption of sedation (DIS). Authors found that method one and two were both associated with a higher rate of UE compared to method three. Therefore, an increased UE risk seems to be inversely proportional to an increase in the level of consciousness.

Use of benzodiazepines

The use of benzodiazepines seems to be significantly related to UE. A review (8) confirms a greater UE incidence in patients taking benzodiazepines (midazolam, lorazepam or diazepam) compared with control patients who did not take benzodiazepines.

A case-control study showed that the use of methadone, haloperidol, and midazolam increases UE risk because of the paradoxical reaction they may lead to (7). The paradoxical effect of midazolam and the suggestion to avoid the use of benzodiazepines to prevent UE is also confirmed in a second literature review (3).

Weaning from ventilation

Many studies confirm that UE occurs more often during the weaning from the mechanical ventilation (3, 8, 9, 13). One case-control study (21) showed that UE events occur in groups of patients under spontaneous ventilation, both with pressure support ventilation (PSV) and continuous positive airway pressure (CPAP). Another study (13) showed how the implementation of weaning protocols reduces the days of mechanical ventilation, the risk of pneumonia infection, the incidence of UE, and the interventions of re-intubation. According to this study, the use of weaning protocols has a high impact on healthcare outcomes and quality, decreasing costs and reducing UE incidence. Moreover, in this study, an increase of UE occurred in patients who were undergoing weaning protocols.

Current literature indicates as useful tools for an effective ventilation weaning programs for the routine screening of patients through attempts to spontaneous respiration (5). The Noninvasive Ventilation (NIV) also seems to prevent up to 91% of reintubation and to reduce up to one third the reintubation risk (22).

Moreover, there are good recommendations that the daily suspension of sedation allows to check as early as possible the presence of the weaning criteria and reduce the negative effects of the sedatives (23). This allows a greater use of short acting medications and lighter sedation with a particular recommendation for the propofol and dexmedetomidine (24).

Endotracheal tube fixation

The lack of a strong endotracheal tube fixation (for example with a single thin tape) was significantly associated with a greater incidence of UE (2, 3; 9, 10, 13; 20, 25-28).

The endotracheal tube fixation can be carried out using different materials such as tapes or plasters, through different methods of tape fixation, or by using the tube's support devices of the tube. The scientific literature has not confirmed the superiority of one specific method and there are still disputes on the fixing material that could prevent the tube's movements or the accidental extubation. In one study (29) emerged that the combination of adhesive tape around the tube together with a suture through the tape was more resistant to accidental removal.

Over the past 50 years, many studies tried to demonstrate the superiority of one method compared to the others. However, it is still an open question what type of fixation method is more effective in reducing UE incidence (30).

A recent study (26) demonstrated how the use of Haider Tube-Guard® compared to the adhesive tape reduces the displacements of the endotracheal tube by decreasing the risk of AE. While the adhesive tape sticks to the surface of the face, the anchorages of the tube of Haider Tube-Guard are fixed to the maxilla and jaw thus reducing the movements of the endotracheal tube. However, further studies should be carried out to demonstrate its reliability in a vari-

ety of clinical settings to ensure maximum safety of the patient.

Physical restraints

Two studies (3, 15) showed that the use of physical restraints is associated with a higher UE incidence. One case-control study (16) considered this factor associated with increased risk 3.11 times for UE. In a survey among ICU European nurses, the most frequent motivations for the use of physical restraints were: patients ripping tubes or venous lines, SE prevention and bed fall prevention. However, the SE seemed to occur despite the use of sedation and restraint. The percentage of UE occurring in patients with physical restraints varies considerably, from 25.6% to 80% (16).

However, in a multidisciplinary survey conducted in ICU setting in 2010 (31) to determine the beliefs of clinical experts in the perception of the UE risk, 72% of respondents (physicians, respiratory therapists, ICU nurses) considered the absence of physical restraint a relevant UE risk factor.

ICU Staff

Nursing care is an important factor that contributes to the patient's UE risk. One of the most relevant UE risk factor seems to be the nurse's absence at the bedside and then by a reduced surveillance of the patient during the UE episode (17). A prospective cohort study showed (32) that in 59% of UE cases, patients were without caregivers at the bedside.

Another important aspect is represented by the nurse's experience because, as emerges from the literature, nurses less experienced are more likely to incur patients' SE. According to one study (15), a nursing staff with less than 5 years of ICU experience may increase the UE risk. This study seems to be in line with the results of another study (17) underlining that patients under the care of a nurse with more than 4 years of ICU experience have UE incidence 2.6% lower.

Also, the nurse/patient ratio is a factor increasing UE risk. A multidisciplinary survey (31) showed that health operators consider a nurse:patient ratio greater

than or equal to 1:3 as a UE risk factor. This perception is also confirmed by the observational data collected in other studies (3).

Moreover, UE episodes seem to occur with a certain rhythm activity during the morning shift, (9) within one hour before and one hour after the shift changes (17) and during the night shift (32). As for the morning shift, a possible cause could be the increase in the nursing care activities during the early morning hours (9). As for the shift changes, a retrospective observational study highlighted how almost 50% of UE occur during nurses' shift changes between 7:00 and 8:30 a.m. and p.m., when patients are less monitored. Lastly, as for the night shift, a 12-month prospective cohort study in a tertiary-care medical ICU (32) showed that the 6% of cases occurred during the night shift, as confirmed by another case-control study (33).

Other studies, connect an increased incidence of UE to an erroneous extubation time planning of the referring doctor. Usually, the doctors are reluctant to perform the extubation after an effective weaning in absence of subjective criteria such as an increase of the state of consciousness, excessive secretions, and a decrease of the respiratory muscular strength. This study highlighted the importance of recognizing the precise criteria that could support the extubation after weaning in ICUs (28). Lastly, a recent study (27) found a reduction in UE rate from 6,82/100 ventilated patients in 2001 to 0.95/100 ventilated patients in 2015 as a result of the use of multidisciplinary and continuous training programs, thus placing the training of health personnel among the factors of UE risk/protection.

Discussions

Risk factors for UE are a widely debated topic in the current scientific literature.

Patients' age and sex are risk factors taken into consideration in all the studies which have dealt with this topic, but it is still difficult to achieve a unanimous recommendation among the opinions expressed by different authors. However, the age of the patient is the second component for the score attribution in the scale Acute Physiology and Chronic Health Evalua-

tion (APACHE II), an instrument frequently used for UE risk assessment in ICUs (34). In this scale one to six points are attributed to patients aged over 44 years, highlighting how, in clinical practice, age is considered as a variable that can directly influence UE risk.

Also, the role of nosocomial infections and chronic obstructive pulmonary disease (COPD) in increasing UE risk cannot be fully based on current literature: the interpretation of these data is compromised by the small number of patients and by the differences in the level of sedation between the groups. In two studies patients with COPD were prone to UE because they had often received prolonged mechanical ventilation with partial ventilation without sedation because of their longer weaning (8, 10).

Therefore COPD, as well as other nosocomial infections, may increase the risk of UE seeing that they are correlated with an increase in the days of intubation and a reduction or absence of sedation.

There is an unanimous consensus that the level of sedation is a risk factor for UE. It is, in fact, procedurally monitored with the use of specific scales as the GCS and RSS, whose critical scores are considered real cut off for the attribution of a patient's UE risk level. However, the UE risk linked to the level of sedation must necessarily be adjusted on the basis of other factors that might operate in cooperation with it as the pharmacological treatment, the type of endotracheal tube fixation and the ICU setting.

The use of benzodiazepines, in fact, as shown in a few studies, seems to increase the UE risk with a paradoxical effect, as well as the use of physical restrictions. The latter theme is much discussed and controversial. This is partially due to the investigation methodologies since there are only observational studies so far that may not directly indicate whether the physical restriction determined the UE or whether physical restrictions were applied to patients at risk for UE. However, current literature strongly suggests the need for establishing better criteria for the use of physical restriction (16). The absence or the use of physical restriction should be an informed choice and not applicable to all intubated patients, since the restlessness - especially when combined with inadequate sedation - and the decreased monitoring of the patient are two of the main risk factors for the UE.

Also, the endotracheal tube fixation is identified as a risk factor, and deserves, together with the weaning protocols, more investigations in order to identify which procedure may have a preventive effect, hence lower the risk of UE.

Finally, an important role in UE risk is represented by the ICU logistics.

The load of patients for a single nurse, shift arrangement, training, and interdisciplinary interaction, directly affect UE risk. It is well documented how heavier working hours and shifts (35) besides adversely affect the professional's life and wellbeing, together with the patient's care outcomes.

Specifically, the increase of the UE risk during the night shift may be mediated by the increased risk of patient's delirium caused by the lack of visible light and of the caregiver's absence, in combination with the reduction of the nursing staff. Longer work duration can increase the risk of errors and near errors and decrease nurses' vigilance (36)

Conclusions

The UE can be defined as a phenomenon caused by multifactorial risks. An increase of the nursing staff could be significantly associated with a reduced UE risk, promoting the improvement of nurses' monitoring and care for the patient. The adoption in nursing practice of greater monitoring of the patient, especially during shift changes, could contribute to significantly reduce the UE incidence. An effective strategy could be, for example, the overlap of different professionals (nurses and doctors). It is also evident that the optimal nurse: patient ratio which would lead to decrease the incidence of UEs would be one-to-one. However, in most circumstances, this ratio is impossible to obtain. Hence, it is crucial to identifying patients who are most at risk for UE and provide them more supervision.

There are many risk factors that the literature suggests and examines and often these are considered ambivalent and contradictory in their effects. This puts the professionals who would like to use an evidence-based practice to rely on the case when it comes to the UE risk estimation. The current state of the art, therefore, indicates the need for studies which can increase

the clarity on this topic, through an effective evaluation of the professional expertise. Retrospective and prospective studies should be implemented in order to progressively strength evidence and concordance on the factors that increase the UE risk. Hopefully, this would inform nursing practice, providing guidelines on the identification of high UE risk patients. Hence, it will allow the professionals who have to work in a setting far from optimal logistics (nurse ratio patient <1:1, shifts of 12 h) to deliver proper assistance and monitoring, selecting from time to time on the basis of unanimous scientific criteria the patient that requires a greater assistance in that particular moment.

References

- Peñuelas O, Frutos-Vivar F, Esteban A. Unplanned extubation in the ICU: a marker of quality assurance of mechanical ventilation. Spain: *Crit Care* 2011; 15(2): 128.
- Boulain T, Association des Reanimateurs du Centre-Ouest. Unplanned extubations in the adult intensive care unit: a prospective multicenter study. *Am J Respir Crit Care Med* 1998; 157(4): 1131-7.
- Bambi S, Baldassini Rodriguez S, Lumini E, Lucchini A, Rasero L. Estubazioni non pianificate nei pazienti in terapia intensiva: un aggiornamento.[Unplanned Extubations in Intensive Care Unit's patients: an update]. *Assist Inferm Ric* 2015; 34(1): 21-9.
- Beckmann U, Gillies DM. Factors associated with reintubation in intensive care – an analysis of causes and outcomes. *Chest* 2011; 120(2): 538-42.
- Bambi S. Accidental extubation in intensive care units: what implications for nursing care? *Assist Inferm Ric* 2004; 23(1): 36-47.
- Whelan J, Simpson SQ, Levy H. Unplanned extubation. Predictors of successful termination of mechanical ventilatory support. *Chest* 1994; 105(6).
- de Groot R, Dekkers O, Herold I, Jonge E, Arbous M. Risk factors and outcomes after unplanned extubations on the ICU: a case-control study. *Crit Care* 2011; 15(1): 19.
- da Silva PS, Fonseca MC. Unplanned endotracheal extubations in the intensive care unit: systematic review, critical appraisal, and evidence-based recommendations. *Anesth Analg* 2012; 114(5): 1003-14.
- Kiekkas P, Aretha D, Panteli E, Baltopoulos GI, Filos KS. Unplanned extubation in critically ill adults: clinical review. *Nurs Crit Care* 2013; 18(3): 123-34.
- McNett M, Kerber K. Unplanned extubations in the ICU: risk factors and strategies for reducing adverse events. *JCOM* 2015; 22(7): 303-11.
- Chien-Ming Chao, Mei-I. Sung, Kuo-Chen Cheng, Chih-Cheng Lai, Khee-Siang Chan, Ai-Chin Cheng, Shu-Chen Hsing, and Chin-Ming Chen. Prognostic factors and outcomes of unplanned extubation. *Sci Rep* 2017; 7: 8636.
- De Lassence A, Alberti C, Azoulay E, Le Miere E, Cheval C, Vincent F. Impact of unplanned extubation and reintubation after weaning on nosocomial pneumonia risk in the intensive care unit: a prospective multicenter study. *Anesthesiology* 2002; 97: 148-56.
- Jarachovic M, Mason M, Kerber K, McNett M. The role of standardized protocols in unplanned extubations in a medical intensive care unit. *Am J Crit Care* 2011; 20(4): 304-11.
- Chuang ML, Lee CY, Chen YF, Huang SF, Lin IF. Revisiting Unplanned Endotracheal Extubation and Disease Severity in Intensive Care Units. *PLoS One* 2015; 10 (10).
- Curry K, Cobb S, Kutash M, Diggs C. Characteristics associated with unplanned extubations in a surgical intensive care unit. *Am J Crit Care* 2008; 17(1): 45-51.
- Chang LY, Wang KW, Chao YF. Influence of physical restraint on unplanned extubation of adult intensive care patients: a case-control study. *Am J Crit Care* 2008; 17(5): 408-15.
- Kavitha Selvan BS, Hawa Edriss MD, Mark Sigler MD, Jim Tseng BA . Self-extubation in ICU patients. *SWRCCC* 2014; 2(8): 31-34.
- Mena JH, Sanchez AI, Rubiano AM, Peitzman AB, Sperry JL, Gutierrez MI, Puyana JC. Effect of the modified Glasgow Coma Scale score criteria for mild traumatic brain injury on mortality prediction: comparing classic and modified Glasgow Coma Scale score model scores of 13. *J Trauma* 2011; 71(5): 1185-92.
- Sessler C N, Grap MJ, Ramsay MA. Evaluating and monitoring analgesia and sedation in the intensive care unit. *Crit Care* 2008; 12(3): S2.
- Tanios M, Epstein S, Grzeskowiak M, Nguyen HM, Park H, Leo J. Influence of sedation strategies on unplanned extubation in a mixed intensive care unit. *Am J Crit Care* 2014; 23(4): 306-14.
- Kwon E, Choi K. Case-control Study on Risk Factors of Unplanned Extubation Based on Patient Safety Model in Critically Ill Patients with Mechanical Ventilation. *Asian Nurs Res (Korean Soc Nurs Sci)* 2017; 11(1): 74-78.
- Burns KE, Adhikari NK, Keenan SP, Meade MO. Noninvasive positive-pressure ventilation as a weaning strategy for intubated adults with respiratory failure. *Cochrane Database Syst Rev* 2010; 4;(8).
- Wip C, Napolitano L. Bundles to prevent ventilator-associated pneumonia: how valuable are they? *Curr Opin Infect Dis* 2009; 22(2): 159-66.
- Barr J, Fraser GL, Puntillo K, Ely EW, Gélinas C, Dasta JF. Clinical practice guidelines for the management of pain, agitation, and delirium in adult patients in the intensive care unit. *Crit Care Med* 2013; 41(1): 263-306.
- Carlson J, Mayrose J, Krause R, & Jehle D. Extubation force: tape versus endotracheal tube holders. *Ann Emerg Med* 2007; 50(6): 686-91.
- Buckley JC, Brown AP, Shin JS, Rogers KM, Hoftman NN.

- A Comparison of the Haider Tube-Guard® Endotracheal Tube Holder Versus Adhesive Tape to Determine if This Novel Device Can Reduce Endotracheal Tube Movement and Prevent Unplanned Extubation. *Anesth Analg* 2016; 122(5): 1439-43.
27. Chao CM, Lai CC, Chan KS, Cheng KC, Ho CH, Chen CM, Chou W. Multidisciplinary interventions and continuous quality improvement to reduce unplanned extubation in adult intensive care units: A 15-year experience. *Medicine (Baltimore)* 2017; 96(27).
 28. Lee TW, Hong JW, Yoo JW, Ju S, Lee SH, Lee SJ, Cho YJ, Jeong YY, Lee JD, Kim HC. Unplanned Extubation in Patients with Mechanical Ventilation: Experience in the Medical Intensive Care Unit of a Single Tertiary Hospital. *Tuberc Respir Dis (Seoul)* 2015; 78(4): 336-40.
 29. Farbod F, Tuli P, Robertson BF, Jackson IT. Endotracheal tube fixation methods for optimal stability: a comparison of adhesive tape, suture, and tape-suture fixation. *J Craniofac Surg* 2010; 21: 1250-1.
 30. Wagner JL, Shandas R & Lanning CJ. Extubation force depends upon angle of force application and fixation technique: a study of 7 methods. *BMC Anesthesiol* 2014; 24: 14: 74.
 31. Tanios MA, Epstein SK, Livelio J, Teres D. Can we identify patients at high risk for unplanned extubation? A large-scale multidisciplinary survey. *Respir Care* 2010; 55(5): 561-8.
 32. Bouza C, Garcia E, Diaz M, Segovia E, Rodriguez I. Unplanned extubation in orally intubated medical patients in the intensive care unit: a prospective cohort study. *Heart Lung* 2007; 36(4): 270-6.
 33. Chang LC, Liu PF, Huang YL, Yang SS, Chang WY. Risk factors associated with unplanned endotracheal self-extubation of hospitalized intubated patients: a 3-year retrospective case-control study. *Appl Nurs Res* 2011; 24(3): 188-92.
 34. Naved SA, Siddiqui S, Khan FH. APACHE-II score correlation with mortality and length of stay in an intensive care unit. *J Coll Physicians Surg Pak* 2011; 21(1): 4-8.
 35. Dall'Ora C, Griffiths P, Ball J, Simon M, Aiken LH. Association of 12 h shifts and nurses' job satisfaction, burnout and intention to leave: findings from a crosssectional study of 12 European countries. *BMJ Group* 2015; 5(9): 1-9.
 36. Scott LD, Rogers AE, Hwang WT, & Zhang, Y. Effects of critical care nurses' work hours on vigilance and patients' safety. *Am J Crit Care* 2006; 15(1): 30-7.
-
- Received: 23 October 2017
Accepted: 3 November 2017
Correspondence:
Chiara Cosentino
Department of Medicine and Surgery,
University of Parma, Parma, Italy
Tel. +393472572416
E-mail: chiara.cosentino1@unipr.it