RECOMMENDATIONS FOR SAFE EXTUBATION

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Extubation is a logical consequence of tracheal intubation. After extubation airway control is equally as important as any other phase of securing the airway during anesthesia. Complications related to extubation are usually minor and less harmless, although in some cases they can be very dangerous and deadly. It sounds paradoxical, but the respiratory complications that follow up extubation process are three times more frequently than those that occur during induction and intubation (1, 2). Accordingly, during the last decade, experts focused on process of tracheal intubation and they paid special attention to the processes of complications associated with this procedure. A significant decline in mortality related to induction period and procedure of intubation, which was evident last twenty years, can be attributed to the widely acceptance of representative guidelines to ensure difficult airway, which undoubtedly lead to safer treatment. Unfortunately the incidence of deaths and serious brain damage related to extubation is almost unchanged over the last twenty years. We conclude that the introduction of the recommendations for treatment in periextubation period could significantly improve the safety of daily anesthesia practice.

The patient position during extubation

Many generations of anesthesiologists learned the classic method of tracheal extubation with left lateral position of the patient and with his head lowered down. Effectiveness of this traditional practice came from the fact that anesthetics that were used at that time had a long eliminating time and a significant emetogenic potential, and because of that it was paid attention of the prevention of aspiration and maintaining a patent airway

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after extubation. This position was prevented tongue falling during extubation to the posterior wall of the pharynx, and facilitated the eventual need for patient reintubation. With respect to all we said above it must be noted that this practice resist the test of time and that can be considered as anesthetic practice based on evidence. On the other hand the modern anesthetics practice increasingly involves extubation position on the back with his head at the level of the body or even above the level of the body. Such practices promote two very important changes in anesthetic dogma. Today an elective surgical patient is very well prepared. Application of anesthetic with perfect pharmacological profile leads to faster recovery and reduces incidence of regurgitation and aspiration. Also, implementing of pharmacological strategies to neutralize residual gastric content is widely used, and the modern anesthesia practice emphasize intake of per oral fluids two hours before induction in order to accelerate passage of gastric contents. Another very important fact that has made changes in doctrine and in anesthesia practice occurs from the fact that modern, technologically innovative supraglottic airway devices have been widely introduced in recent years. The main advantage of application of these devices comes from the fact that there are better tolerated after extubation and they do not lead to laryngeal incompentention. The application of these devices allows significantly greater level of vigilance during extubation. Extubation on your back with elevated head in semi sitting position is recommended for obese patients, in patients with obstructive lung disease, as well as in those where we difficult intubation is expected. This position facilitates the movement of the diaphragm and favors spontaneous respiration, increases the value of functional residual capacity, facilitates expectoration and improves lymphatic drainage by reducing airway edema.

Patients should be extubated awake or anesthetized?

The decision when the appropriate time for extubation is made in relation of two important facts: the first is a real risk of aspiration and the other is the presence or absence of previous difficulties with respiratory tract. As a general rule, patient should be extubated awake. In general, the intensity of hemodynamic stress response is significantly reduced when the patient is extubated in the deep anesthesia. The presence of coughing and straining as response to the presence of the tube in the respiratory tract is also less frequent when extubation is carried out in deep anesthesia. On the other hand, this strategy certainly leads to increased incidence of respiratory complications. However, few studies (mainly in pediatric patients) pointed out significant conclusion about the incidence of respiratory complications

when patients are extubated awake, because of the increased airway reactivity.

When and where to extubate?

Data shows that the threshold of laryngeal adductor neurons excitation involved in laryngospasm reflex varies during the cycle of spontaneous respiration, showing the highest values in a middle of inspiratory part of a cycle. Standard practice is to carry out extubation process at the end of inspirium when the glottis is fully open in order to prevent trauma and development of laryngospasm (3). Most anesthesiologists prefer extubation in the operating room, although data from the UK show that over 40% of all incidents that occur in intensive care immediately after the transfer of extubated patients is related to problems with airway patency. Extubation of the patient is the only responsibility of anesthesiologists despite the fact that many hospitals now have protocols that extubation can be done by any other appropriately trained personnel (4).

Mechanical causes of difficult extubation

Extubation with double lumen tubes (DLT) is commonly related with incidents such as the split on the posterior tracheal wall, bronchial rupture, and unsuccessful extubation procedure. Extubation with DLT is much rigorous compared to extubation with single lumen endotracheal tube since these tubes are such bulky, rigid and lengthy. If it is necessary for any reason in these patients to postpone extubation, DLTs should be replaced with single lumen endotracheal tube during anesthesia. This process can be facilitated by applying exchange catheters that allow insufflations of oxygen, or using of fiber optic devices with additional ports for oxygenation (5). Sometimes the inability to take out the tube is present during extubation. The reasons for this potentially fatal situation should be sought primarily in the inability to blow out the cuff of damaged pilot tube. This incident is rarely caused because of: laryngeal trauma, herniation of ETT cuff, cuff adhesion with tracheal wall or surgical ETT suturing with the surrounding structures. In such a sudden and dramatic situations a slight rotation and tube drawling may be useful, and sometimes it is necessary to perform transtracheal puncture of cuff.

Cardiovascular and respiratory response to extubation

Extubation is usually accompanied by an increase in blood pressure and heart rate in the range of 10 to 30% compared to baseline values. Depending on the intensity of hemodynamic stress response, this phenomenon can

last up to 15 minutes after extubation. This situation has adverse effects on patients with low coronary reserve. For weakening of this response some intravenous infusions should be applied: esmolol, lidocaine, glyceryl trinitrate, magnesium sulfate, remifentanil or propofol infusion. A similar effect can be obtained by orral perioperative applying of nimodipin or topical application of 10% lidocaine. Alternatively, in patients with reduced coronary reserve who are still anesthetized the ETT can be replaced with some model of LM or other supraglotic devices. Incidence of postextubation cough and sore in a throat varies from 38% to 96%. This phenomenon can be prevented when ETT cuff is filled with the liquid instead air, which reduces the possibility of cuff overinflating due to rising of temperature or N2O diffusion. Solution of 2% lidocaine in 1.4% Na-bicarbonate shows a great diffusion profile and reduces the possibility of serious incidents in the case when endotracheal cuffs rupture occurs. In this way the incidence of sore throat in the first 24 hours postoperatively and the occurrence of cough, strain, hoarseness, and restlessness during extubation is significantly reduced. This process can be very useful in patients with increased intraocular or intracranial pressure, in cardiac patients and in patients with pulmonary hyperactivity (6).

Respiratory complications after extubation

The appearance of bronchospasm after extubation is common in active smokers, patients with chronic obstructive pulmonary disease (COPD) and in children with recent respiratory tract infections. Intravenous use of magnesium and lidocaine can be very useful in preventing of laryngospasm. The child positioning on the left lateral side without further manipulation while he is not fully awake is very useful in the prevention of laryngospasm (7). In everyday practice, postextubation airway obstruction can occur due to edema of larynx. Supraglottic edema can cause the epiglottis moving backwards, which then blocks the glottis during inspirium. Subglottic edema is manifested by dramatic stridor. This phenomenon can be especially serious in children, taking into account that the thickening of subglottic mucosa of only 1 mm reduces laryngeal diameter by 35%. Laryngeal edema is often associated with: traumatic intubation, unnecessarily using of large diameter tube, prolonged intubation and the changing position of the head and neck during the operation. Treatment involves application of warm, moist, oxygen-rich gas mixture, nebulized epinephrine or dexamethasone, or a final possibility is reintubation with small tube or heliox therapy. Surgery on the neck and thorax can also lead to postextubation airway obstruction due to direct compression on respiratory tract by the hematoma, and paralysis of the vocal cords caused by direct trauma of vagus nerve. Unilateral paralysis

of vocal cords after extubation presents as hoarseness, and usually disappears with the use of conservative treatment for several weeks. Bilateral paralysis of vocal cords is a condition that requires urgent reintubation of the patient. Among other, rarer cause of postextubation airway obstruction is tracheomalation that occur after long-term external or internal pressure on tracheal rings: long-term intubation, the presence of a large goiter, enlarged thymus, or hematoma. Softening and erosion of vulnerable trachea leads to the collapse of tracheal rings, and it is followed by difficult extubation symptoms, expiratory stridor and whistling. In those cases extubation procedure should be performed in deeper anesthesia in order to avoid coughing and straining. Rare postextubation respiratory complications include: postextubation vocal dysfunction and pulmonary edema (8).

Strategy for successful and safety extubation

Neuromuscular blockade monitoring

The strategy of successful extubation in the first place includes an adequate recovery from neuromuscular blockade, which is very important for maintaining a patency of patient airway and avoiding postextubation hypoxemia. The use of peripheral nerve stimulators to monitor the degree of neuromuscular block is preferred for any elective surgical procedure with the application of neuromuscular blocking agents, and it is absolutely mandatory if muscle relaxants are used in problematic airway. The last recommendations point out that TOFr $\geq$ 0.9 is the minimum required recovery for safe tracheal extubation. On the other hand, pharmacological reversal with anticholesterases should not be initiated until at least two or three responses to TOF stimulation are not present. In the absence of objective monitoring, clinical signs can be used to estimate neuromuscular block recovery which is more appropriate for predicting of respiratory function recovery, such as arms rising of the operating table $\geq$ 10 seconds and maintaining the head lifted $\geq$ 5 seconds (9, 10).

How to recognize the difficult extubation?

Patients with severe cardiorespiratory disorders, obese patients, and patients with congenital or acquired airway disorders and patients who had experienced numerous intubation attempts are certainly the candidates for problematic extubation and eventual reintubation. There are also the surgical factors that include n.recurens demages (thyroid surgery), presence of hematoma (laryngeal and thyroid surgery) and edema (neck surgery, posterior fossa cranial surgery, intermaxillar fixation and odontogenic abscess drainage, Trendelenburg position (11).

Prevention of unsuccessful extubation

In daily anesthesia practice unsuccessful extubation is not common, comparing to the mechanically ventilated and critically ill patients in intensive care units, among which this phenomenon is much more common and varies in the range of 0.4 to 25% of patients (12, 13). In order to identify patients with increased risk for potentially unsuccessful extubation, it is necessary to define precisely this predictors. Moreover, the precise definition of the predictor can identify potentially reversible causes that can be removed just before the planned extubation. Successful extubation is defined as effective airway protection after removing the endotracheal airway tube and it is determined by the volume functionality of secretions in the respiratory track, effective cough reflex function and preserved mental status in the absence of airway obstruction. Airway obstruction occurs in the field of prolonged and multiple intubation attempts, unnecessary use of a wide lumen tube or high pressure in the tube maker. Detection of potential upper airway obstruction in the period while the tube is in the trachea is a real challenge. The absence of audible gas leak near endotracheal cuff (qualitative cuf leak test) is suspected to postextubation stridor and upper airway obstruction. An alternative approach for detecting potential upper airway obstruction in intubated patients includes quantitative method of leaking gas volume measuring next to the tube after cuff volume reduction and calculating the average difference between inspiratory and expiratory volume during the six repeatedly breaths of the patient who is in assisted-controlled ventilation (14). This quantitative test of gas leaking may be expressed either as an absolute value difference between the volume of inspiratory and expiratory volume or leakage can be expressed as a percentage of the inhaled volume. If the value of leakage near the cuff do not exceed more than 110-130 ml or below 10-15% of delivered respiratory volume the risk of threatening upper airway obstruction is significant (15-17). On the other hand, a negative leakage test indicates that upper airway obstruction probably is not present. Thus, Cheng found the upper airway obstruction in only 5 of 193 (2.6%) patients with quantitative leakage of inhaled respiratory volume (more than 24%). But the same study showed that in patients with a positive leakage test postextubation stridor was present in 70% of patients and in only 19% of respondents was necessary to perform reintubation. This frequent false-positive tests the authors attributed to the accumulation of viscous secretions around the tube wall, which disabled gas leak. These false positive tests could lead to excessive use of steroid drugs in prevention, even more to avoid unnecessary prolongation of time spent on mechanical ventilation, it is necessary to identify particular risk groups where we will apply leak test.

Cheng and co-authors also point out, by analyzing both group of their patients, that female patients, and those older than 80 years, with the absence of an adequate level of sedation and low Glasgow Coma (3-8) who were intubated in hospital rooms, not in the operating room, have a higher risk for upper airway obstruction after extubation (18). In any case, the strategy of solving potential upper airway obstruction, include prolonged intubation and mechanical ventilation of patients and consider the possibility of establishing a tracheotomy or preventive using of steroids.

Does the preventive use of steroids reduce the incidence of postextubation laryngeal edema and the need for tracheal reintubation?

Although extubation procedure usually runs without any significant incidents and complications, some patients may develop significant edema of larynx mucosa, although the low pressure high volume cuff tubes were used. The appearance of postextubation laryngeal edema and the need for tracheal re-intubation is relatively common after long-term surgery and several days of mechanical ventilation in intensive care units. Postextubation laryngeal edema is characterized by stridor and dyspnea, and often requires patient reintubation. Beginning of postextubation edema occurs within eight hours of extubation and it is caused by present mucosal edema in glottis region, and edema is caused by pressure or irritation of endotracheal tube. In placebo controlled clinical studies, the incidence of laryngeal edema is in the range of 3-30% of respondents, and consecutive need for reintubation is present in 1 to 5% of respondents. Although the preventive use of steroids had been applied before planned extubation even thirty years ago, until recently there were no relevant clinical evidence that it results in clinical benefit (19, 20). If the patient is mechanically ventilated for more than 24 hours, the optimal time to initiate preventive treatment with steroids is 12 hours before the planned extubation with repeated doses depending on the steroid elimination time. It is believed that the use of steroids after extubation has no preventive effect on the occurrence of postextubation laryngeal edema. However, recent meta-analysis of Fan and associates, which included six randomized, placebo-controlled clinical trials with 1923 patients confirmed that intravenous giving of steroids immediately before extubation reduces the incidence of laryngeal edema for 62% and the need for reintubation reduces for 71%. The same meta-analysis showed that the preventive use of steroids, especially it is more effective if we repeat doses after, will reduce the incidence of laryngeal postextubation edema by 86% and the eventual need for tracheal reintubation reduced by 81%. Data from

this meta-analysis did not indicate any significant side effects (21). Similar evidence is presented in the recent meta-analysis of Jaber and associates (22). In the future, it is necessary to conduct additional clinical trials that will determine the optimal prophylactic dose of steroids and the time interval from the beginning of application of steroids till planned extubation.

Patients who require reintubation after unsuccessful extubation usually do not have a good prognosis with a mortality rate reaching 40% (23, 24). It is unclear why unsuccessful extubation and the need for reintubation are associated with such a high mortality rate. The criteria that define unsuccessful extubation and the need for reintubation includes: increasing PaCO2 ≥ 10 mm Hg, the reduction of pH ≥ 0.1, PaO2 <60 mm Hg, SaO2 <90%, with the use of FiO2> 0.5 - 1 as well as clinical signs of increased respiratory work (tachypnea, increased activity of auxiliary respiratory muscles, paradoxical abdominal breathing). Reintubation procedure is the invasive procedure which can often lead into serious, life-threatening complications such as sudden cardiac arrest, or esophageal intubation, aspiration of gastric contents, heart arrhythmia, pneumonia and pneumothorax (25, 26).

However, studies show that mortality rates associated with reintubation depends primarily on the causes that lead to unsuccessful extubation and duration of the time that has passed from unsuccessful extubation to reintubation. The causes of unsuccessful extubation are divided into two groups. In the first group the airway related causes (airway obstruction accompanied with stridor breathing and threatening aspirations and the inability to maintain airway patency due to the accumulation of pulmonary secretions). The causes which are not directly related to the very airway include: congestive heart failure, respiratory failure, encephalopathy, sepsis and gastrointestinal bleeding, and they are much more likely cause of the failure extubation and reintubation. In addition, this group of etiological factors is statistically more frequently associated with mortality of the patients who are reintubated. On the other hand, patients whose extubation was unsuccessful due to theirs airway problems were reintubated within a short time interval, compared to patients who were reintubated due to other causes mentioned above. The time since extubation to reintubation is a strong predictor of mortality. In this sense, patients who were reintubated after unsuccessful extubation within 12 hours have a higher chance of survival (27).

Airway exchange catheters and the concept of gradual extubation strategy

Airway exchange catheters recently introduced into clinical practice are used primarily for safe endotracheal tube replacement in a patient on

long-term mechanical ventilation, but they can be also alternatively used to provide the access to the airway after extubation and allows safe and fast tracheal reintubation, if it is necessary. Successful reintubation with airway exchange catheters is not so much a new practice, but the number of published studies about this method is not numerous and they are mostly related to pediatric patients (28-30). Patients with difficult airways are exactly representative group who have potentially the greatest benefit of application of this method. Brilliant observational analysis of Thomas Mort was published in November 2007 in the journal of Anesthesia & Analgesia. This analysis paid attention to the routine use of airway exchange catheters in previously intubated patients with known or presumed difficult airway. During this 9-year period of observation it was found that the airway exchange catheters were applied in extubation of 354 patients who were intubated under difficult airway circumstances. Airway exchange catheters remained in the trachea until the end of reintubation, or in the situation where we evaluate that intubation will not be required, respecting by the principle of gradual extubation strategies for difficult airway. The method of gradual extubation strategy was applied in the operating room, recovery room and intensive care units. Forty-seven of 51 patients (92%) were successfully reintubated with airway exchangers of which 41 (87%) during the first attempt. Patients were reintubated with a mild sedative dose, and in the case of severe desaturation patients were ventilated directly through the exchanger tube or with masks and self-expanding balloons. In contrast, patients who have required reintubation at the time when the exchanger has been already removed from the trachea, had a significantly lower percentage of successful reintubation in the first attempt (14%) with frequent application of technically demanding method of securing airway (fiber optic guided intubation, the use of rigid fiber optic devices and surgical approach to the airway). It should be added that the percentage of complications was significantly higher in patients where airway exchange catheters were not used for reintubation. This study clearly shows in the relatively large sample, that the use of airway exchange catheters is effective method of maintaining approach to the airway after difficult airway extubation (31).

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