

CRICOTHYROTOMY – URGENT ACCESS TO THE AIRWAY, WHEN AND HOW?

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Cricothyrotomy or coniotomy is an invasive emergency procedure to establish an airway for ventilation and oxygenation when other routine methods are not possible, or are contraindicated and ineffective. The indications are situations when we cannot ventilate and cannot intubate patients with severe maxillofacial trauma, edema secondary to burns of the face and airway, laryngo-hypopharyngeal obstruction of a wide range of causes such as bilateral vocal cord paralysis because of previous head and neck surgeries, endotracheal intubation, neurologic causes and laryngeal carcinomas, congenital malformations, craniofacial trauma with massive bleeding, etc. There are no absolute contraindications, while relative ones are few and include laceration of the larynx and trachea with or without retraction of the trachea in the mediastinum. In that case, tracheotomy is indicated. Cricothyrotomy is contraindicated in children. To perform the procedure, there are several techniques, i.e. standard surgical, emergency surgical procedure and percutaneous techniques. Early complications (incidence 0-54%) include bleeding, laceration of the thyroid, cricoid cartilage and tracheal rings, perforation of the rear tracheal wall, tube misinsertion, unplanned tracheostomy, wound and cartilage infection. Long-term complications include subglottic stenosis and phonation difficulties. Cricothyrotomy is a temporary solution to obtain ventilation and oxygenation and the need for prolonged ventilation (more than 72 h) has to be replaced with tracheotomy.

KEY WORDS: critical airway, cricothyrotomy, indications, techniques

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INTRODUCTION

Cricothyrotomy or coniotomy is a surgical procedure in which the tube is placed through a small incision in cricothyroid membrane (CTM), called ligamentum conicum, in the subglottic laryngotracheal area to establish airway for ventilation and oxygenation.

HISTORY

The operation was first described in 1805 by Felix Vicq-d'Azyr, a French surgeon and anatomist (1). It was re-introduced again 100 years later, in 1909, by Dr. Chevalier Jackson, an American laryngologist (2). In the pre-antibiotic era, a series of complications main-

ly caused by inflammation after surgery led to tracheal and laryngeal stenosis. These complications pushed surgery into oblivion until the 1970s, when Brantigen and Grow published a study with 655 patients that underwent elective cricothyroidotomy, with a very small percentage of complications, 6.1% in total (3).

Nowadays, cricothyrotomy, as an easier and faster procedure than emergency tracheotomy, has become the treatment of choice for the establishment of ventilation in upper airway obstruction.

Today's new and improved conditions for rapid oro-tracheal intubation (e.g., videolaryngoscopy and better training) have decreased the number of cricothyroidotomies performed in patients with compromised airway. Still, when we cannot intubate or oxygenate the patient, cricothyroidotomy remains the treatment of choice for rapid establishment of the airway.

INDICATIONS AND CONTRAINDICATIONS

The indications for cricothyrotomy are severe maxillofacial trauma, edema secondary to burns of the face and airway, massive bleeding and/or vomiting, laryngo-hypopharyngeal obstruction with tumors, polyps or cysts, vocal cord paralysis of a wide range of etiology such as neurologic diseases and trauma, congenital malformations, laryngeal tumors, intubation injuries, trismus, and other causes of compromised airway.

While there are no absolute contraindications for cricothyrotomy, the relative ones are as follows:

1. laceration of the larynx and trachea with or without tracheal retraction in the mediastinum. In that case, tracheotomy is indicated for stabilization and fixation of the trachea;
2. pediatric trauma population. Children have narrow and funnel-shaped larynx with the narrowest part at the cricoid ring area. This poses a real and increased risk of subglottic laryngeal stenosis. This area is particularly susceptible in children under the age of 12 and any trauma or inflammation can disrupt their development and growth leading to stenosis. Cartilage inflammation and scarring may also result in fixation of the vocal cords and permanent disturbance of respiration and phonation. Therefore, cricothyrotomy is contraindicated in children until 12 years of age (3,4); and
3. when making decision on cricothyroidotomy in patients with any of coagulation disorders, possible complications should be taken in consideration.

The procedure, if needed, should be performed on time. The study by Combes *et al.* showed that the decision making process for cricothyrotomy is too often delayed until ventilation has become impossible and oxygenation compromised (5).

Haukoos *et al.* (6) in their study suggest new clinical decision rules for on-time determination of the necessity of surgical involvement in airway emergency intervention. The rules include penetrating injury, initial systolic blood pressure less than 100 mm Hg, or initial pulse rate greater than 100 beats/min. The rules have been developed to predict which trauma patients require emergency operative intervention or emergency procedural intervention. They validated the rules in an adult trauma population and compared them with the American College of Surgeons' major resuscitation criteria. They concluded that the new rules were more sensitive for predicting the need for emergency operative intervention or emergency procedural intervention (directly compared with the American College of Surgeons' major resuscitation criteria), which could improve the effectiveness and efficiency of trauma triage.

TECHNIQUES

Before we decide to do cricothyroidotomy, we must have ready a set for the procedure and be familiar with it. The set includes the following: scalpel blade no.10 or 11, Trousseau's dilator, tracheal hook, 10 cc syringe, suture material, tracheal tube (cannula) with obturator and inner cartridge, tube fixation ribbon and ambu balloon with ventilation mask.

First step in cricothyrotomy is to find the basic anatomic landmarks and detect CTM. Occasionally, this may be a problem, e.g., in severe head traumatized or obese patients. Many studies deal with this problem and suggest how to solve it. Barbe *et al.* in their study evaluated how ultrasound could help locating CTM by comparing palpation and ultrasonography evaluation. Following a limited training phase, ultrasound allowed a more effective localization of CTM by residents when compared to clinical palpation in overweight patients (7,8).

For locating CTM, we have to identify orientational points (Fig. 1). First is the laryngeal prominence of thyroid cartilage, and second is a hard protrusion of cricoid cartilage placed 2.5 to 3 cm below the first point. Between thyroid cartilage and cricoid ring is 1 cm wide, soft recess of CTM, the site of our intervention. These anatomic landmarks in obese patients are more difficult to find and there is a danger for the thyrohyoid membrane be mistaken for cricothyroid. This is easier with the patient lying down with his head tilted back for better exposure of anatomic landmarks.

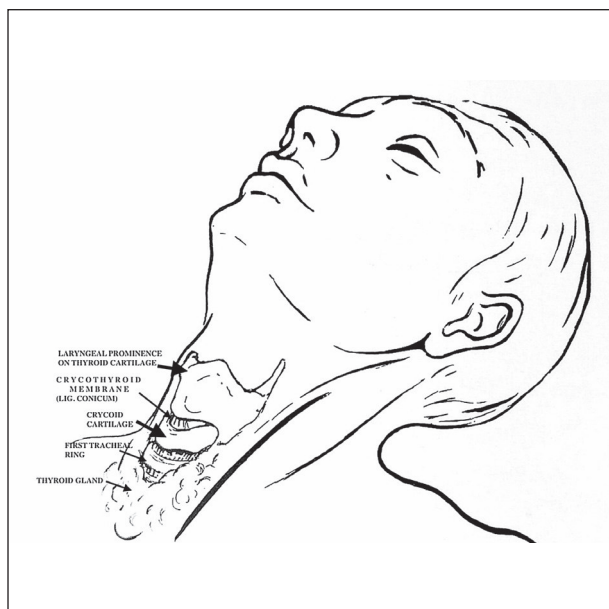


Fig. 1. Neck position and relevant anatomical points for cricothyrotomy (arrows indicate anatomic points, from up to down: laryngeal prominence on thyroid cartilage, cricothyroid membrane, cricoid cartilage, 1st tracheal ring, thyroid gland) (adapted from Padovan I, editor. *Otorinolaringologija – kirurgija usne šupljine, ždrijela, grla i vrata*. Zagreb: Školska knjiga, 1987; p. 253).

As cricothyrotomy is very often an urgent surgical procedure and there is no time for surgical draping, we need standard protective equipment, i.e. gloves, mask, protective glasses, protection clothing (aprons) and shoe cover.

Before starting the procedure, the surgical plane needs to be cleaned with an antiseptic and if possible, the patient needs to be pre-oxygenated with the mask. Most often we do not have time for analgesia or sedation. If the patient is agitated, we have to anesthetize the skin locally with 1% lidocaine. There are several techniques to perform the procedure. For the purpose of this study, we will call them standard surgery, rapid surgery and percutaneous technique.

First grip is equal in all of them: the patient should be lying down, with his head tilted back for better exposure of anatomic, as illustrated in Figure 1. Larynx should be stabilized between the thumb and middle finger of non-dominant hand, and with index finger we palpate the depression over cricothyroid membrane (Fig. 2).

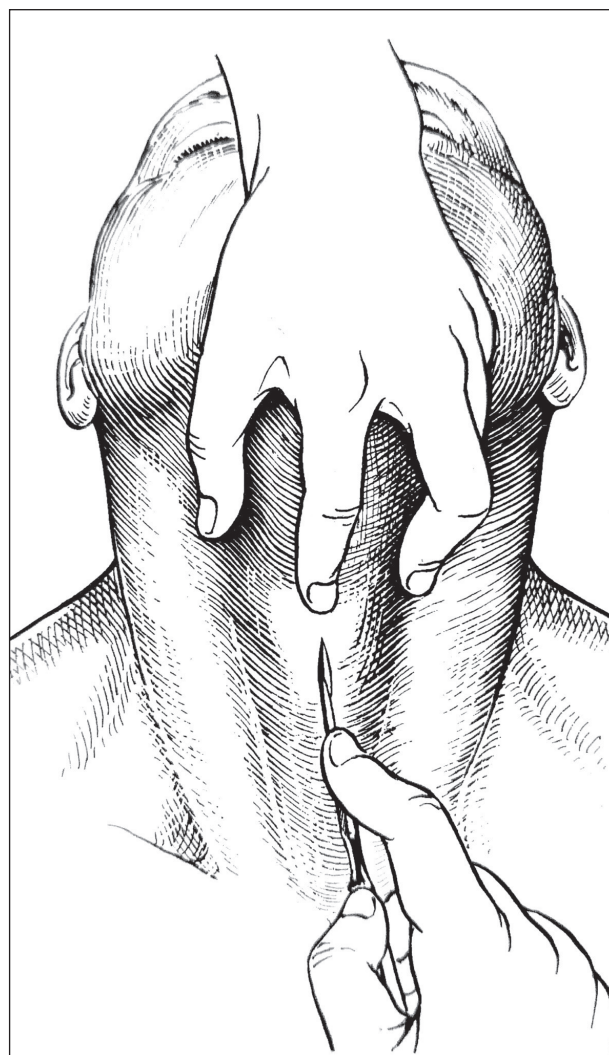


Fig. 2. Cricothyrotomy. Hands position for larynx fixation and cricothyroid membrane identification with index finger and place for surgical incision (adapted from Padovan I, editor. *Otorinolaringologija – kirurgija usne šupljine, ždrijela, grla i vrata*. Zagreb: Školska knjiga, 1987; p. 332).

The standard surgical technique is to make a 2-4 cm vertical incision through the skin and subcutaneous tissue from the mid of thyroid cartilage to the level of second or third tracheal ring (it can be expanded up or down for better exposure of the cricothyroid membrane). With index finger, we palpate the membrane through the incision and when it has been identified with scalpel blade no.11 we make a horizontal incision through the lower portion of the membrane taking care not to wound the posterior wall of the trachea.

We have to be aware of possible bleeding from the cricothyroid artery (a branch of the superior thyroid artery) that runs across the cricothyroid membrane horizontally closer to the top edge. Temporarily, we place the index finger into the stoma and if an assistant is available, he or she should insert the tracheal hook into the opening in the membrane and pick up thyroid car-

tilage. Then we insert the Trousseau dilator with our dominant hand into the trachea, spreading incision in vertical direction. We let our assistant to maintain control of the tracheal hook and dilator and we insert the tube (cannula) into the airway, rotating the dilator for 90 degrees to free the trachea down and finish insertion of the tube removing the hooks and dilator at the same time. Then we remove the obturator from the tube and inflate the cuff (balloon). The procedure is finished by fixing the tube (cannula) around the neck and connecting the tube to Ambu balloon or ventilation system.

When we want or need to do quick cricothyroidotomy and we do not have an assistant, this standard surgical technique has some changes. After we identify the cricothyroid membrane, using the landmarks, we have to stabilize the larynx in the standard way. Then we incise the skin and subcutaneous tissue with vertical incision over the membrane. Through the incision we reconfirm the location of the membrane and pierce it with 1-cm horizontal incision, keeping the blade inserted and taking care not to wound the posterior wall of the trachea by facing the blade down to the trachea. Then we attach the hook to the lower edge of the incision pulling downward simultaneously removing the scalpel. The tube is immediately inserted into the opening.

For percutaneous technique we use commercial kits for cricothyrotomy (various manufacturers), which are similar to percutaneous tracheostomy.

When we hyperextend the patient's neck and identify the cricothyroid membrane, we use a syringe with saline and special needle with catheter to pierce the membrane under a 45-degree angle entering the trachea. We aspirate the air to see the bubbles in the syringe to be sure we are in the trachea. Then we remove the syringe and slip the catheter over the needle into the trachea still keeping 45-degree angle. We remove the needle and the catheter remains. Then we can make a small puncture incision of the skin around the catheter over the cricothyroid membrane. Through the catheter, we carry in guide wire into the trachea. Maintaining control over the guide wire, we remove the catheter. Then we guide coated dilatation catheter with the tube over the guide wire and advance it through the skin and membrane. First we expand the hole with dilatation catheter and then slip the tube over the dilatation catheter placing it in the stoma over the skin and remove the guide wire and dilatation catheter. At the end, we inflate the cuff and check ventilation.

DISCUSSION

As cricothyrotomy is an invasive procedure for rapid establishment of airway, there are many reports and dis-

cussions regarding the time spent for cricothyrotomy. Some of these reports are contradictory. In few studies, the authors report that the standard surgical approach is quicker, whereas others present results that gave advantage to percutaneous approach. The CricKey is a relatively new surgical cricothyrotomy device, developed for emergency military medical situations. CricKey combines the functions of a tracheal hook, stylet, dilator, and bougie incorporated with a Melker airway tube (9). In 2014, Mabry *et al.* (10) found that first-attempt success was 100% (15/15) for CricKey surgical cricothyrotomy and 66% (10/15) for open surgical cricothyrotomy. Surgical cricothyrotomy insertion was faster for CricKey than open technique (34 vs. 65 s). In the study by Schober *et al.* (11), performed by inexperienced health-care providers (5th year medical students) using the cricothyrotomy model on human cadavers performing the procedure, success rate was 94% with standard surgical technique and 100% with a modified surgical technique (new scissors technique). In the study by Helm *et al.* (12), the success rate of the 5th year medical students, with the indicator-guided percutaneous cricothyrotomy kit (PCK device) was significantly lower than that with the standard surgical technique (67% vs. 100%; $p=0.04$). Mariappa *et al.* (13) found that only 30% of the attempts with the PCK device on a pig larynx were placed correctly, compared to 55% with standard surgical technique; in this study, the operators were four experienced intensive care specialists with at least 10 years of airway management experience. In contrast to these results, Assmann *et al.* (14) found a success rate of 95% with the PCK device in a study using a standard cricothyrotomy manikin with an anatomically correct airway. In a study comparing the PCK with a wire-guided technique (Melker Kit) on human cadavers, Benkharda *et al.* (15) report 80% success rate in the PCK group; in this study, the operators were two experienced anesthesiologists. Paix *et al.* (16) in their study conclude that the traditional surgical cricothyrotomy procedures are faster than percutaneous techniques, with the mean time of 83 ± 44 s (r. 29.149 s). Hubble *et al.* (17) in their meta-analysis compared success rates of alternative airway devices, needle cricothyrotomy and surgical cricothyrotomy, and found that needle cricothyrotomy had a comparatively low rate of success (65.8%) but that surgical cricothyrotomy had a much higher success rate (90.5%) and should be considered the preferred approach.

From all the studies investigating success rate of cricothyrotomy, we can say that besides the technique, the experience of the operator is one of the key points of success. Thus, we cannot but agree with Wong *et al.* (18); in their study from 2003 they state that while clinical correlates are unknown, some recommendations are that providers of emergency airway management should be trained on manikins for at least five attempts or until their cricothyrotomy time is 40 s or less.

What can we say about complications of cricothyrotomy? Complications do exist. Bleeding is most often reported but it is not so serious. Complications that are more serious include laceration of the thyroid, cricoid cartilage and tracheal rings, then perforation of the rear tracheal wall, insertion of a tube into the tissue, unplanned tracheotomy, and wound infection and cartilage inflammation. The incidence of complications varies from 0 to 54% in some published studies. Emergency cricothyrotomy has a higher percentage of complications from elective. Long-term complications include subglottic stenosis and phonation difficulties associated with glottic changes (19,20).

We have already said before that cricothyrotomy is contraindicated in children. This rule was confirmed in the study by Boatright *et al.* (21) after data analysis of 8087 patients, mean age 11, and validation of the existing rules to predict emergency surgical intervention in pediatric population. They concluded that neither set of criteria appeared to be sufficiently accurate to recommend cricothyrotomy for routine use in children.

CONCLUSION

Cricothyrotomy is an emergency procedure to establish open airway and ventilation when other routine methods are not possible, or are contraindicated and ineffective. It is a safe and quick procedure to bypass airway obstruction, which can be performed by surgeons, intensivists, and also by inexperienced but trained other healthcare providers. Successfulness correlates with experience of the operator. To perform the procedure, there are several techniques, i.e. standard surgical, emergency surgical procedure and percutaneous techniques. On performing the procedure, a few recommended steps should be followed. It is usually performed with simple surgical set or prepared special kit, taking care of basic anatomic landmarks (hyoid bone, laryngeal prominence, cricoid cartilage) and detecting cricothyroid membrane. Irrespective of the technique used, in all of them larynx should be stabilized between the thumb and middle finger of non-dominant hand, and with index finger we palpate the depression over cricothyroid membrane where we place the tube in the subglottic laryngotracheal space through a small incision.

Cricothyrotomy should be accepted as a temporary airway solution, and if the need for prolonged ventilation is more than 72 h, it has to be replaced with tracheotomy.

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SAŽETAK

KRIKOTIREOTOMIJA - HITNI PRISTUP DIŠNOM PUTU, KADA I KAKO?

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Krikotireotomija ili konikotomija je invazivni kirurški postupak za hitnu uspostavu dišnog puta radi ventilacije i oksigenacije, kada ostale metode nisu moguće, dostupne ili nisu učinkovite. Indikacije za zahvat su ozbiljne traume glave i vrata, edem u području lica, ždrijela i gornjeg dišnog puta različite etiologije, laringo-hipofaringealna opstrukcija zbog obostrane paralize glasnica kao posljedica neurološke bolesti, laringealnog tumora, kongenitalne malformacije, intubacije ili masivnog krvarenja ili povraćanja zbog traume glave, kada nije moguća ventilacija ni intubacija. Apsolutnih kontraindikacija za ovaj zahvat nema, dok su relativne malobrojne: laceracija larinksa i traheje s retrakcijom traheje u medijastinum ili bez nje i tad je indicirana traheotomija radi fiksacije traheje. Krikotireotomija je kontraindicirana kod djece. Za izvođenje zahvata postoji nekoliko tehnika: standardna kirurška tehnika, hitni kirurški postupak i perkutana tehnika. Učestalost komplikacija varira, a među rane (incidencija varira od 0 % do 54 %) možemo ubrojiti krvarenje, laceraciju tireoidne i krikoidne hrskavice ili trahealnih prstena, laceraciju stražnje stijenke traheje i proboj jednjaka, postavljanje kanile u pretrahealni prostor. Moguće kasne komplikacije su subglotična stenoza i poremećaji govora. Krikotireotomiju treba prihvatiti kao hitni pristup dišnom putu, a u slučaju daljnje potrebe za prolongiranom ventilacijom (duže od 72 sata) neophodno ju je zamijeniti traheotomijom.

KLJUČNE RIJEČI: ugrožen dišni put, krikotireotomija, indikacije, tehnike