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PRACTICAL ASPECTS ABOUT TRACHEOSTOMY CANNULA: A SYSTEMATIC REVIEW

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ABSTRACT | Context: Since the first sterling tracheostomy cannula was developed, in the late 1800's, and some modernization has occurred, there have been several reports on flaws surrounding their care. **Objetive:** Provide a comprehensive review about tracheostomy cannulas. **Methods:** A systematic search of the PubMed and Medline databases was conducted on closed drainage system using the following keyword combination: tracheostomy AND cannula. **Results:** From eight hundred eight-three articles retrieved after our preliminary search, 17 articles were chosen for final analysis. Representative schemes were drawn to better understanding of the three distinguished materials types and ten different components (faceplate, cannula, radiopaque line in the cannula, inner cannula, universal hub 15mm, pressure line, pilot balloon, cuff, subglottic aspiration system, obturator), as well as their concerns. **Conclusions:** Knowing and understanding tracheostomy cannulas. particularities may imply in a better approach to the patients, and in minimizing institutional costs.

Key words: Tracheostomy; cannula; neoplasms, head and neck; Airway Management

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INTRODUCTION

First sterling tracheostomy cannula was made in silver and developed in England, in the late 1800's. Since then, there have been a lot of improvements. Nowadays, there are a large number of manufactures and different sizes, models, materials, diameter, curvature, and related contains, which directs to a specific function or patient and may have clinical implication[1].

Although a recent book has been published[2] little specific information to the staff is presented in one single chapter, and many researches indicate flaws around tracheostomy management[1,2,3,4,5,6] which tend to decrease over the years, however remain present.

Therefore, to the best of our knowledge, there is no such study indicating detailing particularities about tracheostomy cannulas, which can imply in safe procedure, safe care among patients who require them. This brings the aim of the present study.

METHODS

Literature search strategy

A systematic search of the PubMed and Medline databases was conducted on tracheostomy cannulas, according to PRISMA recommendation. Therefore, the search was performed using the following keyword combination: tracheostomy AND cannula.

The corresponded meaning to each part identified previously was registered and were available as representative pictures and descriptive information.

Inclusion criteria

Studies were eligible for inclusion if they(1) were related to tracheostomy cannulas; (2) were human studies; (3) were published in English, Spanish or Portuguese; (4) were free full text publishing access. The initial selection was based on the title, second on the abstracts. Those deemed relevant were retained for further analysis, which included selection based on an analysis of the full text of the articles. The authors performed a double-check review of the list of possible studies (ACT and LMM), and in the case of disagreement between the two on whether or not a study was included, the opinion of a third reviewer (ISTN) was consulted.

Manuscripts were cited and presented alphabetically (based on their first authors) to better clarify data presentation.

Exclusion criteria

Papers were excluded if they (i) did not present any additional tracheostomy care; (ii) presented decannulation protocols; (iii) presented technical approaches surrounding tracheostomy procedure; (iv) presented technical approaches surrounding cannula insertion; (v) presented a customized tracheostomy cannula.

Data extraction

The following data were collected for final analysis from each study: air way passage physiology; air way flow passage physiology; cannula's material; Complication causes and related preventions; Components of the cannulas; anatomy or position and interfering.

Based on these collected information, an aggregation of all data and schemes were performed for better exposure and explanation among the issue.

RESULTS AND DISCUSSION

Fifty six were retrieved after our preliminary search, and 53 were considered potentially relevant based on the title. A total of 29 articles were considered eligible due to their abstract contents. After a careful selection, 25 were selected for full-text assessment and 6 were excluded. Finally, 19 articles were chosen for final analysis. (Figure 1)

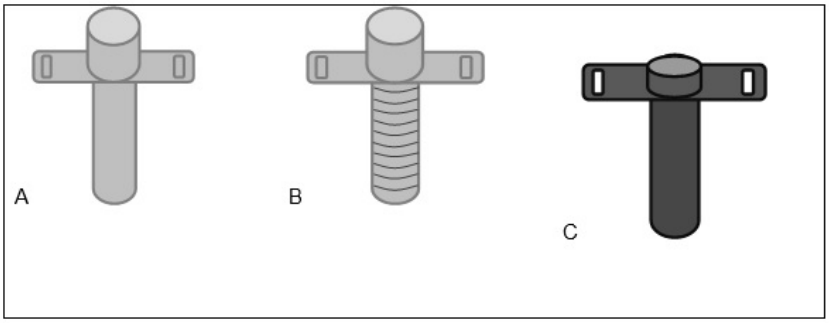

Figure 1. Tracheostomy cannula's materials. A: Plastic tracheostomy cannula; b: Reinforced tracheostomy cannula; C: Metallic tracheostomy cannula.

Source: Data elaborated by the authors.

Selected studies dated from 1963 to 2016[9-27]. Table I shows general description of the included studies and provides information regarding the original cited data (table I).

Table 1. General description of the included studies.

Author and year	air way flow	cannula's material			Compl cause	Compl prev	Cannulas' components									Anatomy / position interfering
		M	P	R			Faceplate	Cannula	Radiopaque line	Inner cannula	Universal Hub	Pressure line/pilot balloon	Cuff	Subglottic aspiration system	Obturator	
Altun, 2015[9]	-	-	-	-	Yes	Yes	-	-	-	-	-	-	-	-	-	-
Berlet, 2016[10]	-	-	Yes	-	Yes	Yes	-	Yes	-	Yes	Yes	-	Yes	-	-	-
Credland, 2016[11]	-	-	-	-	Yes	Yes	Yes	-	-	-	-	-	-	-	-	-
Engels,2009 [12]	Yes	-	Yes	-	Yes	-	-	Yes	-	-	-	-	Yes	-	Yes	-
Garzon,1965 [13]	Yes	Yes	-	-	-	-	-	Yes	-	Yes	-	-	-	-	-	-
Hess, 2005[14]	-	Yes	Yes	-	-	-	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-
Hussey , 1996[15]	Yes	-	-	-	-	-	-	Yes	-	Yes	-	-	-	-	-	-
Kamen, 1971 [16]	-	-	Yes	-	-	-	-	Yes	-	-	-	-	Yes	-	-	-
Klancir, 2016[17]	-	-	-	-	Yes	yes	-	-	-	yes	-	-	-	-	yes	-
Kramp, 2009[18]	Yes	Yes	Yes	Yes	Yes	Yes	-	Yes	Yes	Yes	Yes	-	Yes	yes	-	-
Kraus, 2016[19]	-	-	Yes	-	Yes	-	Yes	Yes	-	-	-	-	Yes	-	-	-
Kunduk, 2010 [20]	Yes	Yes	-	-	-	-	-	Yes	Yes	Yes	Yes	-	Yes	-	Yes	-
Jones, 1976[21]	-	-	-	-	Yes	Yes	-	Yes	-	-	-	-	-	-	-	Yes
Li, 2005[22]	-	-	-	-	-	-	-	-	-	Yes	-	-	-	-	yes	-
Marsico,2010[23]	Yes	-	Yes	-	Yes	-	-	Yes	-	-	-	-	YES	-	-	Yes
Porto, 2012[24]	-	-	Yes	-	Yes	Yes	-	Yes	Yes	-	-	-	Yes	-	-	yes
Richter 2011[25]	-	Yes	-	-	Yes	Yes	-	Yes	-	-	-	-	-	-	-	yes
Young, 1984[26]	Yes	-	Yes	-	-	-	-	Yes	-	Yes	-	-	-	-	-	-
Young, 2006 [27]	-	-	Yes	-	-	-	-	-	-	-	-	-	Yes	-	-	-

Compl: Complication; M: metallic; P: plastic; prev: prevention; R: Reinforced; hyphens correspond to no discussion about the topic in the included paper; yeses correspond to the discussion of the topic in the included paper.

Different contains about tracheostomy cannula according to the research[9-27]

Table 2. Difference between metallic and plastic tracheostomy cannula, according to their possible included parts.

Parts of the tracheostomy cannula	**Metallic**	**Plastic**
Faceplate	Present	Present
Cannula	Present	Present
Radiopaque line in the cannula	Absent	Present
Inner cannula	Present	Sometimes present
Universal Hub 15mm	Absent	Present
Pressure line/pilot balloon	Absent	Sometimes present
Cuff	Absent	Sometimes present
Subglottic aspiration system	Absent	Sometimes present
Obturator	Present	Present

Tracheostomy cannula's material.

Tracheostomy cannula's materials can be plastic, reinforced (armoured) or metallic. (Figure 2) Plastic tubes can be either silicone or polyvinyl chloride (commonly known by its acronyms PVC).4-6Silicone is naturally soft and unaffected by temperature, by the time polyvinyl chloride softens at body temperature (they are thermolabile), conforming to patient anatomy and centering the distal tip in the trachea[7,9,14,18].

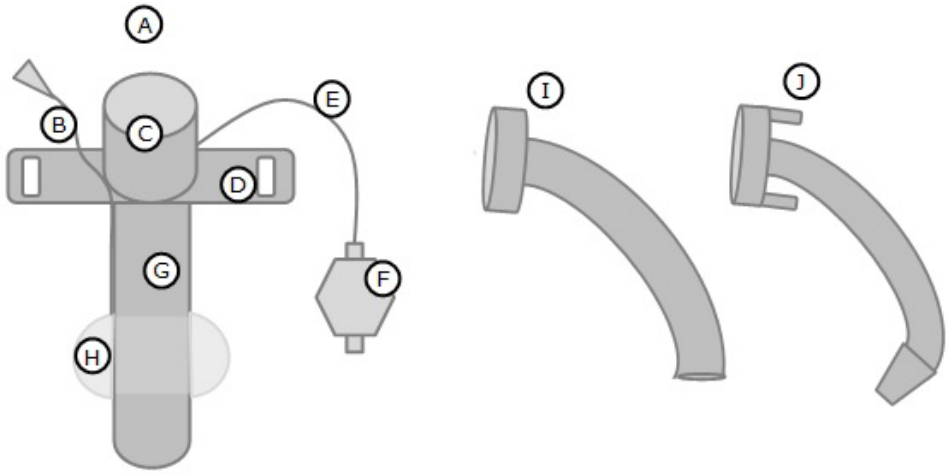

Figure 2. Tracheostomy cannula parts. A: Tracheostomy cannula; B: Subglottic aspiration system; C: Hub; D: Faceplate; E: Pressure line; F: Pilot balloon; G: Fixed cannula; H: Cuff; I: Inner cannula; J: Obturator.

Source: Data elaborated by the authors.

The thermal behaviour of plastic materials provides a possible explanation for our observation of a significant improvement in leakage rates when tracheostomy tubes were tested at body temperature. Tracheostomy tubes are made from polyvinylchloride or polyurethane, and inner tubes are made from polypropylene. These materials are thermoplastics: they expand and become more pliable as temperature rises[10,14]. At body temperature, the leakage rates of these tracheostomy tubes diminishes to less than 1%[10].

Reinforced tubes are plastic ones with stainless steel spiral helical perpendicularly to the fixed cannula. The reinforcement acts as a support structure for the tracheostomy cannula and protects the tracheostomy fixed cannula from buckling and bending[9-23].

Metallic tracheostomy cannulas are constructed of silver or stainless steel[7]. They all have the same 90° curve-angle and diameters, independently on the brand, based on the Jackson sizing system[7]. The only difference on metallic tracheostomy cannulas are their sizes, which can be short, standard and long[4-7,10,14].

People who wear or a metal tube cannot be under the need of mechanical ventilation. Because metallic cannulas do not seal trachea diameter, they allow a certain amount of communication to upper air way and some air leak during ventilation. Other disadvantages include the missing adaptation to the anatomic situation which is due to the material, the discoloration after some time, and the high costs[14,18].

Besides that, patients with reinforced or metallic tracheostomy cannulas cannot take a magnetic resonance image (MRI), because the MRI contains a magnet, metal-containing objects may fly from the body across the room (harming the patient) and will move toward the equipment (damaging it)[9]. Thus, it is recommended to change the tracheostomy cannula into an equivalent plastic one before taking the exam[18].

It's not recommended to wear a reinforced or a metal tracheostomy cannula if a computed tomographic (CT) image of the head, neck and torso is needed because the metal will cause image artifact and impair the evaluation, therefore the image will not be as accurate as it should be. In this case it is also recommended to change the metallic tracheostomy cannula into an equivalent plastic one[10]. Nonetheless, if the CT will be performed in a distant place from head, neck and torso, it will not interfere in the image. In this case the tracheostomy cannula change is not needed[18].

Ten specific parts were found to differ the tracheostomy cannulas and received attention in this current trial. (Figure 2) Although there are differences among them, all kits have something in common. They all have a tracheostomy cannula with a hub and a faceplate and an obturator. Other details refer to presence of absence of a pressure line with a pilot balloon and a cuff, an inner cannula and a subglottic aspiration system.

Each of these mentioned parts have characteristics, specifications and details to take care as follows.The darker colour corresponds to the mentioned details. (Figure 3).

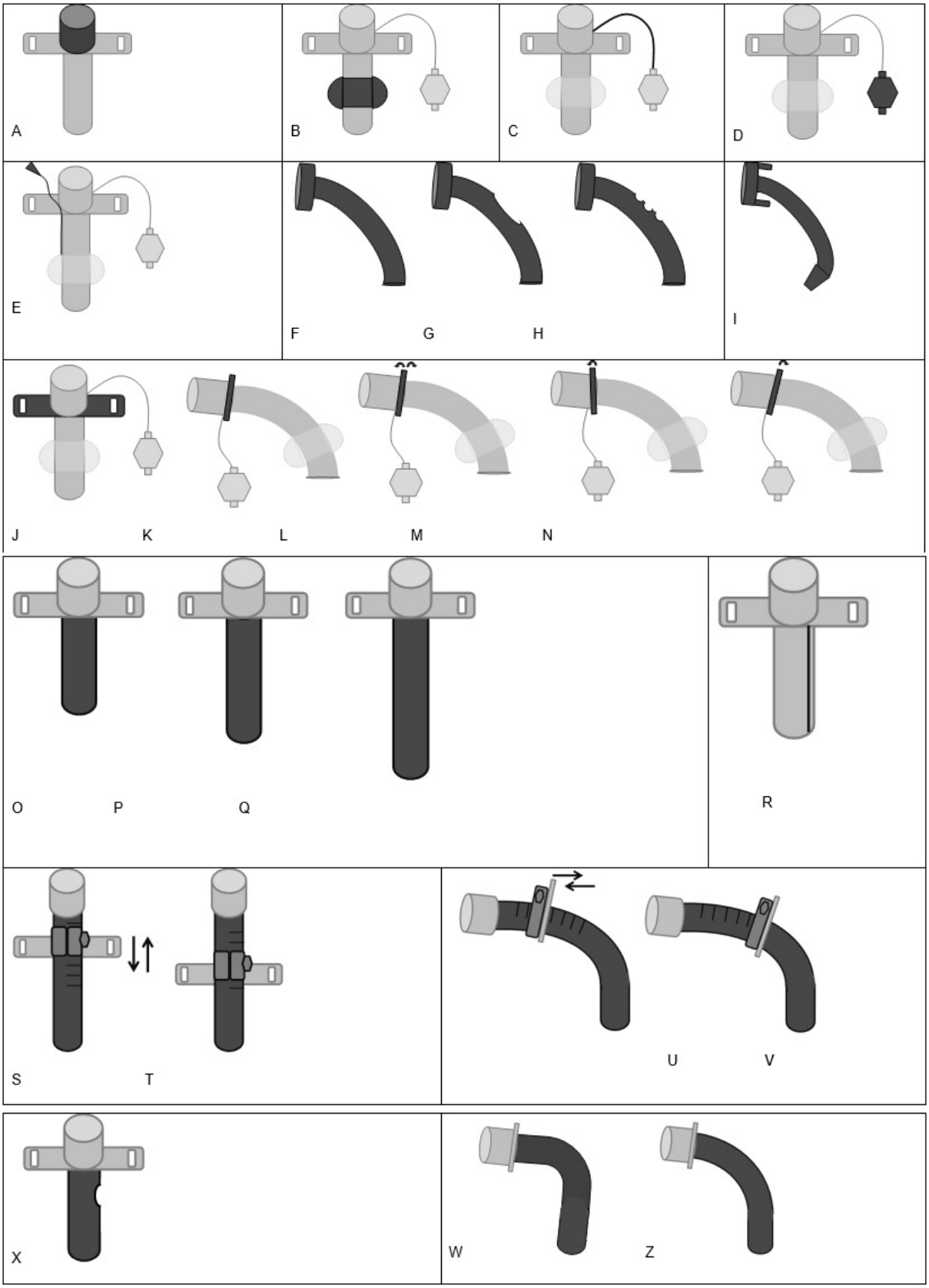

Figure 3. Specific tracheostomy cannula parts. A: Hub; B:Cuff; C:Pressure line; D:Pilot balloon; E: Subglotic aspiration system; F: Solid inner cannula; G: inner cannula with a single fenestra; H: inner cannula with multiple fenestras; I: Oobturator. J-K: Faceplate: K: Fixed faceplate; L: adjustable faceplate; M: faceplate frontlyadjustated; N: faceplate backlyadjustated. O: Small length of the fixed cannula P: Standard length of the fixed cannula; Q: Long length of the fixed cannula. R: Radiopaque line in the plastic fixed cannula. S-V: Adjustable cannula frontal view (S, U) and lateral view (T, V) placed superior (S, U) and distally (T,V); X: Fixed cannula with a fenestra; W: Fixed cannula more angulated; Z: Fixed cannula less angulated.

Source: Data elaborated by the authors.

Universal Hub 15mm

The hub is rounded and it is one of the external parts of the tracheostomy cannula. (Figures 2C; 3A). Hubs are 15 mm diameter in plastic models. In most of the cases universal hubs are fixed in plastic cannulas, however there are some models which have the hub among the kit, as a detached part. They allow perfect attachment to the manual resuscitator, to the mechanical ventilator circuit, and to a speech valve[4,5,14,18]

Metallic tracheostomy cannulas don't have a hub that fits perfectly to these breathing systems[7,14,18]. Metallic hubs are shorter and smaller in all brands than the plastic ones. (Figure 1C).Therefore, in case of ventilation need, only the plastic tracheostomy cannula should be used. Other possibilities can be performed in case of emergency: a) a connector from an endotracheal tube should be removed and placed in the metallic tracheostomy cannula while ventilation is performed; or b) the metallic tracheostomy cannula can be occluded and ventilation is performed with a manual resuscitator in the upper airway (people after total laryngectomy must not have this type of ventilation due to the lack of communication throughout the larynx).

Faceplate

A faceplate, also known as neck plate, is a perpendicular external part of the tracheostomy cannula. It separates the hub from the fixed cannula in a horizontal position. The faceplate supports the main tube structure, and is used to fix the cannula to the neck of the patient. (Figures 2D, 3J-N).2-5In addition to this, the faceplate makes the tracheostomy cannula stable, making the cannula impossible to progress into the trachea[3-6].

The faceplate has two openings, one at each side, called tape eyelet. The cannula can be fastened properly with a cotton tissue (Figure 4C1-C3) throughout theses eyelets and around the neck, not too tight to interrupt circulation, not too loose to decannulate. The ideal fixation with soft tissue should allow a centimeter of distance between the tissue and the neck. When there is a high risk of decannulation or when fixation with a tissue cannot be applied, the faceplate can be sutured directly into the patient's skin[1-4,7,11].

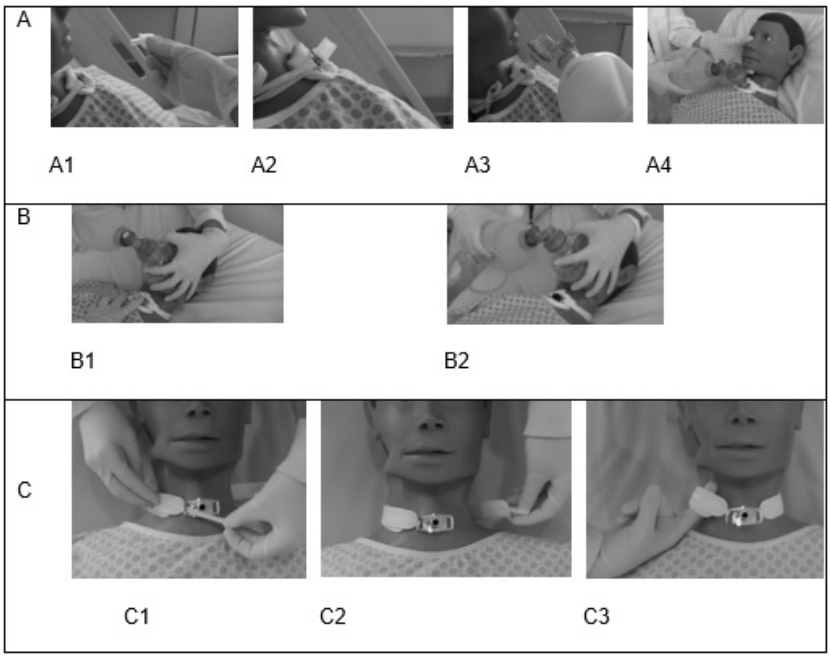

Figure 4. A and B: Ventilation in metallic tracheostomyzed patients. (A1-A4): A1: Placing a connector from an endotracheal into the metallic tracheostomy cannula. A2: the connector is placed into the cannula. A3: ventilation is performed with a manual resuscitator through the metallic tracheostomy cannula. A4: Not that the upper airway can be closed to avoid air leak throughout. B1: the metallic tracheostomy cannula is handed occluded and ventilation is performed with a manual resuscitator through the upper airway with patient in the "ear to sternal notch positioning". B2: the metallic tracheostomy cannula is handed occluded and ventilation is performed with a manual resuscitator through the upper airway with patient in the "ear to sternal notch positioning". C: Tracheostomy cannulas fixation (in metallic or in plastic ones). C1-C2: measure the fixation according to the circumference of the neck, until both extremities can reach the holes in the faceplate and fix one side at a time. C3: do not fix the fixation too tightly. Allow some space between the neck and the fixation.

Source: Data compiled by the authors.

Sterile tracheostomy dressings allow secretions from the stoma to be absorbed and prevent pressure damage from the tracheostomy tube[11]. A correct management of the face plate may imply in a granuloma prevention, because granulosis in its tracheobronchial involvements lead to stenosis. The growing of proliferative tissue towards the larynx and trachea may cause airway obstruction on account of subglottic stenosis. In this situation, the surgical goal is to eliminate the airway obstruction by providing natural airway anatomy. While mild lesions do not require surgical intervention, in fixed lesions, surgical intervention is required, such as tracheostomy, laser resection and dilatation. In tracheostomised patients, granuloma formation surrounding the tracheostomy cannula may occur in the trachea. Inflammation and newly formed granulation tissue result in severe stenosis in the airways[9,11].

In some plastic models, the faceplate contains the tracheostomy cannula configuration: brand, model, number; ID - inside diameter; OD - outside diameter of the outer cannula; and length[1-7,10,23], according to the International Standards Organization method.7In the metallic models, the only information in the faceplate is the number of the cannula, because all other information is similar and does not depend on manufactures[1-7,23].

Dependently on the model and manufacture the faceplate can be either fixed or adjustable. Fixed faceplates are normally perpendicular to the hub. Adjustable faceplates can move back and forth, according to a person's neck anatomy. (Figure 3L-N)1-7,10,23

Fixed faceplates in patients with cervical hyperextension can provide the distal portion of the cannula to move forward and reach the anterior tracheal wall, causing harm to the tracheal[1,13].

On the other hand, whenever a cannula with fixed faceplates is present in patients with head protrusion[11,14,19] the distal portion of the cannula may move in direction to the posterior tracheal wall and cause obstruction or partial occlusion of the tracheostomy tip or patient-ventilator asynchrony[16].

Tracheal wall erosion, tracheo-innominate artery fistula, tracheo-oesophageal fistula and stomal breakdown can also be present[9,10,12,17,19] because posterior membrane is very soft and cannot absorb impact trauma[3,25].

In case of a person's having different cervical anatomy (head protrusion, elderly, obese and kyphotic, head retraction, or shortening of the anterior muscle chain)[19], the adjustable faceplate will make the fixed cannula fit accordingly, without moving the internal part of the tracheostomy cannula, and avoids dysphagia, irritative cough and expulsion of the cannula from trachea. Granulation can also be avoided with the use of adjustable faceplates because it reduces the shear stress through the neck movement[3,14].

Fixed Cannula

The fixed cannula is the main body of the tracheostomy cannula[5]. It is the part of the tracheostomy cannula which is intimate contact to the patient's trachea. (Figures 2G and 3O-Z). The material of the fixed cannula can be metallic, reinforced or plastic. The plastic ones have a radiopaque line throughout its cannula (Figures 2E and 3C). This line can be identified on a chest-RX image to precise the location of the tracheostomy cannula[2,4].

1. Sizes of the fixed cannulas

Fixed cannula's have three different sizes. Based on the Jackson sizes from metallic tracheostomy cannula, they can be short, standard or long for plastic or metallic tracheostomy cannulas[13,14].

Plastic tracheostomy cannulas can also be adjustable. It has an adjustable faceplate (useful for patients with tracheal abnormalities, for patients with unusual anatomy of neck, particularly when the depth of the trachea is such that the fixed curvature of a standard tracheostomy tube is unsuitable (eg obese patients). Not too short neither too long because it can cause damage on the anterior and the posterior portion of the trachea[17-19].

Tracheostomy cannulas of the sizes commonly employed in adults are number 7 and 8 Jackson, resulted in work of breathing similar to mouth breathing. Tube sizes 9 through 12 reduced the

work to values below that of mouth breathing. The trachea of an adult will usually accept a tube of 11 mm. in diameter (number 10 Jackson). The elastic work (work to maintain distention of the lungs) also increased with small size cannula but was similar to mouth breathing with the number 7 and 8 cannulas[13].

2. Angulation of the fixed cannnula

The fixed cannula of the tracheostomy cannula can also differ on its angulations. It can be more or less curveted, which will give a more or a less angled cannula (Figures 3W and 3Z, respectively)[1-5,14,25].

The shape of the tube should conform as closely as possible to the anatomy of the airway, and to the muscle neck effort or cervical position.1,25,26 With abnormal neck positioning were seen in 48% of patients with tracheo-innominate erosions. In 69% of 96 instances, the site of erosion was located at the cannula end and implicates excessive anterior pressure[21] (Figure 5).

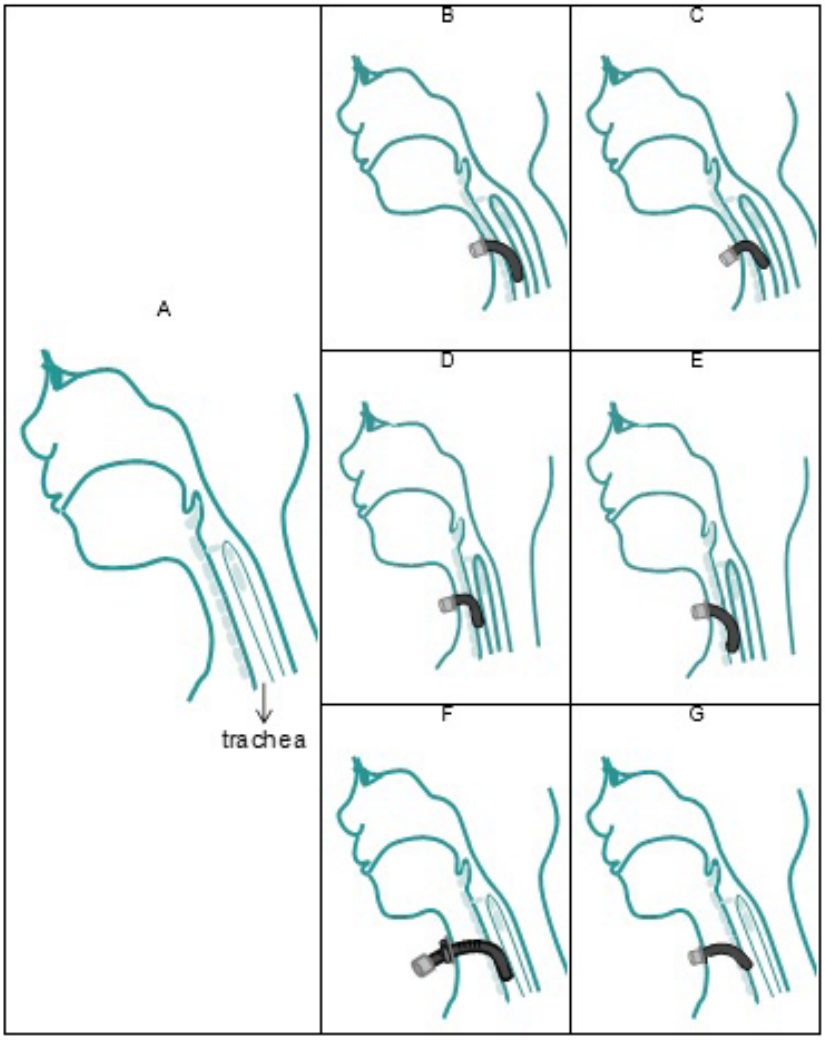

Figure 5. Position of tracheostomy cannulas in the trachea. A: an expected neck and airway anatomy. B: Position of correct curved tracheostomy cannulas in a patient with head protrusion. C. Position of incorrect angled tracheostomy cannula. Note that the distal tip of the tacheostomy cannula touches the posterior wall of the trachea, which can favor lesion to the trachea and cause distal tracheostomy-tube obstruction, compromising ventilation. D. Position of correct angled tracheostomy cannula in a patient with head retraction. E. Position of incorrect curved tracheostomy cannula. Note thatthe distal tip of the tacheostomy cannula touches the anterior wall of the trachea, which can favor lesion to the trachea and cause distal tracheostomy-tube obstruction, compromising ventilation. F. Position of correct adjustable tracheostomy cannula in an obese patient. G. Position of incorrect tracheostomy cannula in an obese patient. Note that this tracheostomy cannula is too short, almost doesn't reach the trachea, being under a high risk of hurting the anterior soft tissue of the neck, and under a high risk of decannulation.

Source: Data elaborated by the authors.

A less angled fixed cannula (112°) can diminish dysphagia and irritative cough in people with tracheostomy cannula. A malpositioned cannula can be a source of patient distress. The fixed cannula is continued from the faceplate to its tip and does not have an additional hole at the tip (called a Murphy's Eye) as endotracheal tubes. This mean if the main opening of the fixed cannula gets blocked by abutting against the tracheal wall, gas flow cannot occur anywhere else[2,3,14].

Once again, if a less angled cannula is placed in patients with head protrusion, with shortening of the anterior muscle chain, and obese the distal portion of the cannula may move in direction to the posterior tracheal wall and cause obstruction or partial occlusion of the tracheostomy tip or patient-ventilator asynchrony[15] tracheal wall erosion,tracheo-innominate artery fistula, tracheo-oesophageal fistula and stomalbreakdown so, whenever the patient has head protrusion, a more curved fixed cannula is indicated[1,14,17].

If a more angled cannula is placed in elderly patients or in patients with head retraction orkyphotic, the distal portion of the cannula may move in direction to the anterior tracheal wall, and cause obstruction or partial occlusion of the tracheostomy tip, patient-ventilator asynchrony, anterior tracheal wall erosion, fistula and stomalbreakdown[1,17]. Subsequently, whenever the patient is found as described above, a less curved fixed cannula is indicated, avoiding complications as cited previously[1,3].

Thus, the correct angulation of a fixed cannula make the difference in ventilation, in work of breathing and in lesion to the trachea[3,16,17].

3. Fenestrated Fixed cannulas

Fixed cannulas can fenestrated or unfenestrated. When cannulas are fenestrated, these can have single or multiple fenestras. Fenestra is a circumscribed opening in the plane convex surface of the cannula, on the posterior portion of the tube, above the cuff. When the cannula in cuffed the fenestras are present above the cuff. Fenestrated cannulas with cuff have the opening in the tube between the external orifice and the cuff[7,12,14,15,17,20].

Fenestrate was designed to allow gas to pass up to and down from the larynx, resulting in communication when on ventilation, used for patients who have difficulty in adapting to a speech valve. However fenestra can hold secretions, which must therefore be under frequent nebulization and evaluated constantly by the staff[15,23].

One aspect of fenestrate cannula is respiratory effort: the effort required to move gas across the native airway in the absence of a fenestration may be substantial. If a patient is to breathe through a native airway, a fenestrated tube should be used unless the tracheostomy tube is a number 4[15].

Another particular issue regarding this topic is that the use of a fenestrated tracheostomy tube in combination with a fenestrated inner cannula is advantageous, because the work of breathing is minimised by the low airflow resistance afforded by these tubes. Even more importantly, swallowing, communication, postural stabilisation, and weight-bearing ability are better supported by dual-cannula fenestrated tracheostomy tubes, particularly when a speaking valve is mounted. However, Subcutaneous emphysema and pneumothorax developing in connection with the use of dual-cannula fenestrated tracheostomy tubes for percutaneous dilatational tracheostomy, many authors advised against the use of these types of tubes in patients who require positive pressure ventilation[10].

Because of these issues related to subcutaneous emphysema and pneumothorax, the UK Intensive Care Society recommended against the use of fenestrated tracheostomy tubes early after stoma.

4. Outer diameter

The outside diameter is the largest diameter of the outer cannula.7The OD of the cannula must be related to the stoma size. If the stoma is bigger than the fixed cannula, cuff will need to be adjusted in a high pressure, but it can damage the trachea wall[7,22]. If the stoma is much bigger than the fixed cannula, cannula can slip out and be exteriorized from the body by a simple cough. If the stoma is much smaller than the cannula, it will be difficult to place the tracheostomy cannula into the neck, without lacerating the skin and soft tissue around it[26,27].

If the OD is too large, leak with the cuff deflated will be decreased, and this will affect the speech with cuff deflation[26].

5. Inside diameter of the fixed cannula

The ID of the tube is the functional ID[10,12-16,18,21,23,24]

If the ID is too small, it will increase the resistance through the tube, make airway clearance more difficult, and increase the cuff pressure required to create a seal in the trachea[2,7,12,13,18,23].

During spontaneous breathing through a tracheostomy, the inside diameter of the fixed cannula is related to the work of breathing[10,24]. The lower the internal diameter is, the higher the input resistance in muscles is[10,12-16,18,21,23,24]

6. With or without an inner cannula (mobile cannula)

An inner cannnula, also called mobile cannula, (Figures 2I and 3F-H) is another optional part of the tracheostomy cannula kit. The inner cannula is removable tube which passes into the outer.5 When the inner cannula is present, the kit receives the name of 'Double lumen'. When the inner cannula is absent, the kit receives the name of 'Single lumen'[23-26].

Once the patient breathes through tracheostomy, there is no filtration through the tracheostomy cannula (which happens to a nosebreather), so it is common to have acumnulated pulmonary secretions in its wall. Because of this possibility, obstructing the tracheostomy cannula with secretion plugs is smaller with the use of inner cannula. The inner tube can be removed and cleaned thus reducing the chance of blockage and facilitating management of tube obstruction. A randomized controlled trial studied two different kind of cleaning the inner cannula: with (A) detergent and chlorhexidine-alcohol or (B) with detergent only, concluded that cleaning the tracheostomy inner cannula with detergent and water is sufficient to achieve decontamination.

Therefore, a kit with inner cannula is well indicated to patients after discharge of hospitals. It is worth mentioning that inner cannula is present only in plastic tracheostomy cannulas, but not in adjustable ones. The inner cannula ends ups diminishing the internal diameter. There is a significant decrease in work of breathing when the inner cannula is removed. Therefore people with tracheostomy cannula who need mechanical ventilation should have their inner cannula removed[28].

Inner cannula can be with or without fenestras, single (Figure 3G) or multiple (Figure 3H). Inner cannulas can have fenestras even if the fixed cannula has fenestras. Generally the fenestrated inner cannula is used with the cuff of the tube deflated and the external orifice of the tube occluded. This allows the patient to breath through his mouth and allows true coughing, as opposed to huffing. The nonfenestrated inner tube should be used when tracheal suction is performed to ensure that the suction catheter does not pass out through the fenestration and impinge on the tracheal wall[15,20,24,25].

Pressure line and pilot balloon

Pressure line communicates the pilot balloon to the internal balloon (cuff) (Figures 2F and 3D). The pilot balloon has its own port with 1-way valve,7 to prevent loss of cuff pressure[13,20].

Patients need to be instructed to not fold the pressure line and to not infuse water in the pilot ballon. Only air must be infusion in the pilot balloon, which will run through the pressure line to the internal balloon (cuff). The luer slip syringe is more appropriate (and not the luer lock syringe) to perform the inflation and the deflating balloon procedure.

With time, both pressure line and pilot balloon can get stiffed due to the contact with the external environment (differences in temperature, contact with products and moisturizers). The difference in temperature (from inside the body to the ambient) can also provide condensation inside the pilot balloon.

Cuff

Cuff is a plastic inflatable part of an endotracheal tube, placed on the lower bottom of the fixed cannula (Figures 2H and 3B). Cuffs can be made

of silicon or PVC, even with a different material. Double lumen or Single lumen cannula can be cuffed or uncuffed[10,12,13,14,18-21,23,24,27].

The inflated cuff is present to seal between the tube and tracheal wall, ensure proper ventilation without air leaking to the upper airway,5 and they also offer some protection from aspiration.

Cuffs can be tapered or cylindrical-shaped. A tapered-shaped cuff considerably improves air-sealing and allows thereby reducing cuff pressure required for sufficient ventilation.

Speech can also be present in patients with a cuffless tracheostomy cannula, once the patient has adequate pulmonary compliance and sufficient oropharyngeal muscle strength for functional swallowing and articulation.

Although tracheal capillary perfusion pressure is normally 25–35 mm Hg , nd pressures above these limits interfere in the capillaries of the tracheal wall and circulation of the tracheal mucosa is no longer secured, the risk of necrosis is increased, the most interesting issue is to ensure cuffs are inflated with the minimal quantity of air until there is no air leak from the stoma or from the upper airway, having this 25–35 mm Hg as an upper limit pressure adjustment, not as a target. . The cuff pressure must not be higher than 35 mm Hg and should be controlled with a manometer[18,30,31].

Patients with tracheostomy cuffed cannula need to have cuff pressure controlled in order to prevent: air leak when on mechanical ventilation; injury to the trachea; esophageal obstruction and tracheoesophageal fistula.

The patient may be able to eat and to speak without a valve speech with oclusion in its hub in cannula models without cuff or with an unflated cuff. Cuffs can also be made of a) high volume low pressure plastic; b) low volume high pressure polastic; 23 or c) foam (polyurethane foam covered by asilicone sheath)[14].

High volume low pressure cuff is more common nowadays because of the lower probability of harming the patient and of having pulmonary aspiration. Leakage of fluid from the subglottic space to the lungs occurs along the longitudinal folds within the wall of an inflated high-volume, low-pressure cuff. The low-volume, low-pressure cuff does not have these folds yet allows convenient and reliable control of tracheal wall pressure[14,27].

The foam cuff has passive cuff inflation. foam cuffs have some advantages: the foam reduces risk of damage from over-inflation of cuff, prevents tracheomalacia, and prevent further lesion whenever tracheal injury related to the cuff is already installed[13].

In a tracheostomy cannula with a foam cuff, the open pilot port also permits compression and expansion of the cuff during the ventilatory cycle. The degree of expansion of the foam is a determining factor of the degree of tracheal-wall pressure, however do not exceed 20 mmHg[25,26]. Before cannula insertion, air in the cuff is evacuated by a syringe attached to the pilot line. Once the cannula is in place, the syringe is removed to allow the cuff to re-expand against the tracheal wall. At this moment, the intra-cuff pressure is at ambient levels because the pilot line remains open to the atmosphere[7]. If the tracheostomy cannula is too small, the foam inflates but there will be air leak and aspiration predisposition. If the tracheostomy cannula is too large, the foam is unable to expand properly and there will be an increase in pressure against the tracheal wall[7,23].

Cuff deflation of the tracheostomy tube is performed not only to facilitate spontaneous breathing and promote swallowing but also, and arguably more importantly, to enable communication[10].

Additional important issues to recall are the followings: First of all, paediatric population require cuffless cannulas due to the conic shape of the trachea[19]. Second of all, metal tubes are only cuffless (Figure 1C). Finally, plastic cannulas, independently on their plastic material can have cuff (Figures 2H and 3B).

Subglottic aspiration system

The subglottic aspiration system communicates the cuff's upper part to the exterior by a line with a

connector proximally. (Figures 2B and 3E). The subglottic aspiration system brings the facility for subglottic aspiration of secretions and may contribute the microaspirations' prevention[20].

Obturator

The obturator is always a kit part of any tracheostomy cannula, no matter its manufacturer. The obturator is always longer than the fixed cannula, and has a rounded-distal-tip. (Figures 2J and 3I).The obturator must be used through the lumen of the fixed cannula at the time of its introduction to the trachea of the patient. The obturatormust be removed once the tube is in place[7,13,20,25].

Because the obturator has this conical shape, it minimizes the risk of injury of the structures involved in traqueoestoma and the tracheal wall while the cannula being introduced[12,13,15,25].

Its right placed, besides right choice of the cannula number may help avoiding damage to posterior or anterior tracheal wall, false passage or paratracheal placement or dislocation of the cannula, which are considered to be responsible for the development of pneumothorax and subcutaneous emphysema[17].

The slightly oiled tracheostomy cannula is inserted with a turning of 90° into the tracheostoma[18].

CONCLUSION

Knowing and understanding tracheostomy cannulas. particularities may imply in a better approach to the patients, and in minimizing institutional costs.

LIMITATIONS

Bias in measurement errors or misclassification can be considered minimal due to the lack of quantitative measurements selection. We did not extract conventional numeric information because this paper did not compare two different treatments, as some systematic review do.

Lack of founding resources may have limited collected studies; nonetheless, as a qualitative review, we believe we have fulfilled some lacking in current literature.

Although this paper has limitations, it clarifies several issues regarding tracheostomy cannulas. which may help daily hospital routine in patients' care. Presentation in pictures themselves, as we did in this current paper is on of strongest point of the publication, have a tough connected approach in educational behavior among healthcare staff.

AUTHOR CONTRIBUTIONS

Tavares AC was responsible for the study design and concept, the literature research, the paper's writing and the critical review. Machado LM was responsible for the lierature research and the critical review.

COMPETING INTERESTS

No financial, legal or political competing interests with third parties (government, commercial, private foundation, etc.) were disclosed for any aspect of the submitted work (including but not limited to grants, data monitoring board, study design, manuscript preparation, statistical analysis, etc.).

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