Review

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Development of an airway bundle in the Emergency Department: improving the odds against the airways

Desenvolvimento de um bundle de via aérea no departamento de emergência

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ABSTRACT

Proficiency in airway management is a fundamental competence of every emergency physician. However, the scenario and patient conditions are often not ideal, increasing the procedural risk. The development of an airway bundle, including an airway trolley with separate drawers, an airway approach plans organized by colors and steps, a checklist and cognitive aids, aims to reduce the morbidity and mortality of the procedure in a scenario where anatomical, physiological and psychological factors tend to cause more difficulties than any other place in the hospital.

Keywords: Airway management; Patient safety; Emergency; Patient care bundles; Checklist; Decision making

RESUMO

A proficiência no manejo da via aérea é uma competência fundamental para todo emergencista. No entanto, o cenário e as condições dos pacientes não são ideais na maioria das vezes, o que eleva o risco do procedimento. Dessa forma, o desenvolvimento de um pacote de via aérea, incluindo um carro específico com gavetas separadas, planos de abordagem à via aérea organizados por cores e etapas, *checklist* e ajudas cognitivas, visa diminuir a morbimortalidade do procedimento em um cenário em que os fatores anatômicos, fisiológicos e psicológicos tendem a causar mais dificuldades do que em qualquer outro local do hospital.

Descritores: Manuseio das vias aéreas; Segurança do paciente; Emergências; Pacotes de assistência ao paciente; Lista de checagem; Tomada de decisões

INTRODUCTION

Airway management is a routine procedure in the Emergency Department (ED). In this setting, there is usually not enough time to fully prepare patients as they do not undergo extensive pre-procedure assessment, do not have an adequate fasting period, and often present with hemodynamic/respiratory instability or imminent airway compromise. These patient-level characteristics along with environmental factors such as an overcrowded and understaffed ED may increase the complexity of the procedure, with increased risk of catastrophic consequences for patients, providers, and the healthcare system.

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The Fourth National Audit Project of the Royal College of Anaesthetists and Difficult Airway Society (NAP4) was responsible for bringing to light a detailed analysis of airway-related complications.[1-3] It showed that clinical outcomes could have been different if a structured approach to airway management had been undertaken.[4] When a difficult airway arises, it is crucial to act in a rapid and systematized manner. Essential equipment, for example, must be logically organized in a nearby location. Nevertheless, evidence from the NAP4 analysis showed that getting basic equipment such as endotracheal tubes, guidewires, nasopharyngeal cannulas, or supraglottic devices can be much slower than anticipated. In these situations, the risk of cognitive overload and deteriorating decision-making ability can negatively affect patient outcomes.[5]

With the goal of minimizing complications related to airway management in the ED, we developed an "airway bundle" that includes a pre and post intubation checklist, a medication box with labels, structured plans and a trolley with color coded drawers.

The main objective of our experience report is to share how we develop an airway bundle. This bundle was created in the ED of the *Hospital de Clínicas de Porto Alegre* (HCPA), a large tertiary hospital with more than 800 beds and an average 30.000 number of ED visits per year.

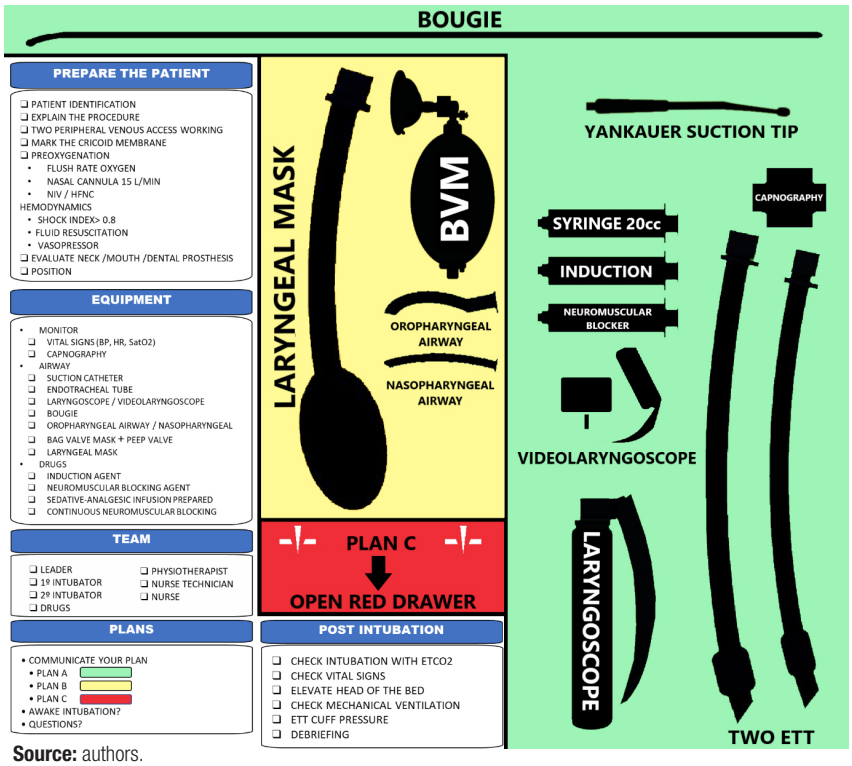
METHODS

The airway bundle was developed to fit the local conditions of our ED after reviewing evidence-based guidelines[5-8] and prior experiences on developing airway trolleys.[9,10] We used an iterative process in which the elements of the bundle were first presented to stakeholders involved in airway management in the ED including registered nurses, nurse assistants, respiratory therapists, residents and attendings. Based on the team's feedback, adjustments were made before its final assembly.

RESULTS

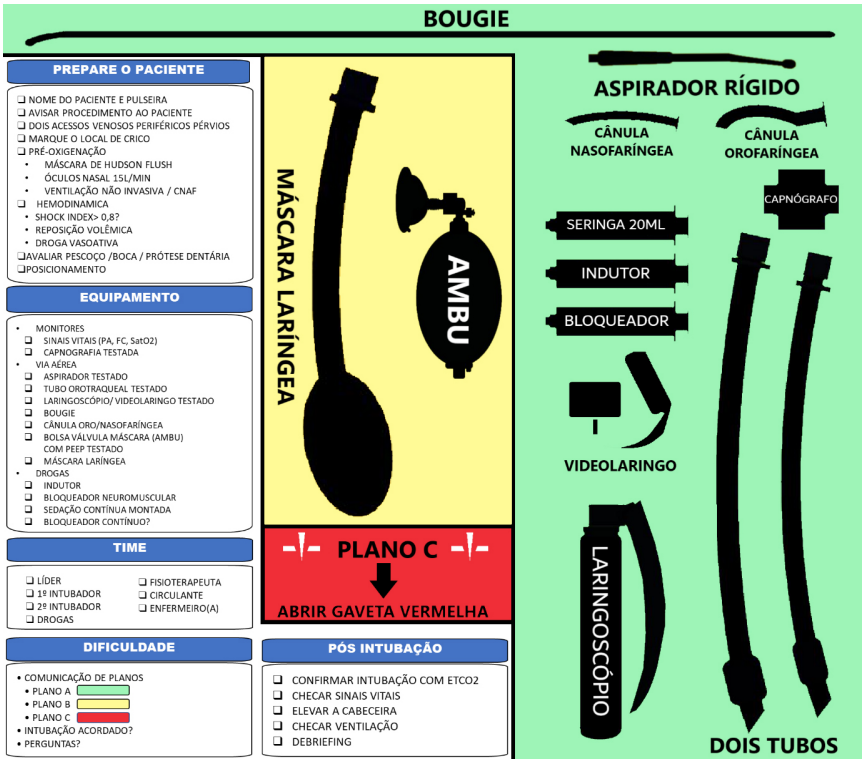
Airway checklist

An airway checklist was created based on prior published examples.[6,11-13] Prior to its final version, we iteratively tested draft versions in real cases and actively asked for feedback from key stakeholders. The final English and Portuguese version are available in the **Figures 1 and 2**, respectively. In order to integrate this element into the bundle, we printed the checklist along with a graphic representation of the procedural materials (i.e., pictogram) and we adhered it to the lid of the trolley (**Figure 3**).



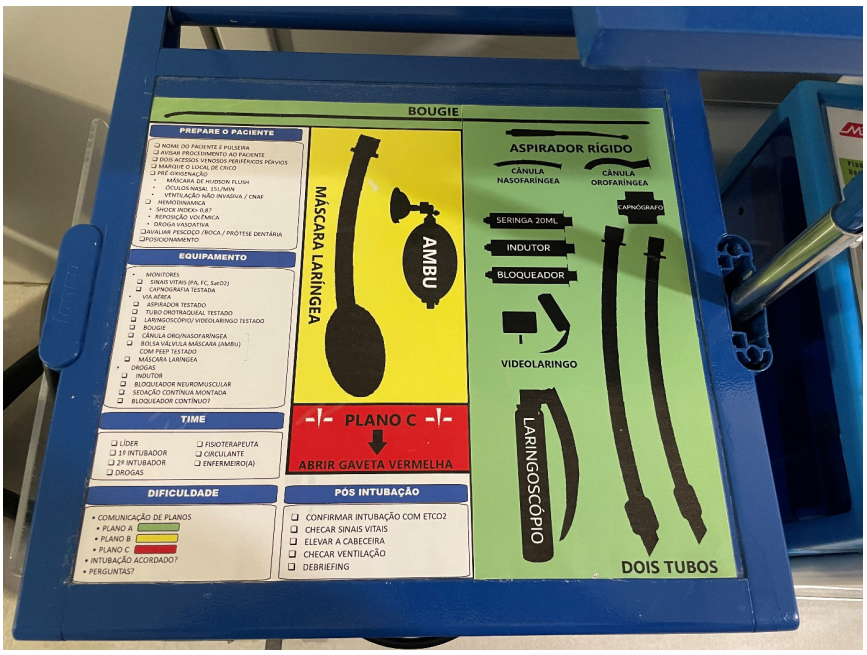
Source: authors.

Figure 1. Checklist in English.



Source: authors.

Figure 2. Checklist in Portuguese.



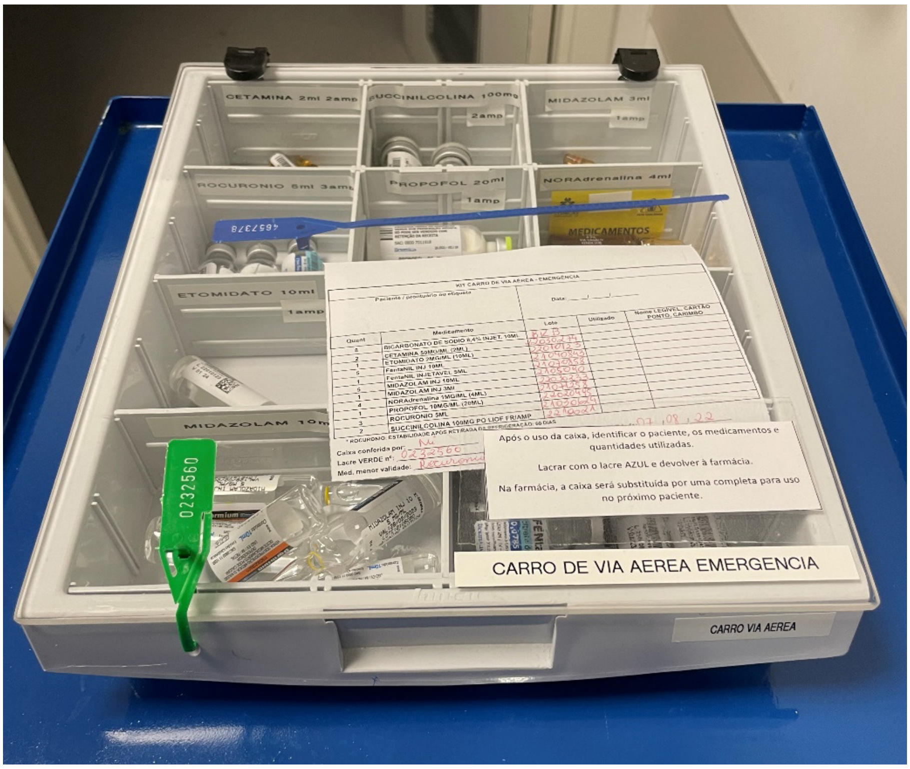
Source: authors.

Figure 3. Airway lid with pictogram.

The checklist was divided into five main elements: patient preparation; equipment, monitors, and medications; role assignment by the leader followed by team members saying their names and roles prior to intubation; physician responsible for the airway explains what is the plan, and ask for questions and suggestions; post intubation: vital signs check, head of the bed adjustment, ventilator settings and, most importantly, debriefing.

Airway medication box

An airway medication box was created in order to expedite the process of acquiring the medications needed for the procedure. It stays on top of the trolley **(Figure 4)**. After discussing the procedural workflow with nursing technicians and pharmacists, we identified that team members often had to moved away from the bedside to get medications during critical periods of the procedure. Also, labeling **(Figure 5)** of each syringe with the different medications was difficult due to time constraints. For this reason, we created labels with drug names and their concentrations. The following drugs were included in this box: etomidate, ketamine, succinylcholine, rocuronium, midazolam, fentanyl, propofol, noradrenaline, and bicarbonate.



Source: authors.

Figure 4. Medication box.

PROPOFOL (10mg/ml)	FENTANIL (50mcg/ml)	ETOMIDATO (2mg/ml)	MIDAZOLAM (5mg/ml)	CETAMINA (50mg/ml)
PROPOFOL (10mg/ml)	FENTANIL (50mcg/ml)	ETOMIDATO (2mg/ml)	MIDAZOLAM (5mg/ml)	CETAMINA (50mg/ml)
PROPOFOL (10mg/ml)	FENTANIL (50mcg/ml)	ETOMIDATO (2mg/ml)	MIDAZOLAM (5mg/ml)	CETAMINA (50mg/ml)
PROPOFOL (10mg/ml)	FENTANIL (50mcg/ml)	ETOMIDATO (2mg/ml)	MIDAZOLAM (5mg/ml)	CETAMINA (50mg/ml)
PROPOFOL (10mg/ml)	FENTANIL (50mcg/ml)	ETOMIDATO (2mg/ml)	MIDAZOLAM (5mg/ml)	CETAMINA (50mg/ml)
PROPOFOL (10mg/ml)	FENTANIL (50mcg/ml)	ETOMIDATO (2mg/ml)	MIDAZOLAM (5mg/ml)	CETAMINA (50mg/ml)
PROPOFOL (10mg/ml)	FENTANIL (50mcg/ml)	ETOMIDATO (2mg/ml)	MIDAZOLAM (5mg/ml)	CETAMINA (50mg/ml)
PROPOFOL (10mg/ml)	FENTANIL (50mcg/ml)	ETOMIDATO (2mg/ml)	MIDAZOLAM (5mg/ml)	CETAMINA (50mg/ml)
SUCCINILCOLINA (10mg/ml)	ROCURÔNIO (10mg/ml)	BICARBONATO 8,4% (84mg/ml)	NORADRENALINA ____mg/ml	ÁGUA DESTILADA
SUCCINILCOLINA (10mg/ml)	ROCURÔNIO (10mg/ml)	BICARBONATO 8,4% (84mg/ml)	NORADRENALINA ____mg/ml	ÁGUA DESTILADA
SUCCINILCOLINA (10mg/ml)	ROCURÔNIO (10mg/ml)	BICARBONATO 8,4% (84mg/ml)	NORADRENALINA ____mg/ml	ÁGUA DESTILADA
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SUCCINILCOLINA (10mg/ml)	ROCURÔNIO (10mg/ml)	BICARBONATO 8,4% (84mg/ml)	NORADRENALINA ____mg/ml	ÁGUA DESTILADA

Source: authors.

Figure 5. Medication labels.

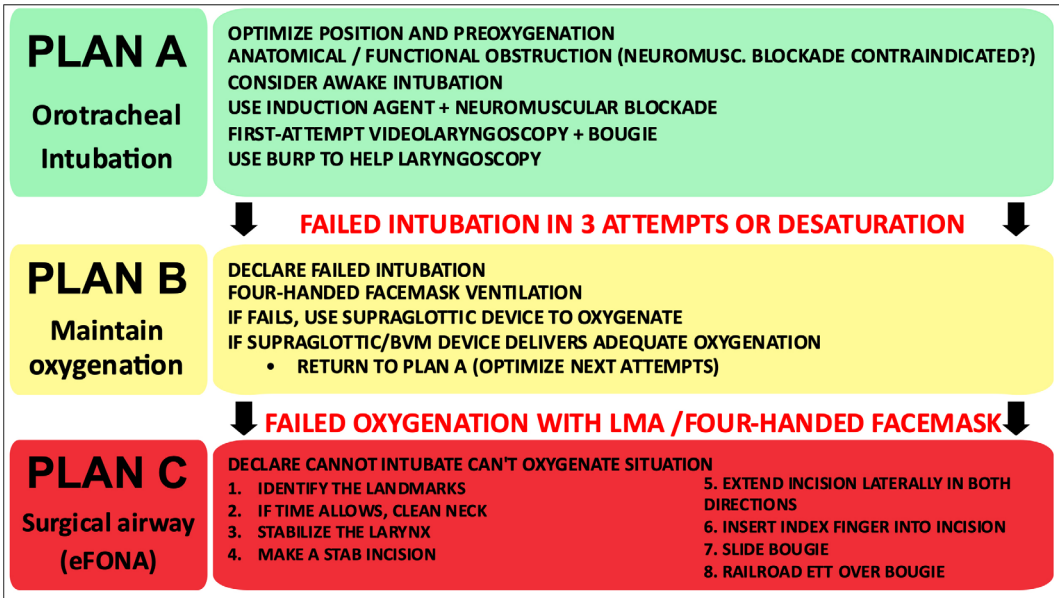
Airway management plans

The definition of plans and the organization of these in sequential form (A, B and C; **Figures 6 and 7**) allows the reproducibility and systematization of these approaches in a simple and logical way. Its use has been associated with better peri-procedural outcomes and less cognitive burden by physicians.[7]

Airway plans are often divided into four: A, B, C, and D. However, we combined C and B because recent evidence shows that joining these plans better reflects an oxygenation rescue phase, interleaving the supra-glottic device, bag-valve-mask and positive end-expiratory pressure (PEEP) valve ventilation.[7] Another reason was that the addition of phases may complicate the decision-making process of performing cricothyroidotomy, a procedure avoided at all costs by many physicians.

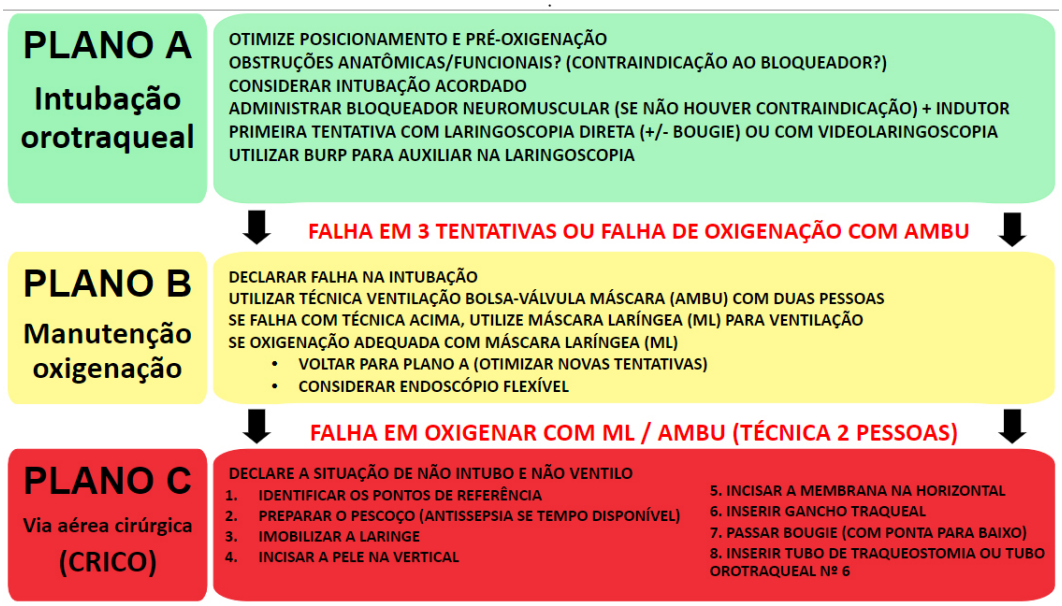
The Difficult Airway Society (DAS) algorithm,[6] the Vortex approach,[14] Sherren et al.[11] and the Bern Hospital protocol in Switzerland[9] were adapted to define the plans that were used in our airway bundle.

Plan A is focused in intubating the patient during the first laryngoscopy. If this fails, the airway physician has two more attempts. If desaturating at any moment during the attempts, it triggers the next plan.



Source: authors.

Figure 6. Airway plans English.



Source: authors.

Figure 7. Airway plans Portuguese.

This "change" should be perceived by the intubator, and if they insist on plan A, someone else (ideally the team "leader" who is not intubating) should guide the change to plan B or C.

Plan A is aimed to achieve the highest first pass success rate possible. Patient position is optimized. Videolaryngoscopy (VL) and bougie are preferred for the first attempt. If glottis visualization is not optimal, displacement of the larynx in the backward and upward directions with rightward pressure on the thyroid cartilage (i.e., backward, upward, rightward pressure [BURP] maneuver) is tried. Another technique that must be used is head elevation by right hand of the physician holding the laryngoscope. Awake intubation using lidocaine spray and gel is another option that should be elicit by the team whenever feasible.

Plan B is aimed to rescue oxygenation. If desaturation occurs during the procedure, risk of post-intubation cardiac arrest increases;[15] therefore, the mindset of the team should shift to a more difficult airway, so that situational awareness increases. If hypoxemia occurs, bag valve mask (BVM) attached to a PEEP valve with the 4- hand technique should be the first choice. In the case it does not change oxygenation, laryngeal mask is the second option. If it improves oxygen saturation, another intubator or a different technique is used (e.g., hyper-angulated blade VL, or fiberoptic intubation) or a different patient position. If it does not enhance oxygenation, airway leader should declare "can't intubate, can't oxygenate" (CICO) situation.

Plan C is cricothyrotomy, and the preferred technique is scalpel-finger-bougie. While preparing for cricothyroidotomy, rescue oxygenation can be attempted with BVM and two people (4-hand technique for mask sealing). As this procedure rarely occurs and it is associated with a highly stressful situation,[16] it is paramount that team members train it through regular simulations.

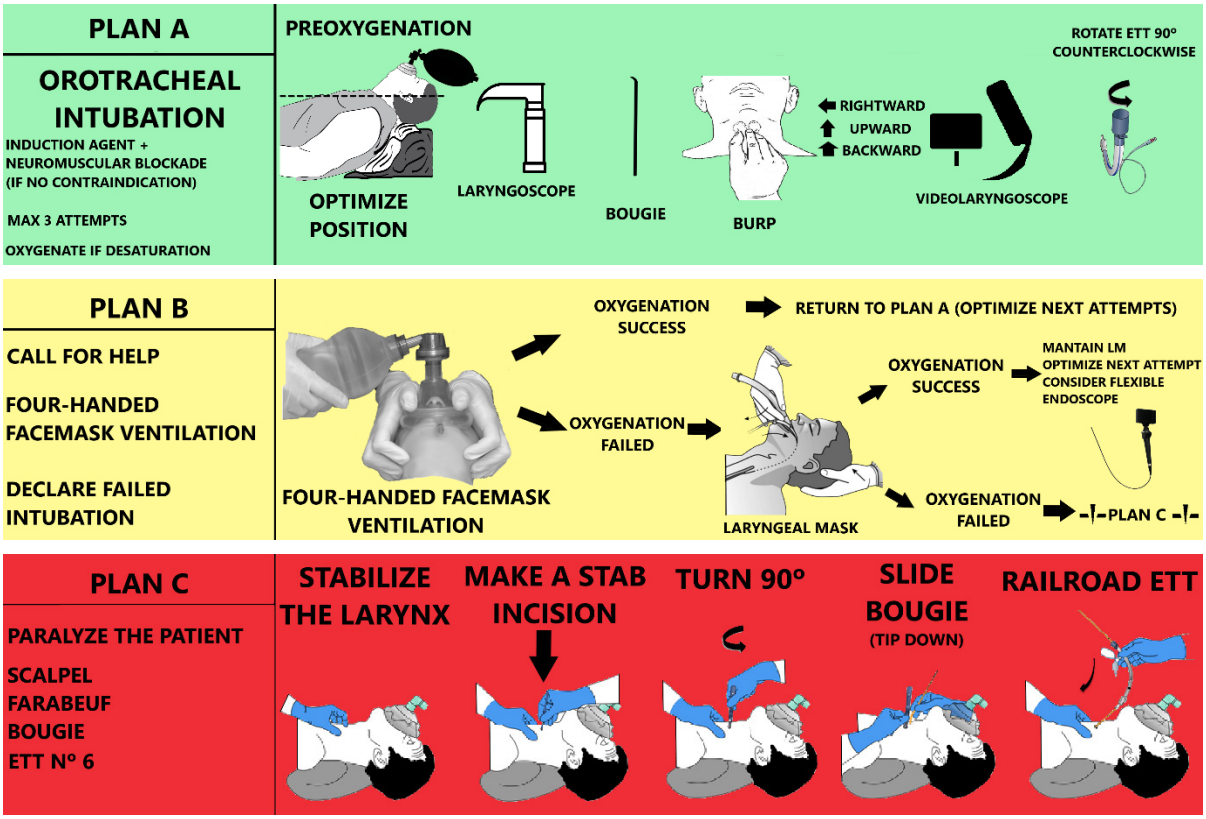
The trolley and its color-coded drawers

The arrangement of the materials occurs according to the management plans (A, B and C). The goal is simplicity, logic, organization, and standardization. To facilitate the intubation process, some cognitive aids were added.

All drawers are individually sealed in order to facilitate the checking process by the nursing staff and are easily identified by the plans with two types of cognitive aids, colors and images of the procedure that will be performed on each plan. The colors follow the traffic light/signal order. Plan A is green, B is yellow and C is red (**Figures 8 to 11**).

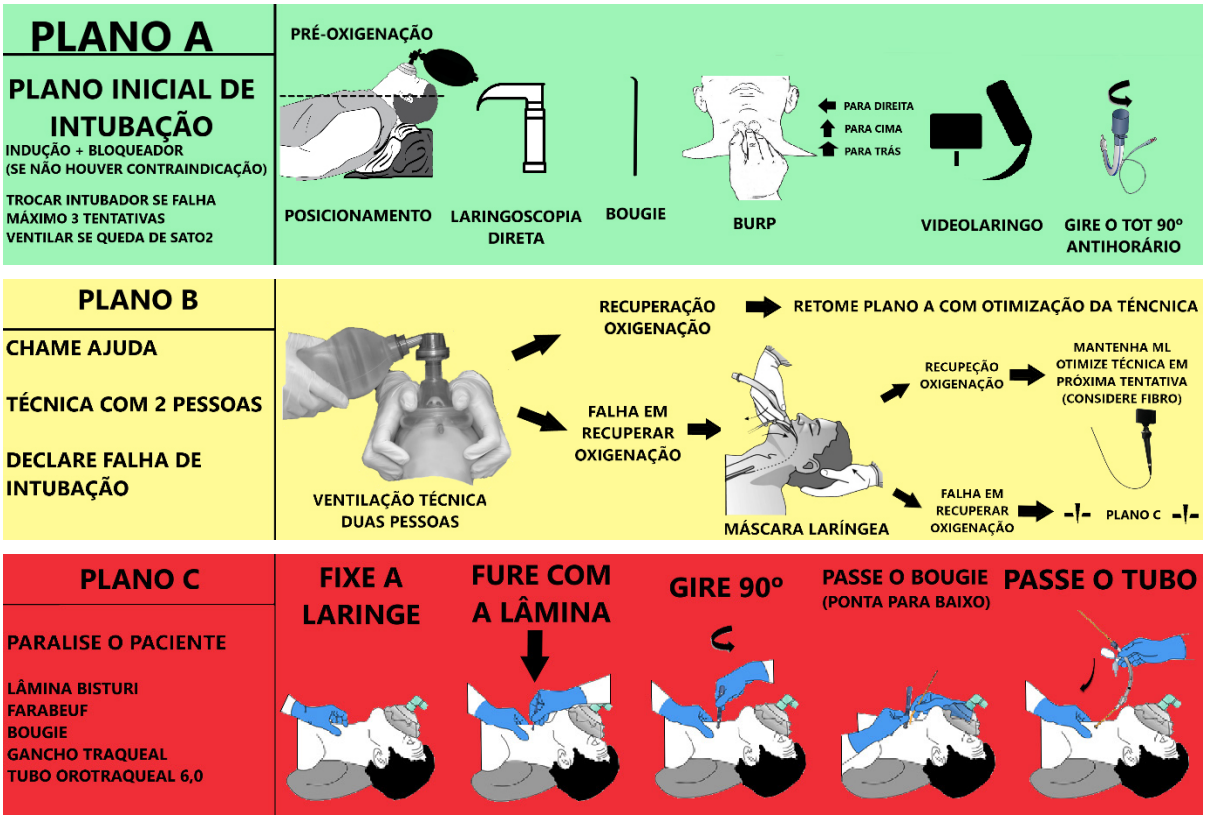
Source: authors.
Figure 8. Airway trolley.

Source: authors.
Figure 9. Airway trolley.



Source: authors.

Figure 10. Color coded drawers English.



Source: authors.

Figure 11. Color coded drawers Portuguese.

The location of the airway trolley is easily approached, broadly marked and widely known by ED stakeholders. Ideally, it should be located in the area where airway management is most frequently performed. In our service, the resuscitation bay is where most intubations are performed. However, situations that require stabilization of a definitive airway may also occur in other areas of the ED and, occasionally, it is not possible to transfer these patients to the place near the trolley. Therefore, the presence of wheels and easy mobilization of the trolley is of paramount importance. It can then provide immediate availability of all needed equipment, thus not depending on the availability of materials in certain areas of the ED or on the displacement of an employee from the bedside to get them. The equipment available in each drawer is listed in **Table 1**.

DISCUSSION

In this quality improvement project, we developed an airway bundle composed of a trolley with color coded drawers representing structured airway plans (A, B, and C) along with a pre-intubation checklist adhered to its lid, a medication box with labels and extra cognitive aids. The materials described here were selected based in their availability at our hospital.

We discussed here how human factors, cognitive aids, checklists and logically organized and selected materials play a fundamental role in airway management.

Importantly, the development of an airway bundle must be a multidisciplinary and continuous construction, in which all members of the team must be proficient in the organization, flow and knowledge of its elements. For this, simulations between team members must be performed as a routine.

Differently from the operating room setting, the ED, the Intensive Care Unit (ICU) and the ward have environmental differences that increase the complexity and challenges of airway management.[7] Therefore, it is of paramount importance that when performing airway management, cognitive tools are available to assist the professionals participating in the procedure. In addition, the ready availability of all materials, medications, and devices is key for procedural success. Although multiple guidelines exist, whether difficult, pediatric, obstetric, or in the ICU, few studies have addressed the development and/or implementation of airway trolleys. Most guidelines provide generic guidance on assembly, some indicating minimum material, but not enough for easy adaptation.[10]

Table 1. Material available in each drawer of the airway trolley

Plan A – green drawer	Plan B – yellow drawer	Plan C – red drawer
Laryngoscope handle	Oropharyngeal airway n°. 3	Scalpel blade 11
ETT 7	Oropharyngeal airway n°. 4	Shoelace
ETT 7,5	Oropharyngeal airway n°. 5	ETT 6
ETT 8	Nasopharyngeal airway n°. 9	Tracheostomy cannula n°. 7
ETT 8,5	Nasopharyngeal airway n°. 10	Tracheostomy cannula n°. 7,5
Battery	Nasopharyngeal airway n°. 11	Tracheostomy cannula n°. 8
Macintosh blade n°. 4	Capnograph	Tracheostomy cannula n°. 8,5
Macintosh blade n°. 5	Bag valve mask	Bougie
Miller blade n°. 4	Syringe 20mL	Syringe 20mL
Shoelace	Laryngeal mask n°. 3	Sterile glove 7,5
Stylet	Laryngeal mask n°. 4	Sterile glove 8
Bougie	Laryngeal mask n°. 5	Sterilizing solution
Capnograph	Lidocaine gel	Gauze
Syringe 20mL		Cricothyrotomy kit
Surgical pen		
Lidocaine gel		
Lidocaine spray 10%		
Magill forceps		
Yankauer suction		
Videolaryngoscope		

ETT: endotracheal tube.

Human factors and the airway

To summarize airway management in a one-page algorithm is to underestimate how environmental, human, and psychological factors affect the outcome of such a risky procedure. Even highly trained teams fare worse when environmental factors are suboptimal.[17] There is evidence that emergency airway management is directly influenced by human factors including but not limited to leadership, communication, interpersonal relationships and teamwork.[18] Most importantly, the interaction between these components and psychological, cognitive, environmental and cultural aspects play key roles in how smoothly the airway is managed in the ED.[1,2,5,6,19] The discussion of these factors in the current guidelines highlight that airway management should be approached in a multidisciplinary way and based on simulations.[20]

In the coronavirus pandemic, the number of intubations was higher than in any other period in history. In an attempt to meet emergency demands in the midst of a catastrophe, the provision of numerous, previously less common and less used devices such as bougies and laryngeal masks (LMA) did not result in a more effective approach, but rather increased the degree of uncertainty about when, how, and on whom to use such devices.

The airway trolley is not an intubation closet, or a small storeroom with wheels. A well-organized airway trolley should contain an adequate amount of strategically selected and positioned equipment.[21] The goal is to be simple without being simplistic, so that at times of cognitive overload there is no doubt or indecision about which device to use. This also reduces the number of decisions the team must make, decreasing mental effort.

Another key point in standardizing equipment is that fewer new techniques need to be learned, and those available can be mastered by the team. The Australian and New Zealand College of Anaesthetists (ANZCA) advocates that it is potentially dangerous to store excess equipment within the airway trolley.[8]

The use of cognitive aids

Equipment layout is an important piece of airway management. The airway trolley should follow the precepts of clinical integration, that is, its layout should be aligned with the workflow, physical space, and operational procedures of the institution so that the cognitive aids become an extension. All drawers have different icons, letters and colors, facilitating identification.[21]

One cognitive aid used was color coding, which consists in the use of chromaticity to differentiate items in the same panel, ensuring compatibility, standardization, significance, discriminability and detectability, as well as a systematic classification of certain items. This helps in preventing errors and can increase patient safety.[22]

Color coding is useful as long as the expectation of the chosen color is compatible with the reality of the team that will use it. One of the most common stereotypes is that of the traffic light: green, yellow and red, which indicates operating within tolerance, attention and stop and refocus, respectively.[9] The goal is to increase the situational awareness of the entire team about the plans and their respective colors. This workflow execution and progression is identified as a suggestion for intubation planning. This does not prevent that, for example, the team chooses to perform the first attempt directly by executing plan C, if this is the best option after their analysis.

Another simple, but fundamental safety instrument is the use of color-coded medication labels. In an emergency situation the medications must be quickly aspirated and most of the time, they are not clearly identified, which increases the risk to the patient. We proposed to the nurse team the use of pre-coded labeled stickers with the dilution of drugs, in order to facilitate the adherence to correct identification of syringes.

Checklists

Most checklists finish when the intubation is completed. We added a fifth part because severe complications may occur 15 minutes after the intubation,[23] thus the procedure does not finish when intubation is completed. Physicians have difficulties in adhering to checklists. In a five-year audit in the operating room, for example, the overall completion rate was only 60%.[24] It is likely that in the ED environment, adherence might be much lower.

We consider a differential of our checklist the accomplishment of a debriefing after the end of the airway management. Because it is considered a procedure that may have serious consequences, an immediate evaluation must always be done to identify factors that could be improved for the next intubation. By doing so, we can foster a safe space for improvement each time and then bring better care to the next patient. In addition to performing a pause during the shift and

decreasing the cognitive overload, the debriefing may represent a moment to observe the psychological needs of the individuals involved.[25,26]

Airway plans and materials

The use of airway plans aims to systematize the cognitive and technical aspects available in different airway management situations. Algorithms are not a rule, but rather a suggestion for action. It is important to emphasize that the algorithms presented do not simplify the complexity of airway management in a few phrases and images. Therefore, they should only be used as a guide.

There are different blades and tube sizes in the green drawer. There is more than one handle in case of malfunction. Spare batteries are fundamental for the handles. There is one capnography kit as it is the gold standard for confirming intubation. Surgical pen is used to delineate the cricothyroid membrane, one of the first steps. Magill forceps should be use in the case of a foreign body. Lidocaine spray and gel are present for lubrification of the tube and if an awake approach is chosen for airway management.

Two recent systematic reviews[27,28] showed a benefit of the video over the traditional laryngoscope and the use of the hyperangulated blade in difficult airways, increasing the first-pass rate.

The airway suctioning equipment includes flexible and rigid aspirators, as intubations performed in the emergency setting do not respect the optimal fasting time and often patients have large amounts of secretion and food debris in the airway. This content is not adequately removed by the common flexible aspirator; thus, the availability of a rigid aspirator is required.

Tube introducers (i.e., bougie) are usually seen as rescue devices in intubation. However, we included them in plan A/Green drawer because of recent evidence[29] that shows a significant increase in the first-pass rate. In addition, staff should be proficiently trained to use the materials when needed. We believe that using the bougie as rescue equipment shortens their learning curve.

Second generation LMA, those that are capable of draining gastric secretion and have a better local seal, must be present in the second drawer. Two units of each different size, in order to provide options for a better seal. The PEEP valve must be present in the kit for coupling to the BVM, as this improves alveolar recruitment and, consequently, oxygenation, the cornerstone of airway management.

Oropharyngeal and nasopharyngeal devices are fundamental for maintenance of airway patency, especially in an oxygenation rescue phase of management.

The cricothyroidotomy kit contains: a tray, two tracheal hooks, Metzenbaum scissor and a needle holder. It is stored inside the 3rd drawer. It is important to note that in the management of CICO situations, it is no longer acceptable to get the materials in a disorganized manner and at the time of the situation. The Plan C equipment in separate in kits, containing the devices described in the check table. This, in addition to organizing, facilitates the execution of the procedure, reducing cognitive overload and the stress of the situation.

Limitations

There are several limitations to the present work. First, this is a description of airway bundle development by a single center in Brazil, without any test comparing it with standard of care. Therefore, it is not superior to other airway bundles.

Second, it is not an implementation or an audit paper, thus changes may occur in the future once the bundle is fully implemented in our ED.

Third, many of the equipment available in our tertiary hospital-based ED may not be available in other institutions, especially those with less resources.

Fourth, some elements of our bundle such as the actual trolley, the use of a checklist for intubation and color codification do not have robust evidence to justify their use as standard of care. For example, the only randomized controlled trial that has evaluated the use of a checklist for endotracheal intubation of critically ill adults did not find changes on periprocedural outcomes or in mortality.[30] Nevertheless, we believe these elements are important because with a checklist and a structured plan all the airway team is on the same page for the procedure, the color-coded drawers set the tone and an organized trolley helps nurses to get and check materials faster.

CONCLUSION

By using the multiple tools presented in this bundle, we believe it is possible to optimize airway management in the Emergency Department. Unlike most of the available resources in the literature that describe a difficult airway trolley, the prototype presented here is aimed to be routinely used in all intubations since every emergency intubation can become a difficult

airway, even though there are no clear predictors for this. Importantly, every Emergency Department should have its bundle adjusted to their local needs and to their resources in order to reduce adverse events related to this procedure.

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