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A NOVEL ADJUSTABLE BOUGIE COMAPARED WITH COOKS AIRWAY CATHETER FOR INTUBATION TO CMAC VIDEO LARYNGOSCOPY

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Abstract

Background: Endotracheal intubation is a crucial skill in managing difficult airways. While video laryngoscopes like the C-MAC improve glottic visualization, the success of intubation also depends on the adjunctive devices used. This study evaluates the efficacy of a novel adjustable bougie compared with the traditional Cook's Airway Exchange Catheter (CAEC) during intubation using C-MAC video laryngoscopy.

Aim: To compare first-pass success rate, intubation time, ease of use, and complications between the novel adjustable bougie and Cook's Airway Exchange Catheter in elective intubation using C-MAC video laryngoscopy.

Materials and Methods: "This prospective, randomized comparative study was conducted on 60 ASA I–III patients aged 30–60 years undergoing elective surgery under general anesthesia at Saveetha Medical College, Chennai. Patients were randomly allocated into two groups: Group A (n=30) used the adjustable bougie, and Group B (n=30) used the CAEC for intubation. Outcome measures included first-pass success rate, time to intubation, ease of intubation (Likert scale), complications, and need for additional maneuvers. Data were analyzed using SPSS v26.0 with a significance level of $p<0.05$".

Results: The adjustable bougie group demonstrated a higher first-pass success rate, shorter intubation time, and improved ease of intubation compared to the CAEC group. Complication rates and need for additional maneuvers were lower in the bougie group, though not statistically significant.

Conclusion: The novel adjustable bougie proved to be more effective and user-friendly than the traditional CAEC when used with C-MAC video laryngoscopy, offering improved intubation outcomes in elective airway management.

Keywords: Adjustable bougie, Cook's Airway Exchange Catheter, C-MAC, video laryngoscopy, intubation, airway management, first-pass success.

LIST OF ABBREVIATIONS

C-MAC – Karl Storz Video Macintosh Laryngoscope
CAEC – Cook's Airway Exchange Catheter
ETT – Endotracheal tube
VL – Video laryngoscopy
AECs– Airway exchange catheters
CICV– Can't Intubate Can't Ventilate
CICO – Can't Intubate Can't Oxygenate
DAS – Difficult Airway Society
DL– Direct laryngoscopy
HA – Hyperangulated
CL – Cormack-Lehane grade
GEB – Gum-elastic bougie
OHCA – Out-of-hospital cardiac arrest
ED - Emergency department
IV – Intravenous
ICU – Intensive care unit
VMAC – Video Macintosh Laryngoscope

Kg– Kilogram
cm - Centimeter
ASA – American society of anesthesiologists
P value – Probability value
SPSS – Statistical package for social sciences
SD – Standard deviation

INTRODUCTION

Endotracheal intubation is a critical skill in airway management, especially in patients with anticipated or unanticipated difficult airways. The advent of video laryngoscopy, such as the C-MAC video laryngoscope, has significantly improved glottic visualization and increased the success rate of intubations in difficult airway scenarios. However, despite improved visualization, the actual passage of the endotracheal tube (ETT) can remain challenging due to anatomical variations or restricted access, necessitating the use of adjuncts like bougies and airway exchange catheters.

Many practitioners now advocate for the use of rigid video laryngoscopy in managing difficult airways. Previous research has illustrated that video laryngoscopes enhance the view of the larynx and alleviate difficulties during intubation (1,2). Studies have consistently demonstrated superior laryngeal views compared to DL. Particularly, novices have exhibited higher rates with VL" in routine airway management (3,4). Additionally, both our research and others findings indicate that video laryngoscopes serve as a valuable backup option when direct laryngoscopy fails (5). Intubation, a cornerstone of airway management in medical practice, demands precision and efficacy, particularly in challenging scenarios. As technology evolves, video laryngoscopy has emerged as a valuable tool, offering enhanced visualization of the airway anatomy during intubation procedures. Within this realm, the choice of adjunctive devices plays a crucial role in optimizing intubation success rates, minimizing complications, and ensuring patient safety.

However, for experienced providers, the potential for video laryngoscopy to enhance intubation success, especially in cases of predicted difficult airways, remains uncertain. Some authors have proposed that patients with indicators of "difficult DL may benefit the" visualization of the larynx provided by video technology compared to direct laryngoscopy (6). Despite favorable intubation conditions and high success rates observed with video laryngoscopes in these studies, their interpretative value is limited. It offers advantages for managing predicted difficult airways in routine clinical practice, particularly when applied to a large and diverse patient population by various providers. Of particular relevance is the question of whether video laryngoscopy improves the success rate of the initial intubation attempt compared to conventional laryngoscopy a critical concern for "anesthesiologists, as multiple laryngoscopy attempts are associated with increased morbidity and mortality" (7,8).

The chip extends a 60° optical axis vertically to transmit images to a video display monitor.

Among the adjunctive devices used in video laryngoscopy-assisted intubations, both the adjustable bougie and the hooks airway catheter have garnered attention for their potential benefits.

Cook's Airway Exchange Catheter (CAEC) has long been used as an effective tool in facilitating endotracheal intubation and tube exchange, offering features such as oxygen insufflation and jet ventilation compatibility. However, its rigidity and lack of dynamic maneuverability can limit its effectiveness in navigating complex airway anatomy.

A novel, adjustable bougie has recently been introduced, offering the advantage of tip angulation and real-time directional control, allowing for better steering through the vocal cords under video laryngoscopic guidance. This added flexibility may improve first-pass success rates and reduce intubation time, especially in challenging airway cases. "This study" aims to compares the novel adjustable bougie with the traditional Cook's Airway Catheter during intubation using C-MAC video laryngoscopy.

AIM AND OBJECTIVES:

AIM:

The study aims to compare the success rates, time to intubation, and ease of use of the adjustable bougie versus Cook's airway catheter when used with CMAC video laryngoscopy.

OBJECTIVES:

- To compare the success rate of first-pass intubation using the adjustable bougie versus Cook's airway catheter when intubation is performed under CMAC video laryngoscopy.
- To compare the time to successful intubation between the two devices.
- To compare the complication rates associated with the use of both devices during intubation.

REVIEW OF LITERATURE

Effective airway management is a cornerstone of anesthetic and critical care practice. The advent of video laryngoscopy (VL) has revolutionized the approach to difficult airways, providing enhanced glottic visualization compared to direct laryngoscopy. Among various VL devices, the C-MAC video laryngoscope has emerged as a widely used tool due to its ergonomic design, high-resolution camera, and the ability to use standard Macintosh blades, making it familiar and user-friendly for clinicians.

Despite improved visualization with VL, successful endotracheal intubation may still be hindered by anatomical factors, especially when the oral-pharyngeal-laryngeal axis is not aligned. In such cases, adjuncts like bougies and airway exchange catheters (AECs) play a critical role in facilitating intubation.

Epidemiology of Airway management:

Tracheal Intubation: Risks and the Importance of First-Pass Success

Routine tracheal intubation generally has a high success rate, with failure occurring in approximately 1 in 1,000–2,000 cases (9,10). However, when intubation failure coincides with the inability to ventilate or oxygenate—referred to as "Can't Intubate Can't Ventilate" (CICV) or "Can't Intubate Can't Oxygenate" (CICO)—the situation becomes critical. Such life-threatening events are estimated to occur in 1 in 5,000–10,000 routine cases and as frequently as 1 in 200 in emergency settings (11,12).

Consequences of Failed Intubation

Intubation failure may lead to complications such as unrecognised oesophageal intubation, pulmonary aspiration, hypoxia, cardiac arrest, and even death. The risk of these adverse outcomes is significantly higher in emergencies, where failure rates rise to 1 in 300–800 cases (9). Notably, CICO events account for over 25% of anaesthesia-related deaths (13).

Significance of First Attempt Success

Data suggest that each failed intubation attempt increases the risk of complications. Compared to success on the first or second try, patients requiring multiple attempts face a significantly increased risk of severe hypoxia, oesophageal intubation, aspiration, and cardiac events. Therefore, achieving first-pass success is critical, especially in critically ill patients (14).

Guidance from Major Airway Reports

Findings from the NAP4 audit indicate that many airway emergencies began with difficult intubation, often worsened by repeated unsuccessful attempts. The 2015 Difficult Airway Society (DAS) guidelines highlight the need to maximise the success of the first attempt and minimise the number of laryngoscopy attempts to avoid airway trauma and deterioration into CICO (15).

Predictive Factors and Risk Mitigation

The American Society of Anesthesiologists' Closed Claims Project revealed that 60% of adverse respiratory events were due to ventilation failure, difficult intubation, or oesophageal intubation. Alarmingly, half of the cases with anticipated airway difficulty lacked appropriate precautions. When difficult laryngoscopy is attempted without preparation, the risk of complications increases dramatically (16,17).

Role of Videolaryngoscopy

Although videolaryngoscopes (VL) are not foolproof, they provide superior glottic visualisation and higher first-attempt success rates compared to direct laryngoscopy (DL), particularly in difficult airway situations. Effective airway management depends on identifying high-risk patients early and matching them with appropriate techniques and devices to improve outcomes and reduce complications.

Videolaryngoscopy and Intubation Success

The 2016 Cochrane review confirmed that videolaryngoscopes (VLs) reduce failed intubation rates, enhance laryngeal view quality, and are especially effective in anticipated difficult airways. When direct laryngoscopy (DL) fails, VL use as a rescue technique achieves success rates up to 92%.

Improved First-Pass Success and Safety

The 2022 Cochrane review supported these findings, reporting higher first-pass success and fewer hypoxaemic events with VL. Hyperangulated blades significantly reduced oesophageal intubation, while less force applied during laryngoscopy was linked to fewer cases of dental or soft tissue trauma (18).

Enhancing Teamwork and Training

VL allows shared visualization of the airway, improving communication, team coordination, and education. It enables assistants to better anticipate equipment needs and optimize external maneuvers, particularly beneficial during challenging airway scenarios (19,20).

Specific Patient Populations Benefiting from VL

VL proves advantageous in patients with limited cervical spine movement, obesity, those undergoing thyroid surgery, or procedures requiring tracheostomy or double-lumen tubes (21,22,23). These devices are especially helpful when precise airway access is crucial (24).

Consideration as Standard of Care

Growing evidence supports adopting VL as the standard approach for intubation (25,26). Large observational studies, such as the one by De Jong et al., show improved ease of intubation, reduced reliance on rescue techniques, and fewer difficult laryngeal views (27).

Beyond the Operating Room

VL has shown benefits in intensive care units, emergency departments, and prehospital care, particularly for improving first-attempt success and reducing oesophageal intubations (28,29,30). However, results vary, especially with inexperienced users, highlighting the need for dedicated training (31).

Evidence Strengths and Limitations

Despite strong overall support for VL, study limitations exist. Many trials have small sample sizes, design heterogeneity, or use simulated scenarios. The broad categorization of all VLs as one group may not account for device-specific differences. Understanding both general VL principles and individual device features is essential for optimal airway management (32).

Principles of Videolaryngoscopy

Videolaryngoscopy (VL) uses embedded cameras, prisms, or fiberoptics in the laryngoscope blade to provide an indirect view of the glottis, eliminating the need for a direct line of sight. This allows the operator to visualize the laryngeal inlet without aligning the oral, pharyngeal, and laryngeal axes (33).

In contrast, direct laryngoscopy (DL) relies on anatomical alignment through lower cervical flexion, upper cervical extension, and upward lifting of the epiglottis using the blade tip in the vallecula—commonly described by the three-axis alignment or two-curve theories (34). The sniffing position and head extension help to align or flatten these curves for a clear view (35).

VL bypasses these alignment requirements, making it essential for clinicians to understand this difference for effective use.

Types of Videolaryngoscopes

Videolaryngoscopes are broadly classified into three categories: channelled devices with fibreoptic bundles (e.g., Pentax), channelled devices with lenses and prisms (e.g., Airtraq), and unchannelled devices using video technology (e.g., C-MAC, GlideScope, McGrath). The King Vision offers flexibility as it can function in either mode. Rigid optical stylets like Bonfils and Shikani are a distinct category and not included in this classification.

“Figure 1 shows Videolaryngoscope models. From left to right: the Airtraq (channelled device); the GlideScope (unchannelled device; hyperangulated blade shown here); and the CMAC (unchannelled device; Macintosh-style blade shown here)”.

Video Technology in Videolaryngoscopy

Most videolaryngoscopes use a camera near the blade tip to capture and transmit glottic images to a screen (15). This proximity often provides a better and wider view of the glottis than direct laryngoscopy, especially with hyperangulated (HA) blades (25). However, a clear view does not always ensure smooth endotracheal tube passage, as depth perception can be limited—highlighting the need for device-specific training.

“Figure 2 shows Videolaryngoscope blade designs. From bottom to top: the traditional direct laryngoscope Macintosh blade; the CMAC videolaryngoscope with Macintosh blade; and the CMAC videolarnygoscope with hyperangulated D-blade”.

Channelled Videolaryngoscopes

These devices feature a curved blade with an integrated tube channel, allowing guided tube placement. When the glottic view is centralised, tube insertion is usually straightforward. If not, minor blade adjustments or use of a bougie may help. Channelled devices are bulkier and require adequate mouth opening but are advantageous in patients with restricted neck mobility (36).

Unchannelled Videolaryngoscopes

Unchannelled devices vary by blade type:

- Macintosh-style blades (e.g., McGrath Mac, C-MAC) support both direct and indirect laryngoscopy.
- Hyperangulated blades (e.g., CMAC-D, GlideScope LoPro) offer superior indirect views in difficult airways but require specific technique and cannot perform direct laryngoscopy.

Selecting the right videolaryngoscope design based on patient and clinical context is essential for successful intubation.

Differences in VL Technique: Macintosh vs. Hyperangulated (HA) Blades

Videolaryngoscopy techniques vary significantly between Macintosh-style and hyperangulated (HA) blades. Macintosh VL requires deeper insertion into the vallecula and some alignment of airway curves, similar to direct laryngoscopy. HA blades, however, follow the natural anatomical curve, require shallower insertion, and do not use lifting force along the handle axis (37).

Visualisation and Tube Delivery

While HA blades often provide superior glottic views, tube insertion is more challenging and typically requires an airway adjunct, such as a malleable stylet shaped to match the blade's curvature. In contrast, Macintosh VL may or may not require an adjunct, with a straight bougie and coudé tip commonly used if needed (38).

“Figure 3 shows Airway adjunct conformed to the hyperangulated blade shape. From bottom to top: a standard tracheal tube with normal anatomical curvature; a tracheal tube with malleable stylet in situ conformed to the shape of a hyperangulated CMAC-D blade; the CMAC-D videolaryngoscope”.

Adjunct Selection and Caution

Adjunct choice depends on airway anatomy, operator experience, and institutional protocols. Some manufacturers offer dedicated stylets for their devices. Incorrect use of adjuncts may cause trauma or intubation failure, emphasizing the importance of proper training.

Device Versatility

Videolaryngoscopes compatible with both blade types offer flexibility, enabling clinicians to tailor their approach to the patient's needs and the clinical scenario.

Screen Configuration of Videolaryngoscopes

Videolaryngoscopes come with either handle-mounted screens (e.g., McGrath) or stand-alone monitors (e.g., C-MAC), with some models offering both options (e.g., GlideScope Go) (39) .

Stand-Alone Monitors

Stand-alone screens provide better image quality and a larger, shareable view, which can enhance training, team coordination, and multidisciplinary airway management, especially in critical situations (39).

Handle-Mounted Screens

While more portable and ideal for emergency or non-theatre settings, handle-mounted screens may limit shared viewing and often require the team to reposition for visibility (39).

"Figure 4 shows McGrath videolaryngoscope with handle-mounted screen. Macintosh blade (attached) and hyperangulated X-blade (unattached)".

Disparity Between Availability and Use

Despite widespread availability of videolaryngoscopes (VL) in over 90% of UK hospitals, regular use remains low, with many clinicians still relying on direct laryngoscopy (DL), even in difficult airway scenarios (36).

Contributing Factors (36)

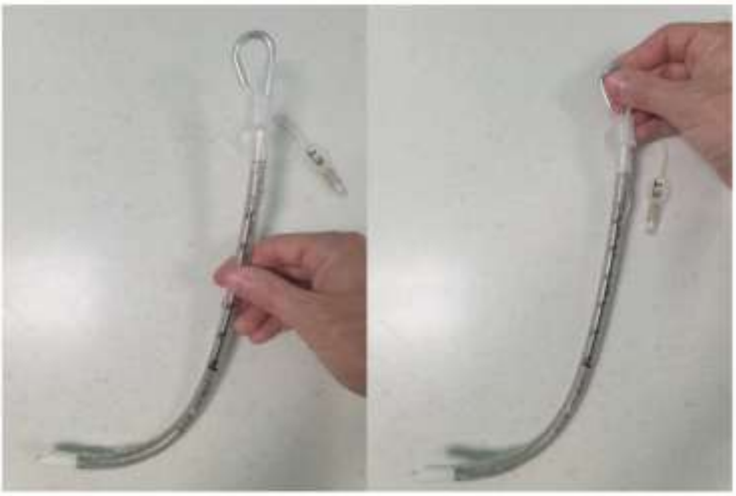
- **Unequal Access Across Departments**: VLs may not be uniformly available in all key areas (e.g., theatres, ICUs, EDs).
- **Lack of Structured Training**: Many institutions introduced VLs without formal teaching, leading to reduced confidence and proficiency.
- **Device Variability**: Frequent changes in VL models across hospitals hinder familiarity and skill retention.
- **Environmental and Logistical Concerns**: Single-use devices and complex cleaning protocols for reusable ones may discourage regular use.
- **De-Skilling Concerns**: Fears about losing DL proficiency are often unfounded; VL-trained clinicians perform well in both techniques.

Misconceptions and Evidence

- **Soiled Airways**: Contrary to belief, VL generally outperforms DL even in bloody or contaminated airways, especially with techniques like SALAD.
- **"Seeing Yourself Fail" Phenomenon**: A good glottic view with VL does not guarantee easy tube delivery, often due to improper technique or adjunct choice. Familiarity and ergonomics are key.

Optimisation Strategies for VL Use

- Keep the glottis centred on screen.
- Match airway adjunct to blade type (e.g., malleable stylet for HA blades).
- Hold stylet proximally to improve control.
- Avoid over-insertion—insert only until glottis is visible.
- Accept a partial glottic view if it facilitates successful tube passage.

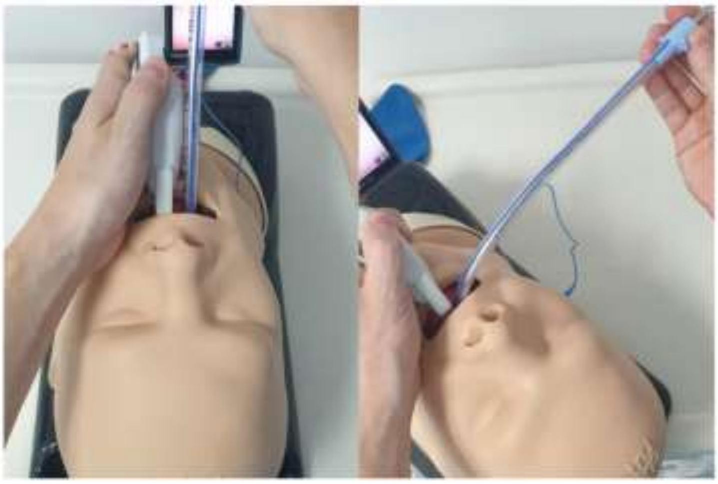


"Figure 5 shows Hand grip position for manipulating the tracheal tube/malleable stylet when using a videolaryngoscope with a hyperangulated blade. Left to right: hand grip at the mid-point of the tube; hand grip at the proximal end of the tube/stylet (recommended to allow greater manoeuvrability of the tracheal tube tip)".

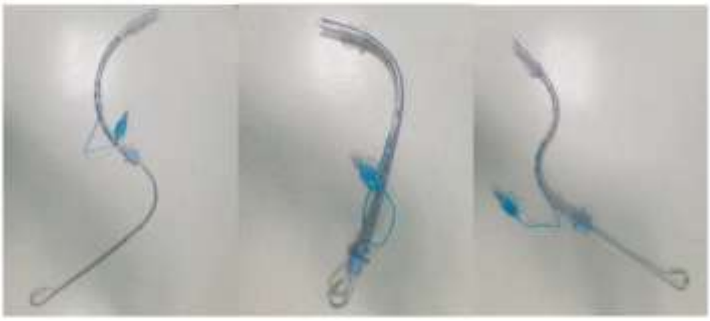
Advanced Videolaryngoscopy Techniques (40)

To enhance success in challenging intubations, several advanced strategies can be employed:

- **Lateral Tube Introduction**: Insert the tube at a 90° angle through the mouth corner with retromolar rotation towards the glottis to avoid arytenoid impingement.
- **Reverse Loading Technique**: For anteriorly placed larynxes, load the tube onto the stylet in a 180° reversed orientation so its natural curve faces posteriorly upon advancement.
- **Cooper Manoeuvre**: When using a hyperangulated (HA) blade, vertically lift the stylet and tube along its straight axis to better align the tip with the glottis.



"Figure 6 shows Technique for the insertion of the tracheal tube/stylet. From left to right: in-line (following videolaryngoscope blade); and at 90 degrees to blade (inserted at the corner of mouth, advanced in the retromolar direction and then rotated inwards towards the glottis)".



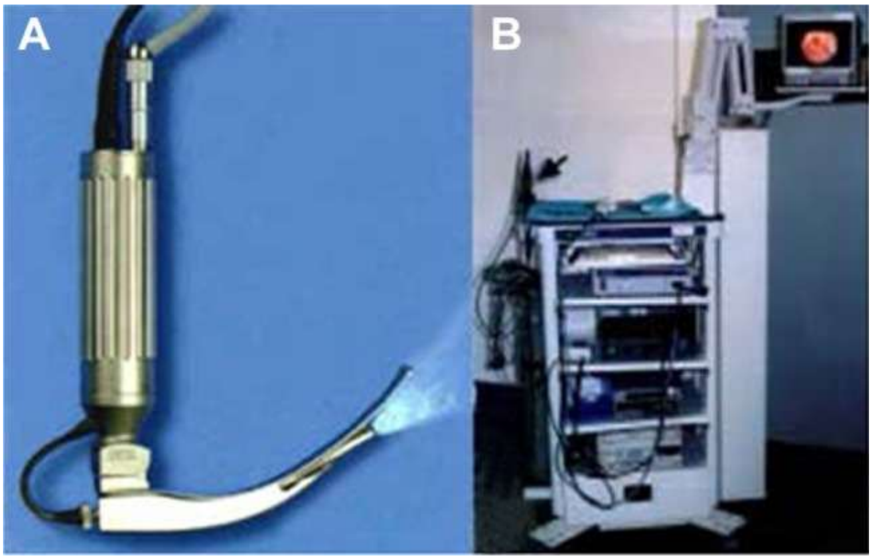
"Figure 7 shows "Reverse loading" of a tracheal tube onto a curved malleable stylet. From left to right: loading of the tracheal tube onto the stylet, with the normal anatomical curvature of the tracheal tube orientated at 180 degrees to the curvature of the stylet; the tracheal tube fully loaded onto the stylet; and the tracheal tube being advanced off the stylet, with the curvature of the tube pointing the tip posteriorly".

Embracing Change and Recognising Limits in Videolaryngoscopy (40)

Adoption of new medical technologies like videolaryngoscopy (VL) often faces resistance, necessitating a shift in perception from using VL only in difficult cases to embracing it as a routine choice due to its benefits for both patients and the clinical team. However, VL is not universally applicable—limitations such as restricted mouth opening or specific anatomical and physiological factors may render it unsuitable. In such cases, alternative strategies like flexible bronchoscopy or surgical airways may be more appropriate. Understanding VL's limitations, along with familiarity with available equipment and maintaining core airway skills such as facemask ventilation and supraglottic airway use, is essential to ensure safe and effective airway management.

C-MAC Video Laryngoscope System

The C-MAC video laryngoscope, introduced by Karl Storz GmbH & Co. KG in 1999, integrates a compact color video camera into a conventional laryngoscope handle, designed to enhance glottic visualization. It utilizes a standard Macintosh blade, with an image and light bundle running through a guide tube recessed 40 mm from the blade tip. The system connects to a control unit via a camera cable, while the light source is linked separately. Designed for portability, the setup is mounted on a mobile cart featuring an adjustable 8-inch monitor positioned on the patient's left side, allowing for optimal viewing during intubation (41,42).



"Figure 8 shows (A) A Macintosh blade connects to the handle, with an integrated image and light bundle routed through a metal guide tube positioned 40 mm from the blade tip.
(B) The system is mounted on a mobile cart that includes an 8-inch monitor for real-time video display".

Storz V-MAC Video Laryngoscope

The Storz V-MAC (Berci-Kaplan) video laryngoscope is an advanced version of the original video Macintosh system. It features a laryngoscope handle integrated with a fiber-optic light cord and a camera cable emerging from its top, which connect to an external light source and camera control unit. The system includes a large 8-inch monitor for enhanced visualization, offering improved clarity during airway management procedures (43).

C-MAC Video Laryngoscope: Design and Advancements

The C-MAC video laryngoscope, a refined version of the V-MAC device, features a simplified and portable design with three main components: a laryngoscope, an electronic module using semiconductor chip technology, and a 7-inch detachable monitor. Weighing around 1 kg with the battery, it delivers enhanced image quality and portability. Unlike the V-MAC, the C-MAC includes improved optics, a wider field of view, video quality adjustment options, and easy image and video recording via secure digital (SD) card. A key innovation is the pocket-sized 2-inch monitor attached to the handle, making it ideal for both pre-hospital and emergency use (41,42,44).

The C-MAC system offers three reusable metal Macintosh blades (sizes 2–4), designed with a closed, hygienic structure and slanted edges to minimize tissue trauma. The larger proximal flange (2.5 cm) compared to other videolaryngoscopes provides more space for tracheal tube manipulation but may require a wider mouth opening. The blade tip integrates a 320×240-pixel CMOS video chip with a fog-resistant lens and 80° viewing angle, ensuring clear, wide-angle visualization near the glottis (45).

Recent enhancements include lighter, ergonomically redesigned handles and the introduction of disposable versions with robust plastic blades to prevent breakage. However, the bulk of these disposable blades may reduce maneuverability and visualization. Unique to the C-MAC is its ability to function as both a direct and video laryngoscope using a Macintosh blade, offering a familiar view for clinicians and serving as a backup in cases of lens contamination or video failure (46).

“Figure 9 shows (A) Storz Berci-Kaplan DCI® (V-MAC) videolaryngoscope; (B) Storz C-MAC videolaryngoscope; (C) portable C-MAC with integrated 2-inch pocket monitor; (D) updated lightweight C-MAC handle with multifunction interface”.

Intubation Technique with the C-MAC Videolaryngoscope

The C-MAC videolaryngoscope can be used for both direct and video-assisted laryngoscopy. When used as a direct laryngoscope, the intubation technique mirrors that of a traditional Macintosh blade: the device is inserted from the right side of the mouth, the tongue is swept to the left, the blade tip is placed in the epiglottic vallecula, and the laryngoscope is lifted to visualize the larynx. If visualization is inadequate, maneuvers such as external laryngeal pressure or adjusting the blade position like switching to a straight blade approach may improve the view (41,47).

For videolaryngoscopy, a midline insertion without tongue sweep offers a clear glottic view by positioning the camera below the tongue base. While a stylet is not always necessary, it can assist in directing the tube tip toward the glottis, particularly in challenging airways. Studies indicate stylet use with the C-MAC is lower (around 10%) compared to McGrath (76%) and Glidescope (60%). In patients requiring cervical spine stabilization, using a stylet with C-MAC reduces intubation difficulty, duration, and the need for a bougie. Unlike videolaryngoscopes with sharply curved blades, the C-MAC’s straighter blade design usually allows smoother tube passage without the need for a steep distal bend in the styletted tube (41,48,49).

Performance of C-MAC Videolaryngoscope in Normal Airways

Although videolaryngoscopes like the C-MAC were originally developed to aid in difficult intubations, their routine use in all patients regardless of predicted airway difficulty has shown to improve overall intubation success, reduce complications from repeated attempts, and enhance operator skill with continued use. The dual capability of the C-MAC for both direct and video laryngoscopy makes it a versatile tool for standard airway management (41).

Several observational and randomized controlled trials have demonstrated that C-MAC and V-MAC videolaryngoscopes provide superior laryngeal views compared to traditional Macintosh laryngoscopy in patients with normal airways. While intubation times may vary slightly with some studies reporting longer durations with C-MAC the quality of the view, reduced use of adjuncts, and less force on maxillary incisors are consistent benefits. For example, studies have shown that C-MAC improves glottic visualization and reduces mucosal trauma and external manipulation needs, particularly in non-standard positions like right lateral decubitus. However, some evidence indicates that the C-MAC may trigger greater hemodynamic responses than the Macintosh blade. In cases involving double-lumen tubes, the C-MAC enhanced glottic views and procedural ease, though the number of intubation attempts remained similar to those with direct laryngoscopy (46,50,51).

C-MAC Videolaryngoscope in Difficult Airway Management

Initially developed to address difficult intubations, videolaryngoscopy particularly the C-MAC has become a preferred first-line tool for anticipated or encountered airway challenges. Current airway management guidelines recommend videolaryngoscopy as a rescue option following failed direct laryngoscopy. Studies show that in patients with predicted difficult airways, both V-MAC and C-MAC videolaryngoscopes provide better laryngeal views, higher first-attempt success rates, and reduced intubation times compared to direct laryngoscopy, though complication rates remain similar (52,53).

In scenarios simulating difficult airways, such as cervical spine immobilization, C-MAC improves glottic visualization but offers inconsistent advantages in intubation time and overall success. Among morbidly obese patients, C-MAC enhances visualization and enables quicker intubation. Additionally, in cases where direct laryngoscopy yields poor glottic views or fails entirely, C-MAC has demonstrated high success rates with minimal complications. Collectively, these findings highlight C-MAC's value as a reliable and effective device for both predicted and unanticipated difficult airways (54,55).

C-MAC Videolaryngoscope in Emergency Airway Management

Emergency intubations, often performed in high-pressure settings such as emergency departments, ICUs, and prehospital care, can be complicated by hemodynamic instability and respiratory distress, increasing the risk of difficult laryngoscopy and intubation. The C-MAC videolaryngoscope has gained prominence in these scenarios, as it allows clinicians to quickly switch between direct and video laryngoscopy, improving first-attempt success rates. Studies have shown that C-MAC provides better laryngeal visualization and a higher success rate compared to direct laryngoscopy, particularly in predicted difficult intubations. Additionally, C-MAC has been linked to a lower rate of esophageal intubations in emergency settings (56).

However, there are mixed results regarding its overall impact on intubation success and time. Some studies have found that C-MAC improves laryngeal views but does not significantly enhance success rates or reduce intubation times. In certain cases, issues such as technical malfunctions or airway obstructions have led to failures with C-MAC. Despite these drawbacks, C-MAC remains an effective tool for emergency airway management, especially for less experienced intubators, by providing clearer visual guidance and potentially reducing complications like esophageal intubation (57).

Comparison of C-MAC Videolaryngoscope with Other Devices

Several videolaryngoscopes, including the C-MAC, Glidescope, McGrath, and Bonfils, have been compared for their efficacy in different airway management scenarios. In normal airway patients, studies show that while the intubation success rate with C-MAC is comparable to other devices, it offers shorter intubation times and attenuates hemodynamic responses better than some alternatives. In predicted difficult airway cases, the Glidescope provides superior laryngeal views, but the intubation time, success rate, and attempts are similar to those of C-MAC. For cervical spine immobilization patients, C-MAC requires more attempts and optimizing maneuvers compared to the Glidescope, although the laryngeal view is comparable (58,59). In bariatric surgery, the V-MAC version of C-MAC outperforms McGrath and Glidescope by reducing intubation time and attempts. Additionally, in emergency settings, C-MAC and KingVision offer similar success rates, with C-MAC showing better first-pass success. The findings suggest that no single device is universally superior, as each has unique advantages in specific situations. Health care providers should be skilled in using multiple devices depending on the clinical circumstances (60).

C-MAC Videolaryngoscope in Tracheal Intubation Teaching

Teaching tracheal intubation with direct laryngoscopy can be stressful for both instructors and students, as instructors cannot always see what students are visualizing. The C-MAC videolaryngoscope, by providing a shared high-quality, magnified view on a monitor, enhances the teaching process. It allows instructors to explain airway anatomy and guide students in real time, eliminating the need for the "peer over my shoulder" teaching method (43,61). Studies have shown that video-assisted training with C-MAC reduces the learning curve for students, improving intubation success rates and reducing esophageal intubation incidents. Novices trained with C-MAC perform better in simulated difficult airway situations compared to those trained with traditional Macintosh laryngoscopes. However, a study indicated that while C-MAC enhances initial skill acquisition, retention may require ongoing practice, as students trained with C-MAC had longer intubation times after a break in practice compared to those trained with the Macintosh device (62.63,64).

Bougie Use in Intubation

Bougies have long been an integral tool in difficult intubation scenarios, providing assistance in guiding the endotracheal tube (ETT) through the larynx. Traditionally, bougies are used to assist with intubation when direct laryngoscopy fails or when a more stable airway visualization is required. The advent of videolaryngoscopes, like the C-MAC device, has revolutionized airway management by improving visualization and simplifying the intubation process. However, despite the advancements in videolaryngoscopy, certain airway conditions and anatomical variations still present challenges, requiring adjunctive tools like bougies.

Adjustable Bougie Concept and Design

An adjustable bougie, designed to be more flexible and customizable in length and stiffness, is a new concept aimed at improving the efficacy of intubation. This novel bougie allows the user to modify its stiffness and shape according to the patient's airway characteristics and the laryngoscopic view provided by the C-MAC video laryngoscope. The ability to adjust the bougie's form based on real-time conditions could potentially improve tube insertion, reduce trauma, and enhance intubation success, especially in challenging cases.

C-MAC Videolaryngoscope and Bougie Use

The C-MAC videolaryngoscope provides superior laryngeal views compared to direct laryngoscopy, aiding in difficult airway management. The high-definition camera and monitor allow the intubator to visualize the airway in real-time, making it easier to guide the endotracheal tube. However, in cases where visualization is compromised or if the laryngeal anatomy is difficult to navigate, an adjustable bougie may offer critical support. Several studies have highlighted the benefits of combining C-MAC videolaryngoscopy with bougies, demonstrating that bougies improve first-pass intubation success and reduce complications such as esophageal intubation and airway trauma.

A Novel Adjustable Bougie for Intubation with C-MAC Video Laryngoscopy

The upper airway consists of various structures, including the oral cavity, pharynx, and larynx, all contributing to air filtration and humidification. The larynx, which is innervated by the vagus nerve, plays a critical role in vocal cord movement during intubation. The trachea, which bifurcates at the fifth thoracic spine, has cartilaginous rings and soft membranous portions. Its anatomical features, such as the angle between the trachea and bronchi, are essential when using a bougie for intubation. The bougie guides the endotracheal tube into the trachea, reducing the risk of esophageal intubation. While adult airway structures are well-defined, special considerations are needed in pediatric patients, where anatomical differences such as a larger tongue, cephalad larynx, and shorter trachea complicate intubation. The adjustable bougie, when used with the C-MAC video laryngoscope, can enhance intubation in both adult and pediatric patients by improving visibility and adaptability, facilitating safer and more accurate tube placement.

Indications and Contraindications for Using a Novel Adjustable Bougie with C-MAC Video Laryngoscopy

Endotracheal intubation is often necessary in emergency settings to secure the airway and ensure adequate ventilation, particularly in patients with compromised respiratory function, reduced consciousness, or signs of hypoxia and hypercarbia. Assessment typically involves evaluating mental status, airway patency, oxygen saturation, and respiratory parameters. In trauma cases, a Glasgow Coma Scale score of 8 or lower usually indicates the need for intubation. However, while there are no absolute contraindications, relative factors such as severe orofacial trauma, cervical spine injuries, or potential improvement with non-invasive ventilation should be considered before proceeding. In such cases, if intubation remains essential, alternative airway management techniques, including surgical airways, should be prepared. The use of a novel adjustable bougie in conjunction with the C-MAC video laryngoscope offers improved maneuverability and visual guidance, enhancing intubation success, especially in challenging scenarios (65).

Essential Equipment for Intubation Using a Novel Adjustable Bougie with C-MAC Video Laryngoscopy

Effective airway management with the C-MAC video laryngoscope and a novel adjustable bougie requires thorough preparation and appropriate equipment. Key preparatory steps include establishing intravenous access, continuous hemodynamic monitoring, pulse oximetry, and $EtCO_2$ monitoring. Emergency tools such as a suction catheter, resuscitation medications, and a defibrillator must be readily available. Pre-oxygenation is achieved using devices like nasal cannula, high-flow systems, or bag-valve masks with PEEP valves and supplemental oxygen. For direct laryngoscopy, essential tools include a functional laryngoscope with various blades, endotracheal tubes, a malleable stylet, syringes, and securing tape. In video laryngoscopy, a powered video laryngoscope with compatible stylets is required. Backup airway tools, such as a laryngeal mask airway, Magill forceps, a bougie, and a cricothyrotomy tray, should also be accessible to ensure readiness for difficult airway situations (66).

Preparation and Airway Assessment for Using a Novel Adjustable Bougie with C-MAC Video Laryngoscopy

Proper preparation begins with a thorough airway evaluation, especially when time allows. This includes reviewing any history of prior or difficult intubations and assessing external anatomical features that may indicate a challenging airway, such as limited neck mobility, obesity, or facial trauma. A helpful tool for airway assessment is the "LEMON" mnemonic: Look for external abnormalities, Evaluate the 3-3-2 rule (mouth opening, mandibular-hyoid distance, and hyoid-thyroid distance), Mallampati score ($\geq$3 may suggest difficulty), Obstruction or obesity that could impair vocal cord visualization, and Neck mobility limitations. Recognizing these factors allows clinicians to anticipate challenges and prepare for alternative intubation strategies, ensuring safer use of devices like the C-MAC videolaryngoscope and an adjustable bougie (66).

Optimal Positioning, Equipment Preparation, and Oxygenation Strategies for Adjustable Bougie Use with C-MAC Video Laryngoscopy

Proper **patient positioning** is essential for successful intubation. The "sniffing position" aligns the oral, pharyngeal, and laryngeal axes and is considered ideal for direct laryngoscopy. This is achieved by elevating the head and extending the neck so that the external auditory meatus is level with the sternal notch. In obese patients, head elevation with towels or positioning devices may be needed to achieve this alignment (67).

The **endotracheal tube (ETT)** must be chosen based on patient characteristics—typically size 7.0 for women and 8.0 for men, with adjustments for procedures like bronchoscopy. Pediatric tube sizing is based on age-specific formulas. Tubes should be prepared with a malleable stylet, shaping the distal tip at a 35-degree angle and checking the cuff for leaks (68).

Medication administration often follows a rapid sequence intubation (RSI) protocol, which involves giving a sedative and a paralytic in rapid succession to improve first-pass success and minimize aspiration risk. Ketamine is commonly used for delayed sequence intubation (DSI) in agitated or hypoxic patients. Awake intubation is reserved for patients with difficult airways and requires careful sedation and topical anesthesia (69).

Pre-oxygenation is a critical step to reduce desaturation risk during apnea. Methods include non-rebreather masks delivering high FiO2, bag-valve masks, or positive pressure devices like CPAP or BiPAP in patients with shunt physiology. Pre-oxygenation should be sustained for at least 3 minutes, aiming for end-tidal oxygen levels >90% (70,71).

Lastly, **apneic oxygenation** helps prolong safe apnea time during intubation. Oxygen is delivered via nasal cannula at up to 15 L/min, or high-flow systems, to maintain oxygenation even without active ventilation—an especially useful technique when using C-MAC video laryngoscopy with a bougie in difficult airways (72).

Intubation Technique Using C-MAC Video Laryngoscopy with an Adjustable Bougie

Pre-Intubation Check

Successful intubation begins with proper patient positioning and equipment verification. The operator should confirm the laryngoscope light source is functional and the blade is secured. The laryngoscope is held in the left hand and inserted from the right side of the mouth, gently advancing while applying upward and outward pressure at a 45-degree angle to displace the tongue and visualize the airway (73).

Curved and Straight Blade Techniques

With a curved blade, the tip is placed in the vallecula to indirectly lift the epiglottis and expose the vocal cords. In contrast, a straight blade is inserted midline to directly lift the epiglottis by advancing the tip beneath it. Both techniques aim to achieve a clear view of the glottis for tube placement (74).

Endotracheal Tube Placement

Once the vocal cords are visualized, the endotracheal tube (ETT) with a stylet is inserted to the right of the blade and guided through the cords. If visualization is challenging, the operator may manipulate the airway with the right hand and then transfer the position-holding to the assistant (75).

Video Laryngoscopy Approach

When using the C-MAC video laryngoscope, the technique mirrors direct laryngoscopy. However, video laryngoscope blades may occasionally hinder ETT advancement despite a clear glottic view (Cormack-Lehane grade 1). A partial view (grade 2) may ease ETT passage (76).

Bougie Assistance in Difficult Airways

In cases of poor glottic visualization, a bougie serves as a valuable adjunct. Its angulated tip helps navigate the airway, and tactile feedback confirms tracheal entry. The ETT is then advanced over the bougie and positioned properly (77).

Post-Intubation Steps

After tube insertion, the cuff is inflated with air, the stylet is removed, and the ETT is connected to capnography and a ventilation device. Ideal ETT depth is generally 21 cm in women and 23 cm in men at the incisors, though height-based adjustment is recommended.

Using an adjustable bougie enhances control and flexibility during intubation, particularly when combined with C-MAC video laryngoscopy in challenging airways (78).

Complications of Intubation with C-MAC and Adjustable Bougie (78)

Respiratory Risks

The most concerning complication is hypoxemia, often caused by multiple failed attempts or misplaced tubes. Preventive strategies include effective pre-oxygenation, apneic oxygenation, and prompt confirmation of tube placement.

Cardiovascular Effects

Bradycardia may occur due to vagal stimulation, while hypotension and cardiac arrest can result from sedative agents, especially in critically ill patients. Adequate pre-intubation resuscitation and reliable IV/IO access are crucial for managing these risks.

Mechanical Injuries

Complications such as oropharyngeal lacerations, dental trauma, and aspiration may arise from poor technique or unrecognized hazards. Post-intubation issues include mucosal or uvular necrosis and rare cases of tracheal rupture from overinflated cuffs. Cuff pressure monitoring (20–30 cm H_2O) helps reduce these complications.

Studies on Bougie Use with C-MAC Videolaryngoscope

1. Bougie in difficult airway management:

A study by Eum et al. (2024) demonstrated that the use of bougies with videolaryngoscopes, such as the C-MAC, significantly improved intubation success in patients with difficult airways (79). The study found that the bougie

provided a stable guide for endotracheal tube placement, which was especially useful when laryngeal views were suboptimal. Similar results were noted by Ruetzler et al. (2020), who reported that bougies reduced the number of intubation attempts in difficult airway scenarios (80).
The study by Komasawa et al in 2015 assessed the effectiveness of a tracheal tube introducer (gum-elastic bougie, GEB) in simulated difficult infant airway scenarios. Fifteen anesthesiologists performed intubations on an infant manikin under varying conditions: normal (Cormack-Lehane grades 1–2), cervical stabilization (grades 2–3), and anteflexion (grades 3–4), both with and without a GEB. All intubations were successful in the normal and cervical stabilization settings regardless of GEB use. However, in the anteflexion scenario, only one participant succeeded without the GEB, while success significantly improved with its use (P = 0.005). Intubation time was similar in normal conditions but significantly reduced with the GEB in more difficult scenarios. GEB use enhanced success rates and reduced intubation time in challenging infant airway simulations (81).
The study by Bonnette et al in 2021 compared outcomes of Bougie-assisted versus non-Bougie endotracheal intubation (ETI) in out-of-hospital cardiac arrest (OHCA). Among 1,227 patients who underwent ETI, 35.9% were Bougie-assisted. First-pass success rates were similar between groups (53.1% vs. 42.8%), while overall ETI success was slightly higher with Bougie use (56.2% vs. 49.1%). Bougie-assisted ETI took longer (median 13 vs. 11 minutes) and was associated with lower hospital survival (3.6% vs. 7.5%), though no significant differences were found in ROSC, 72-hour survival, or favorable neurologic outcomes. Bougie use slightly improved ETI success but may prolong procedure time and reduce survival, leaving its role in OHCA uncertain (82).

2. Adjustable Bougie in airway management:

The introduction of an adjustable bougie is relatively novel. The study by Driver et al. (2021), the adjustable bougie was shown to reduce the need for repeated intubation attempts, especially in patients with limited airway space or challenging anatomical features (83). By adjusting the bougie's flexibility, intubators could manipulate the device to better fit the patient's anatomy, improving ease of intubation.
The study by Kaushal et al in 2011 evaluated the success of endotracheal intubation using a gum-elastic bougie (GEB) and the reliability of "palpable clicks" and "hold-up" in an emergency department (ED) setting. Over one year, 26 adult patients underwent intubation attempts with a GEB. The overall success rate was 76.9%, with a 73.7% success rate when used for clinical indications and 85.7% when used for training. "Palpable clicks" had limited sensitivity (55%) and specificity (80%), while "hold-up" had low sensitivity (33.3%) but high specificity (100%). GEB proved moderately effective in rescue airway situations, but clinical indicators like clicks and hold-up were unreliable (84).

3. Combination of Adjustable Bougie and C-MAC Videolaryngoscope:

The integration of the adjustable bougie with C-MAC videolaryngoscopy has been explored in recent studies. A study by Mahli et al. (2021) assessed the performance of the adjustable bougie when used with C-MAC for orotracheal intubation in a simulated difficult airway model (85). The findings indicated that the combination of the two tools significantly increased first-pass success rates compared to traditional intubation methods. Furthermore, the adjustable bougie allowed for easier navigation in anatomically difficult airways, enhancing the overall success rate and reducing the time required for intubation.
The study by Tosh in 2018 compared oral intubation using a 60° angled styletted endotracheal tube versus bougie-assisted intubation under videolaryngoscopic guidance in 70 surgical patients. Intubation was significantly easier and faster with the styletted tube (88.6% vs. 25.7% ease; 16.97 ± 7.91 vs. 77.43 ± 35.55 seconds; $P < 0.001$), with fewer requiring multiple attempts (5.7% vs. 57.1%; $P < 0.001$). Bougie use was associated with higher mean arterial pressure post-intubation, though heart rate remained unchanged. The 60° styletted tube proved more efficient and effective for intubation with a C-MAC videolaryngoscope (86).
The study by Cavus et al in 2010 evaluated the effectiveness of the C-MAC® videolaryngoscope in 60 patients undergoing routine anesthesia induction. Blade insertion and glottic visualization were successful on the first attempt in all cases, with tracheal intubation achieved in all patients—52 on the first attempt, 6 on the second, and 2 on the third; 13% required a bougie. Most patients achieved a Cormack-Lehane Class 1 or 2a view, especially with external manipulation. Median intubation time was 16 seconds (range 6–58 s). In three cases with difficult direct laryngoscopy (Cormack 3–4), the C-MAC with a Size 4 blade and straight blade technique improved visualization and enabled successful first-attempt intubation (87).
The study by Angerman et al in 2018 anaesthetist-led helicopter emergency medical service, combining C-MAC videolaryngoscopy with a Frova bougie and a standardized rapid sequence induction protocol significantly improved first-pass intubation success. Over 22 months, 543 adult intubations showed a 98.2% first-pass success rate, compared to 85.7% in the prior control group (n = 238), $p < 0.0001$. This approach led to consistently high success rates in prehospital airway management (88).
The study by Dilek et al in 2017 reported that steep angle of the C-MAC D-Blade® videolaryngoscope poses challenges with standard endotracheal tubes. In a randomized crossover manikin study simulating difficult intubation, five methods—three stylets (hockey-stick, D-Blade, CoPilot), a gum elastic bougie, and no stylet—were compared across 265 intubations by 33 residents and 20 experts. Intubation without a stylet required more attempts and took significantly longer. The D-Blade, CoPilot, and hockey-stick stylets enabled the fastest intubation and easier vocal cord passage. Correct stylet choice improves the efficiency of intubation with the C-MAC D-Blade®. Further clinical studies are warranted (89).

The study by Dilek et al in 2017 done in patients with simulated restricted cervical mobility, intubation using a 60° angled C-MAC stylet was significantly easier (75% vs. 16.7%) and faster (26.8 s vs. 47.2 s) than using a bougie under C-MAC D-blade guidance, with fewer attempts required. Both techniques produced similar hemodynamic responses. The C-MAC stylet proved to be a more effective and time-efficient aid (90).

4. Clinical benefits and limitations:

Although the combination of C-MAC and an adjustable bougie shows promise, a randomized control trial by Waldron et al. (2023) raised concerns about the potential for over-reliance on bougies, especially when visualizing the airway may be challenging (91). The study emphasized that while the bougie could be useful in complex airway cases, its use should be integrated with proper technique and caution to avoid complications, particularly in cases where the laryngeal view is already clear.

The adjustable bougie, when used in conjunction with the C-MAC video laryngoscope, has demonstrated considerable promise in improving the success rates and safety of tracheal intubation, particularly in difficult airway scenarios. It allows for better manipulation and adaptation to patient-specific airway characteristics, thus reducing complications and enhancing intubation efficiency. However, more comprehensive studies and clinical trials are needed to establish definitive guidelines and protocols for its use in routine clinical practice.

Cook's Airway Exchange Catheter (CAEC):

The Cook Airway Exchange Catheter is a hollow, semi-rigid device primarily used for:

- Exchanging endotracheal tubes,
- Acting as a conduit for oxygen insufflation or jet ventilation, and
- Serving as a guide for reintubation, especially in difficult or failed airway scenarios.

CAECs are favored due to their atraumatic tip, length, and lumen allowing oxygenation, making them safer and more versatile compared to traditional bougies.

Synergistic Use of CAEC with C-MAC Video Laryngoscopy

The combination of a C-MAC video laryngoscope with a CAEC is increasingly studied and used in clinical practice, especially in the following scenarios:

- Anticipated or known difficult airway.
- Reintubation after extubation failure.
- Intubation in patients with anatomical abnormalities or airway tumors.

4. Literature Support and Evidence

- Joshi et al. (2017) evaluated the success rates of using CAECs with video laryngoscopy and found that this combination improved first-pass success rates in difficult airway situations, particularly when direct visualization was limited (92).
- Hansel et al. (2022) reported that video laryngoscopes, such as the C-MAC, significantly enhanced glottic views compared to direct laryngoscopy, especially in patients with Cormack-Lehane Grade 3–4 views. The addition of adjuncts like CAECs improved the ease of tube passage (93).

Advantages of the CAEC-CMAC Combination

- Visual guidance via C-MAC allows for accurate placement of the CAEC.
- CAEC serves as a stable guidewire for ETT advancement, minimizing trauma.
- Allows oxygen insufflation or jet ventilation during prolonged intubation attempts.
- Reduces the risk of loss of airway during tube exchanges.

Limitations and Considerations

- Requires skill and familiarity with both devices.
- Jet ventilation through CAEC requires careful pressure monitoring to avoid barotrauma.
- Risk of esophageal misplacement if visualization is not maintained.

Recent Trends and Simulation Training

Simulation-based training has emphasized the use of CAECs with VL devices like C-MAC. Studies show improved performance and success rates in simulated difficult airway scenarios with this combination, supporting its inclusion in difficult airway algorithms and training protocols.

MATERIALS AND METHODS

"TRIAL DESIGN":

Prospective randomized "comparative study"

"STUDY AREA":

"This study was conducted in the Operation Theatre at Saveetha Medical College and Hospital in Chennai".

"STUDY POPULATION":

"The patients" undergoing Elective intubation belonging to American society of Anesthesiologists I, II and III who are above 30 years to 60 years scheduled for general anaesthesia will be enrolled in the study. Totally 60 patients were selected and equally divided into two groups are Phase I and Phase II. In each group, 30 patients were selected for this study.

Procedure:

All "patients were premedicated with glycopyrolate 0.2 mg/kg as per institutional protocol.standard ASA monitors were applied .After preoxygenation general anesthesia was induced with iv propofol (2-2.5mg/kg), Fentanyl (1-2mcg/kg)", and a muscle relaxant(Atracurium 0.5mg/kg) Intubation was performed using CMAC video laryngoscopye(Size and blade selected as appropriate).we divided as a two group

GROUP I (Bougie group): Patients intubated using an adjustable bougie.

A novel adjustable bougie allows real time modification of angulation and curvature was visualizer into the trachea on the CMAC video laryngoscope. "The Endotracheal tube was railroaded over the bougie into the trachea"

GROUP II (Cook's airway catheter group): Patients intubated using the Cook's airway catheter.

The cooks airway catheter was used as a stylet like introducer and advanced into the trachea under CMAC visualization. "The Endotracheal tube was advanced over the catheter into the trachea"

The following parameters were recorded

1.First pass success rate

2.Time to intubation (from insertion of laryngoscope to confirmation of tube placement)

3.cormack Lehane grade

4.Ease of intubation

5.complication :Airway trauma , Desaturation(<92%),oesophageal intubation

"STUDY PERIOD":

The study was conducted during the period of September 2022 to April 2024

INCLUSION CRITERIA:

- American society of Anesthesiologists I, II and III were included in this study
- "Patients undergoing general anaesthesia who are above 30 to 60 years"
- "Patients who gave informed and written consent form"
- "Adult patients requiring elective intubation".
- Difficult airway predicted or encountered
- Patients for whom CMAC video laryngoscopy is planned for intubation

EXCLUSION CRITERIA:

- American society of Anesthesiologists IV
- Pregnant women were excluded
- Patients who are below 30 years
- Patients with known contraindications to video laryngoscopy or the use of either bougie/Cook's airway catheter
- Patients with severe upper airway obstruction or trauma where these devices are contraindicated

"SAMPLE SIZE DETERMINATION":

"The saple size is 60 (30 in each group) was calculated based on a similar study conducted by Batuwitage et al in the year 2014 (94). The level of significance and power were taken as 5 % and 90% respectively".

SAMPLING TECHNIQUE: Simple Random sampling method

"CLINICAL TRIAL REGISTRATION NUMBER": CTRI/2025/04/103428

"ETHICAL COMMITTEE APPROVAL":

"The ethical committee approval was obtained with the ethical approval number (090/09/2024/IEC/SMCH) from the institutional Human Ethics Committee of Saveetha Medical College and Hospital in Chennai".

Outcome Measures:

- **Primary Outcome:**
  - **"First-pass intubation success rate**: Defined as the successful placement of the endotracheal tube (ETT) in the trachea on the first attempt".
- **Secondary Outcomes:**

1. **"Time to successful intubation"**: Time from the insertion of the laryngoscope into the patient's mouth until confirmation of ETT placement by capnography.
2. **Ease of intubation**: Assessed via a Likert scale from 1 (very easy) to 5 (very difficult) as reported by the intubating anesthetist.
3. **Complications**: Any adverse events during or after intubation, such as airway trauma (e.g., bleeding, dental injury), esophageal intubation, hypoxemia (SpO_2 < 90%), and hemodynamic instability.
4. **Need for additional maneuvers**: Requirement for adjunctive devices or changes in technique (e.g., head repositioning, external laryngeal manipulation) during intubation.
5. **Patient-specific factors**: Exploration of how factors like BMI, Mallampati score, neck mobility, or history of difficult intubation may influence success rates.

DATA COLLECTION:

Patients undergoing elective intubation scheduled for "general anesthesia were included in the study. Each subject was informed about the study and given the choice to refuse enrollment. They were assured that their identity and personal information would be kept strictly confidential. Written informed consent was obtained from all participants before enrolment".

“Demographic parameters such as age, gender”, BMI, ASA physical status, Mallampati and Cormack-Lehane grade were collected. Patients aged 30 to 60 years, classified as ASA I, II or III scheduled for general anesthesia. “A total of 60 patients were randomly divided into two groups”. In Phase I, patients were intubated” using an adjustable bougie (**Bougie group**), while in Phase II, patients were intubated using the Cook’s airway catheter **(Cook's airway catheter group)** both assisted by C-MAC video laryngoscopy.

“STATISTICAL ANALYSIS”:

“To analyze the data, SPSS (IBM SPSS Statistics for Windows, Version 26.0, Armonk, NY: IBM Corp. Released 2019) is used. The results of the Normality tests, Kolmogorov-Smirnov and Shapiro-Wilks, revealed that the data follows a normal distribution. Therefore, to analyze the data, a parametric test was applied. Descriptive statistics determined the variables frequency, percentage, mean, and SD. Independent sample t-test was used to analyze weight, Height, and Intubation time between groups A and B. The Chi-square test was used to find the association of ASA, Mallampati, CL gradings, Number of attempts and complications. The significance level is fixed at 5% ($\alpha = 0.05$). P-value <0.05 is considered to be statistically significant”.

RESULTS

“Table 1: Age-wise distribution among the study participants” according to Bougie

“Age group”	N	%
“30-40 yrs”	7	23.3
“41-50 yrs”	11	36.7
“51-60 yrs”	12	40.0

Table 1 presents the age-wise distribution of study participants who underwent intubation using the adjustable bougie. Among the participants, the majority were between 51–60 years of age, accounting for 40% of the study population. This was followed by 36.7% in the “41–50 years age group and 23.3% in the 30–40 years age group”. The data indicates that the highest proportion of individuals intubated using the adjustable bougie belonged to the older age group (51–60 years), suggesting a wider use or need for airway intervention in this demographic during the study.

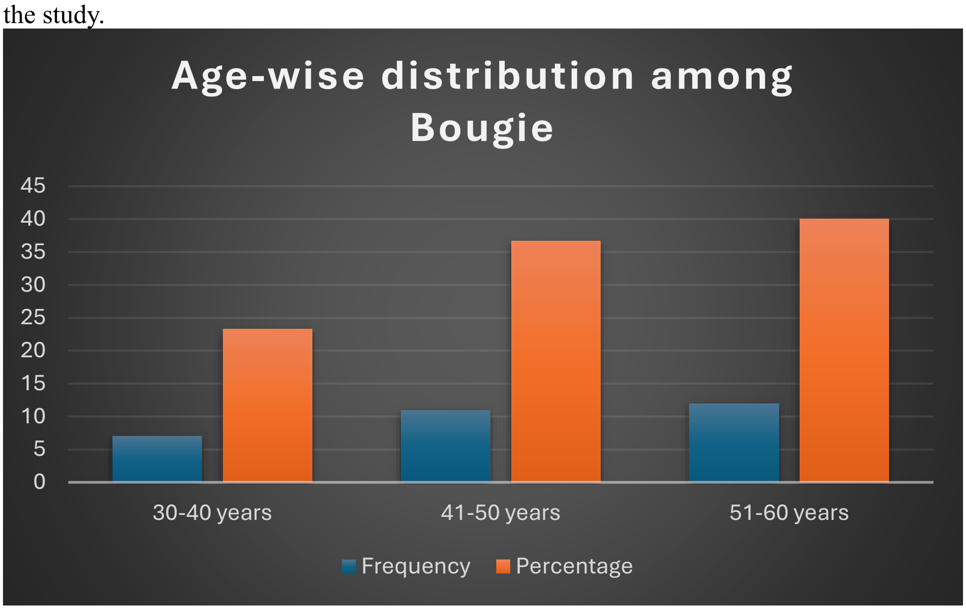
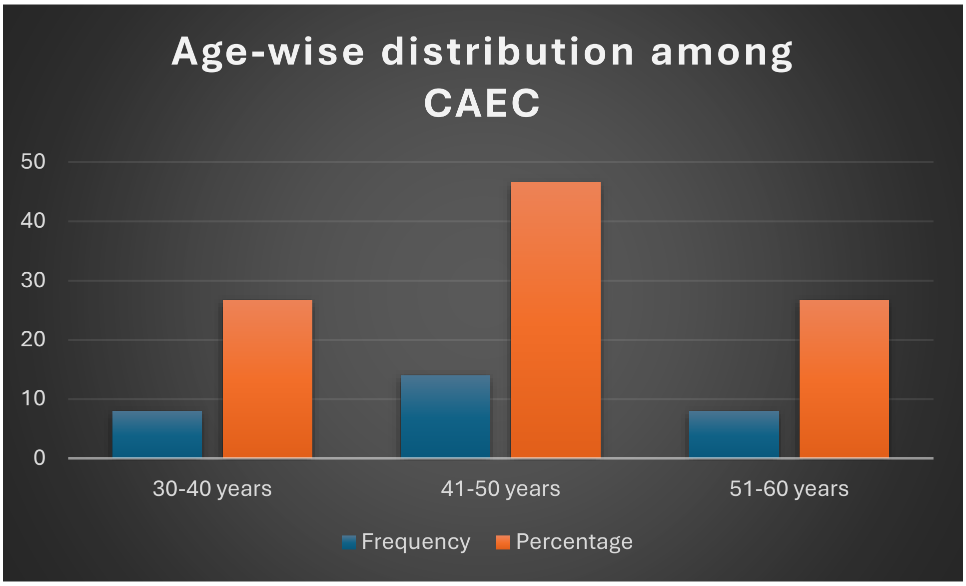


Table 2: Age-wise distribution among the study participants” according to CAEC

“Age”	N	%
“30-40 yrs”	8	26.7
“41-50 yrs”	14	46.6
“51-60 yrs”	8	26.7

Table 2 shows the age-wise distribution of participants who underwent intubation using the Cook’s Airway Exchange Catheter (CAEC). The highest proportion of participants, 46.6%, belonged to the 41–50 years age group, indicating that this age range was most commonly represented in the CAEC group. Both the 30–40 years and 51–60 years age groups had equal representation, with 26.7% each. This suggests a relatively balanced distribution across the age ranges, with a slight predominance of middle-aged individuals in the CAEC group.



"Table 3: Mean and Standard Deviation of age among the study participants"

"Variables"	"Group"	"Mean"	SD	Standard error mean	P value
Age in years	Bougie	48.03	7.876	1.438	0.693
	CAEC	46.67	8.491	1.550	

"Table 3 presents the mean age and standard deviation" of study participants in both the adjustable bougie and Cook's Airway Exchange Catheter (CAEC) groups. "The mean age in the bougie group was 48.03 ± 7.876 years, while the CAEC group" had a slightly lower mean age of 46.67 ± 8.491 years. "The P value of 0.693 indicates that there is no statistically significant difference in the mean age between the two groups", suggesting that age distribution was comparable across both intervention groups.

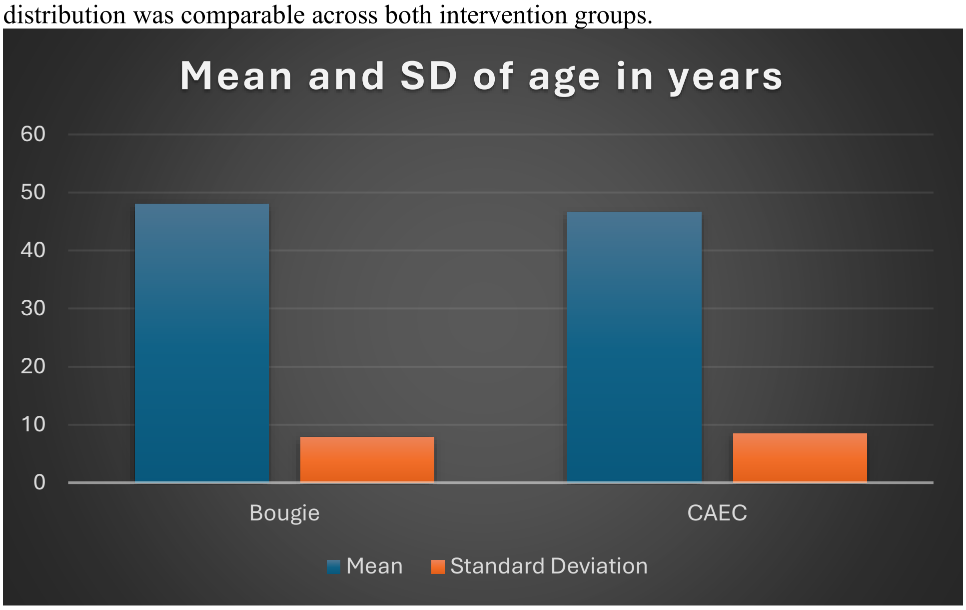
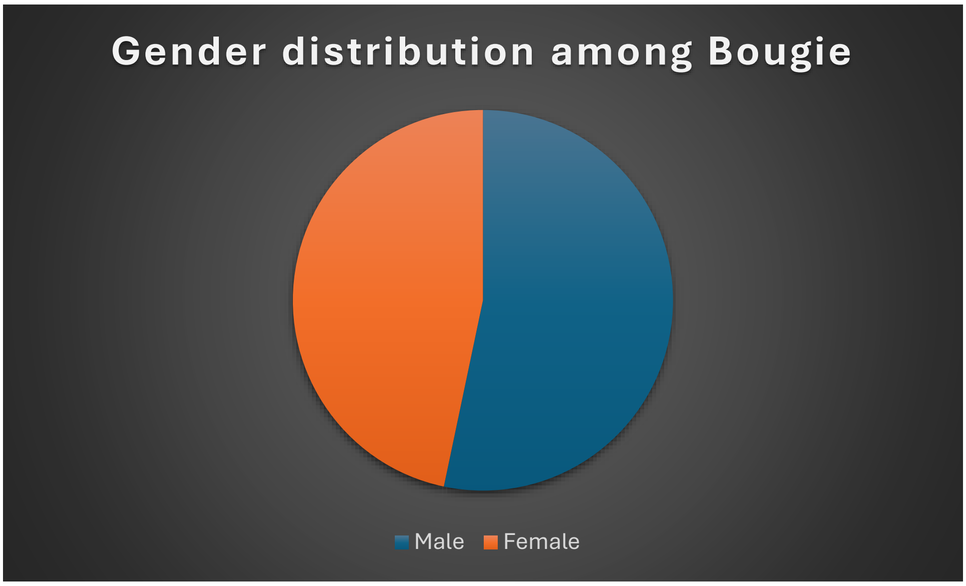


Table 4: "Gender distribution among the study participants"

"Gender"	Bougie		CAEC	
	N	%	N	%
"Male"	16	53.3	22	73.3
"Female"	14	46.7	8	26.7

"Table 4 illustrates the gender distribution among study participants" in the adjustable bougie and Cook's Airway Exchange Catheter (CAEC) groups. In the bougie group, males comprised 53.3% and females 46.7%, indicating a nearly balanced gender distribution. In contrast, the CAEC group had a higher proportion of male participants at 73.3%, with females making up only 26.7%. This shows a male predominance in the CAEC group compared to a more evenly distributed gender representation in the bougie group.



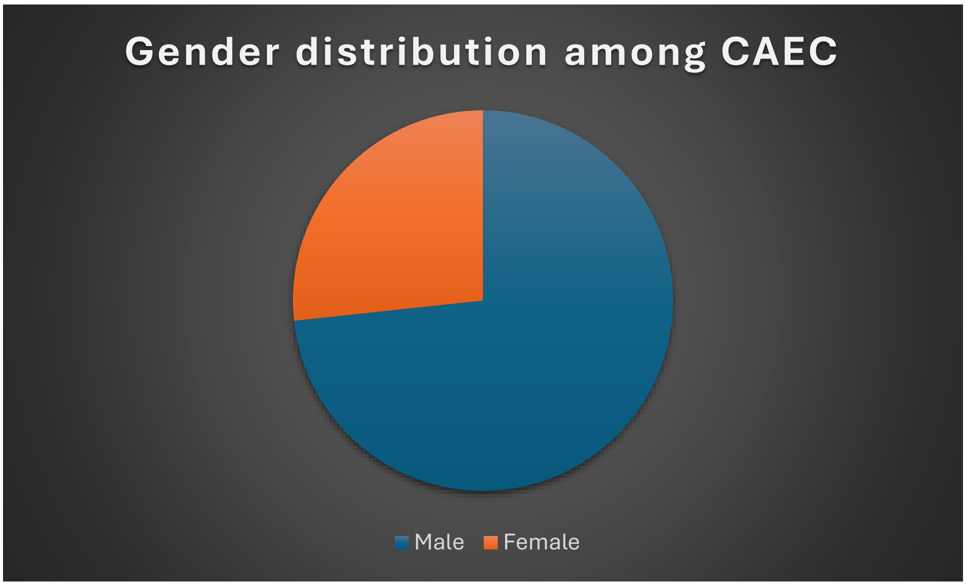


Table 5: "Mean and Standard Deviation of weight among the study participants"

"Variables"	"Group"	"Mean"	"Standard Deviation"	"Standard error mean"	"F value"	"P value"
Weight in kg	Bougie	71.47	11.166	2.039	3.518	0.06
	CAEC	71.50	8.333	1.521		

Table 5 presents "the mean and standard deviation" of weight among participants in both the adjustable bougie and Cook's Airway Exchange Catheter (CAEC) groups. The mean weight in the bougie group was 71.47 ±11.166 Kg, while the CAEC group had a nearly identical mean weight of 71.50 kg ± 8.333 Kg. "The P value of 0.06" indicates "that there is no statistically significant difference" in the mean weight "between the two groups", suggesting that weight was well-matched across both study populations.

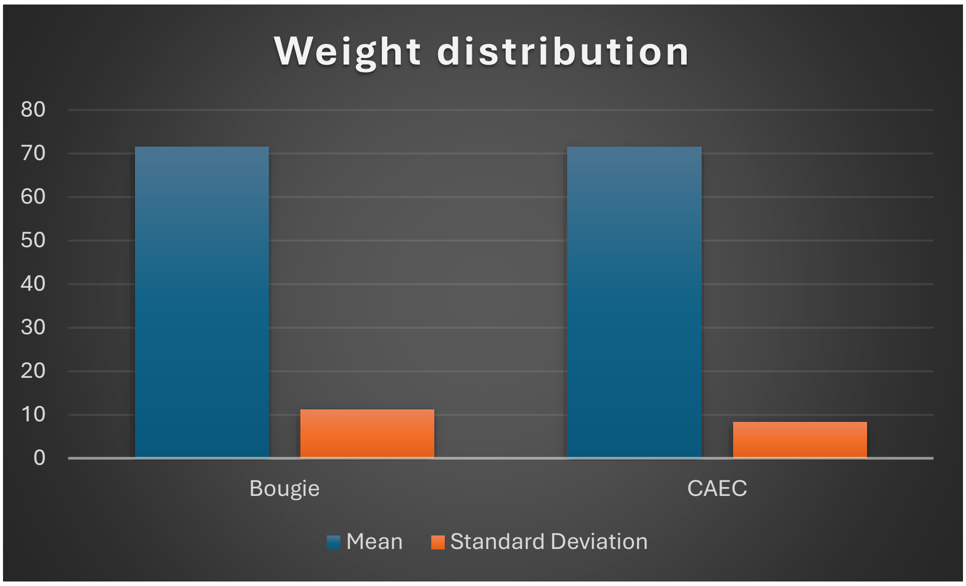


Table 6: "Mean and Standard Deviation of height among the study participants"

"Variables"	"Group"	"Mean"	"Standard Deviation"	"Standard error mean"	"F value"	"P value"
Height in cm	Bougie	170.07	5.336	0.974	2.019	0.161
	CAEC	168.30	6.115	1.116		

"Table 6 shows the mean and standard deviation of height" among participants in the adjustable bougie and Cook's Airway Exchange Catheter (CAEC) groups. The mean height in the bougie group was 170.07 ± 5.336 cms, while the CAEC group had a slightly lower mean height of 168.30 ± 6.115 cms. The P value of 0.161 indicates that the difference in height between the "two groups is not statistically significant", suggesting that participants "in both groups were comparable in terms of height".

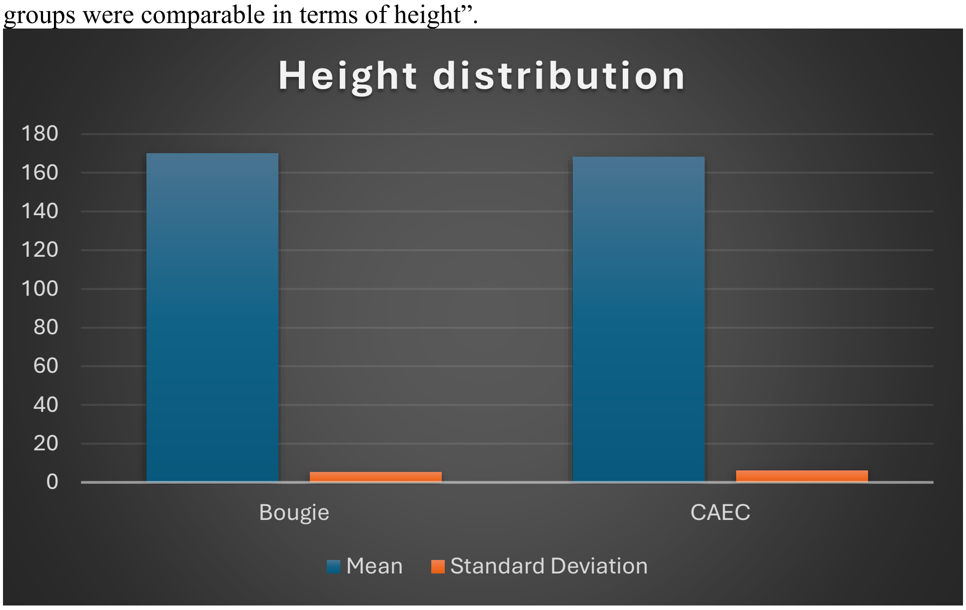


Table 7: ASA grading distribution among the study participants

ASA "grade"	Bougie		CAEC		P value
	N	%	N	%	
I	12	40.0	4	13.3	0.06
II	10	33.3	12	40.0	
III	8	26.7	14	46.7	

Table 7 presents the distribution of ASA (American Society of Anesthesiologists) physical status grading among participants in the adjustable bougie and Cook's Airway Exchange Catheter (CAEC) groups. In the bougie group, 40% of participants were classified as ASA Grade I, 33.3% as Grade II, and 26.7% as Grade III. In contrast, the CAEC group had a lower proportion of ASA Grade I participants (13.3%) and a higher proportion in Grades II

(40%) and III (46.7%). “The P value of 0.06 suggests” a trend toward a “difference” in ASA grade distribution between the two groups, with higher-risk patients (ASA II and III) “in the CAEC group, although the difference is not statistically significant”.

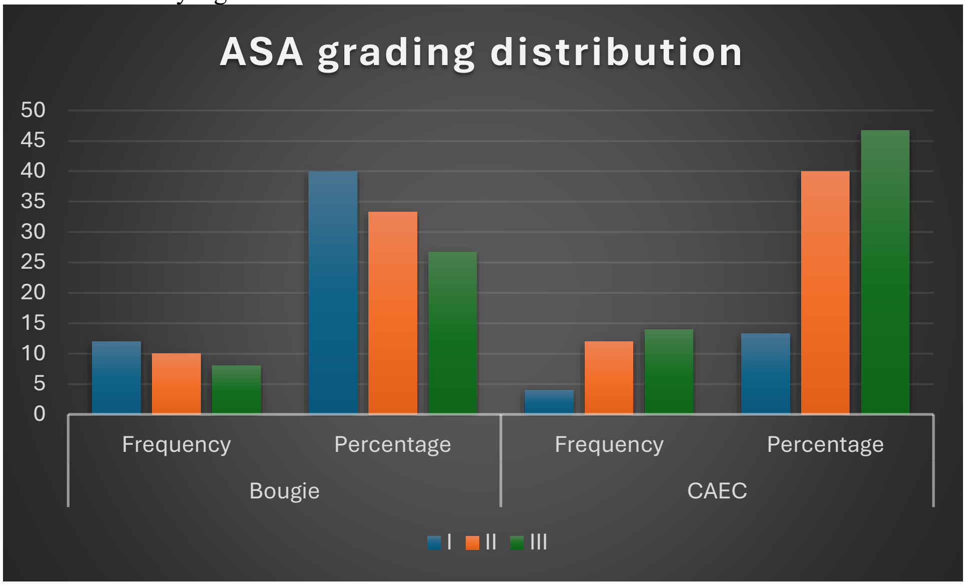


Table 8: Mallampati grading distribution among the study participants

Mallampati grade	Bougie		CAEC		P value
	Frequency	Percentage	Frequency	Percentage	
I	8	26.7	11	36.7	0.437
II	13	43.3	14	46.6	
III	9	30.0	5	16.7	

Table 8 shows the distribution of Mallampati grading among participants in the adjustable bougie and Cook’s Airway Exchange Catheter (CAEC) groups. In the bougie group, 26.7% were classified as Mallampati Grade I, 43.3% as Grade II, and 30% as Grade III. In the CAEC group, 36.7% were Grade I, 46.6% were Grade II, and 16.7% were Grade III. While both groups had a majority of participants in Grade II, the bougie group had a higher proportion of participants with Grade III airways, potentially indicating more challenging airway conditions. “The P value” of 0.437 “suggests no statistically significant difference” in Mallampati grade distribution “between the two groups”.

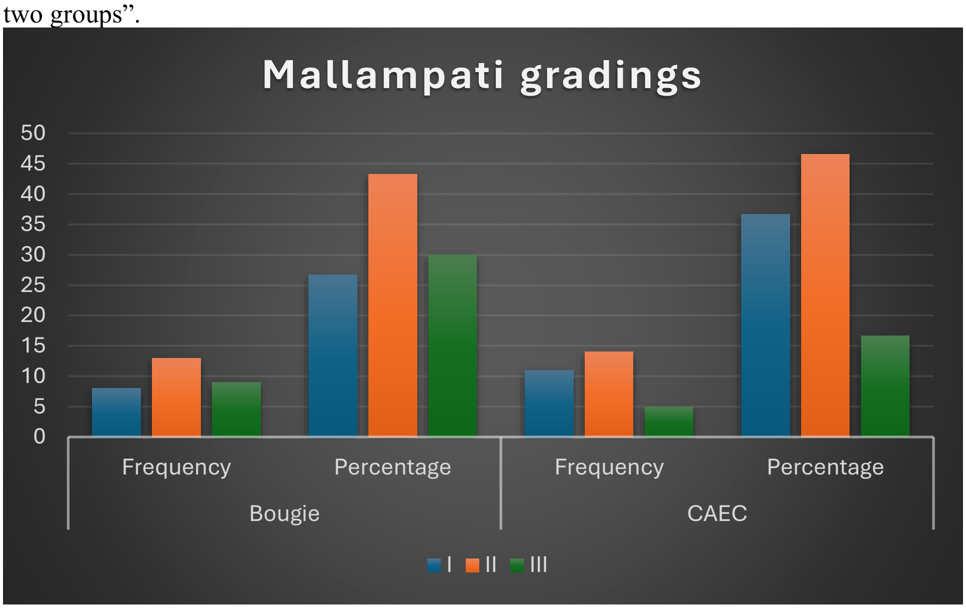


Table 9: CL grading distribution among the study participants

CL grade	Bougie		CAEC		P value
	Frequency	Percentage	Frequency	Percentage	
I	13	43.3	12	40.0	0.830
II	6	20.0	8	26.7	
III	11	36.7	10	33.3	

Table 9 presents the distribution of Cormack-Lehane (CL) grading among participants in the adjustable bougie and Cook's Airway Exchange Catheter (CAEC) groups. In the bougie group, 43.3% of participants had a CL Grade I view, 20% had Grade II, and 36.7% had Grade III. Similarly, in the CAEC group, 40% "had Grade I", 26.7% had "Grade II", and 33.3% "had Grade III". The distribution of CL grades appears comparable between the two groups, with the majority having either Grade I or III views. "The P value of 0.830 indicates no statistically significant difference in CL grade distribution between the groups", suggesting similar airway visualization conditions during intubation.

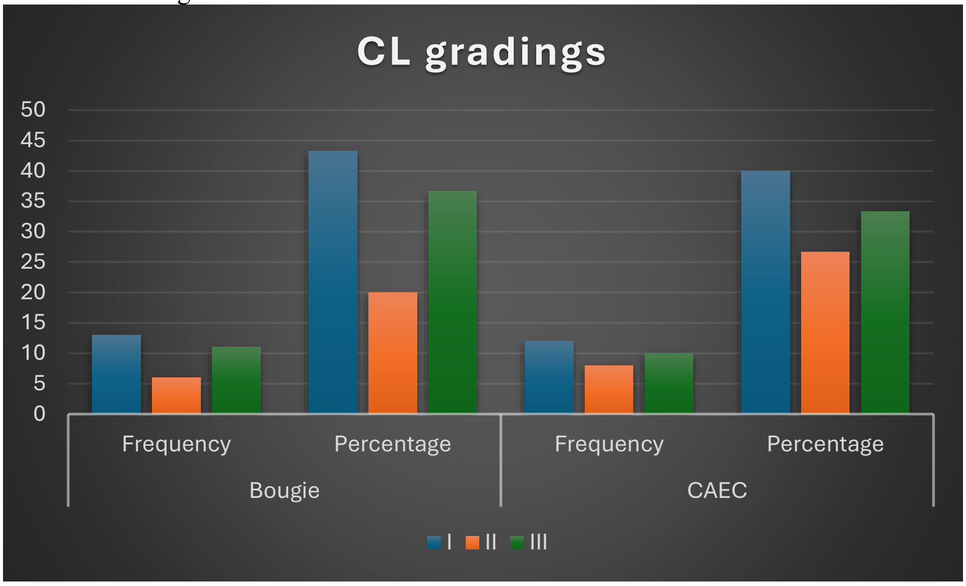


Table 10: Association between bougie and Cooks airway exchange Catheter (CAEC) of mean and Standard Deviation of Intubation time in seconds

"Variables"	"Group"	"Mean"	"Standard Deviation"	"Standard error mean"	"F value"	"P value"
Intubation time in seconds	Bougie	23.23	2.635	0.481	15.883	**0.001***
	CAEC	26.50	5.036	0.919		

Table 10 compares the mean intubation time in seconds between the adjustable bougie and Cook's Airway Exchange Catheter (CAEC) groups. The mean intubation time for the bougie group was 23.23 ± 2.635 seconds, whereas the CAEC group had a higher mean intubation time of 26.50 ± 5.036 seconds. "The P value of 0.001 indicates a significant different", with the adjustable bougie demonstrating a faster intubation time compared to the CAEC. This suggests that the bougie may offer greater efficiency during intubation using CMAC video laryngoscopy.

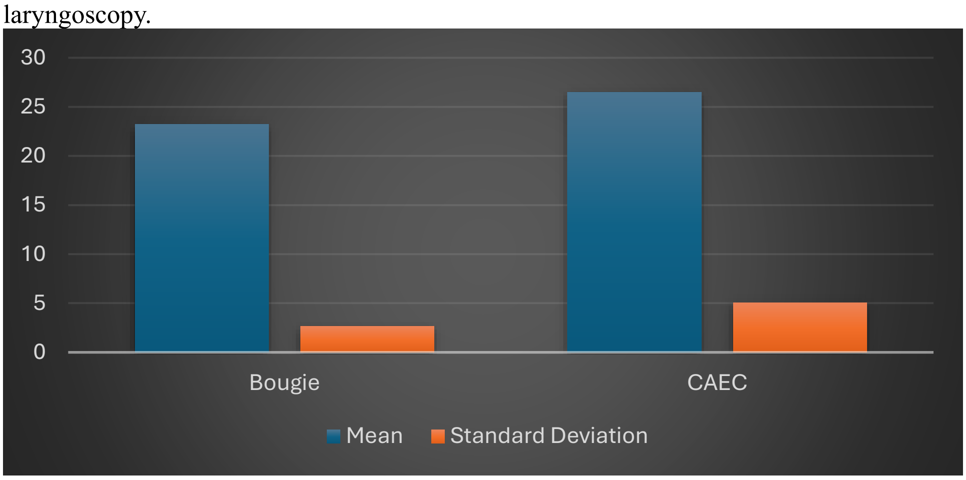


Table 11: Number of attempts distribution among the study participants

No of attempts	Bougie		CAEC		P value
	Frequency	Percentage	Frequency	Percentage	
1	18	60.0	10	33.3	**0.03***
2	12	40.0	20	66.7	

Table 11 illustrates the distribution of the number of intubation attempts among participants using the adjustable bougie and Cook's Airway Exchange Catheter (CAEC). In the bougie group, 60.0% of participants were successfully intubated on the first attempt, whereas only 33.3% achieved first-attempt success in the CAEC group. Conversely, 40.0% of the bougie group required a second attempt compared to 66.7% in the CAEC group. "The P value of 0.03 indicates a significant difference", suggesting that the adjustable bougie is associated with a higher "first-attempt success rate", and potentially more efficient intubation compared to the CAEC when using CMAC video laryngoscopy.

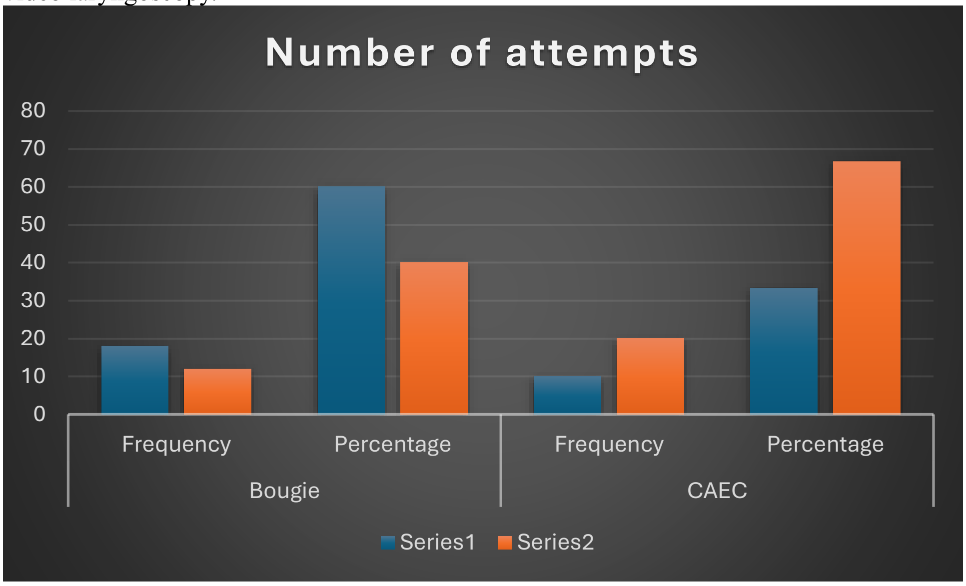


Table 12: Success distribution among the study participants

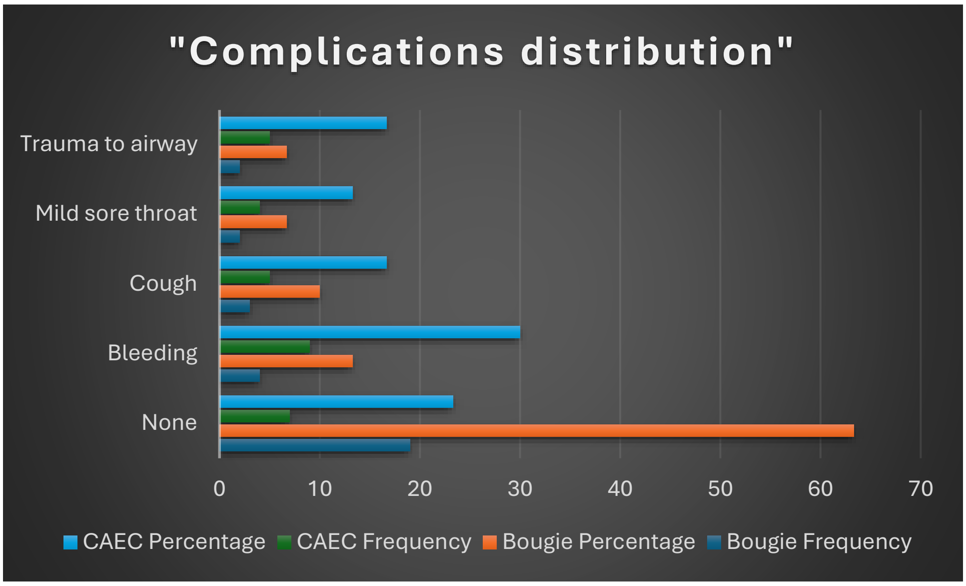
Success	Bougie		CAEC	
	Frequency	**Percentage**	**Frequency**	**Percentage**
Yes	30	100.0	30	100.0

Table 12 demonstrates that both the adjustable bougie and Cook's Airway Exchange Catheter (CAEC) groups achieved 100% success in intubation, with all 30 participants in each group successfully undergoing the procedure. This indicates that both techniques were equally effective in ensuring successful intubation when used with CMAC video laryngoscopy, highlighting their reliability in clinical practice.

Table 13: Association between bougie and Cooks airway exchange Catheter (CAEC) of complications distribution among the study participants

Complications	Bougie		CAEC		P value
	Frequency	**Percentage**	**Frequency**	**Percentage**	
None	19	63.3	7	23.3	**0.04***
Bleeding	4	13.3	9	30.0	
Cough	3	10.0	5	16.7	
Mild sore throat	2	6.7	4	13.3	
Trauma to airway	2	6.7	5	16.7	

Table 13 presents the distribution of complications among participants in the adjustable bougie and Cook's Airway Exchange Catheter (CAEC) groups. A significantly higher proportion of participants in the bougie group (63.3%) reported no complications compared to just 23.3% in the CAEC group, "with a P value of 0.04 indicating significant difference". In CAEC group, a higher percentage of participants experienced complications such as bleeding (30%), cough (16.7%), mild sore throat (13.3%), and trauma to the airway (16.7%). The bougie group, in contrast, had a lower incidence of these complications, particularly bleeding and trauma to the airway. This suggests that the bougie may be associated with fewer complications compared to the CAEC when used for intubation with CMAC video laryngoscopy.



DISCUSSION

The comparison between the novel adjustable bougie and Cook's airway exchange catheter (CAEC) for intubation using C-MAC video laryngoscopy highlights significant differences in their performance, effectiveness, and complication rates.

In the present study the age distribution among participants in both groups was relatively balanced, allowing for a fair comparison across different age brackets. In the bougie group, the majority of patients (40%) "belonged to the 51–60 years age group, followed by 36.7% in the 41–50 years group" and 23.3% in the 30–40 years group. In contrast, the CAEC group had the highest representation (46.6%) in the 41–50 years age group, with equal proportions (26.7%) in both the 30–40 and 51–60 years groups. This relatively uniform age distribution reduces potential confounding effects of age-related anatomical variability in airway management, ensuring that differences in intubation outcomes between the two devices are less likely to be influenced by participant age.

In similar studies, such as those by Moon et al. (2013), age has been shown to influence intubation outcomes, with older age groups sometimes experiencing more difficulty in securing the airway (95). However, in this study, both devices showed comparable success rates despite the age differences in the groups, suggesting that factors other than age, such as the device's design and ease of use, might play a more significant role in the intubation process. The results indicate that both the bougie and the CAEC are effective tools for intubation across a wide age range, but the differences in age distribution could be further explored to understand their impact on device efficacy in a broader demographic.

The present study "the mean age in the bougie group was 48.03 ± 7.876 years", while it was 46.67 ± 8.491 years in the CAEC group. These findings align with those of Batuwitage et al. (2014), who also reported balanced demographic profiles between intubation device groups in their comparative study, ensuring that outcome differences could be attributed to device performance rather than patient age (94). In contrast, a study by Nouruzi-Sedeh et al. (2009) observed age-related variability influencing intubation success with different airway devices, particularly in older patients with limited neck mobility (3). However, in our study, the similarity in age distribution and mean age between groups supports a more reliable comparison of the efficacy and safety profiles of the two devices when used with C-MAC video laryngoscopy.

In the current study, gender distribution revealed a slightly "higher proportion of males in both groups, with 53.3% males in the bougie group and 73.3% in the CAEC group". Although the distribution was not statistically analyzed here, the groups appeared reasonably balanced to ensure fair comparison. This distribution aligns with the findings of Aziz et al. (2011), where male predominance was seen in airway studies due to the higher prevalence of difficult airway indicators like obstructive sleep apnea and increased neck circumference in males (5). However, "in contrast, a study by Nouruzi-Sedeh et al. (2009)" emphasized that female patients tend to have easier intubation profiles due to more favorable airway anatomy, potentially affecting device performance outcomes (3). Despite the gender variation in our study, the near-balanced female representation in the bougie group allows a meaningful comparison and may highlight the potential utility of the adjustable bougie in anatomically smaller or more variable airways, commonly seen in female patients.

In this "study, the mean weight of participants in both groups" was nearly identical—71.47 kg in the bougie group and 71.50 kg in the CAEC group indicating well-matched study populations in terms of body weight. This similarity helps minimize weight-related bias in evaluating the efficacy of the two airway adjuncts. Comparable weight distribution is crucial, as increased body weight has been associated with difficult airway scenarios due to factors such as limited neck mobility or increased soft tissue around the oropharynx. A study by Adnet et al. (1997) also noted the importance of weight in predicting intubation difficulty, highlighting that a balanced comparison enhances internal validity (96). In contrast, other studies, such as those by Shailaja et al. (2014), have observed variations in device performance based on patient BMI, suggesting that even subtle differences could influence ease of intubation (97). However, in the present study, the comparable mean weights suggest that observed differences in performance between the devices are more likely due to device characteristics rather than patient variability in weight.

"In the present study, the mean height of participants in the bougie group" was 170.07 cm, while it was slightly lower at 168.30 cm in the CAEC group, indicating that both groups were relatively similar in terms of height distribution. This comparability reduces the likelihood of height influencing the outcomes related to intubation success or difficulty, as anatomical factors like neck length or tracheal positioning could potentially affect intubation dynamics. Similar findings were observed in a study by Aziz et al. (2012), where patient height did not significantly impact first-pass intubation success when using video laryngoscopy, affirming the neutrality of this factor when device performance is being assessed (53). Conversely, a study by Wong et al. (2019) suggested that in extremely tall or short individuals, airway axis alignment might vary, possibly influencing the ease of ETT advancement (98). However, in the context of the current study, the closely matched average heights between the two groups suggest that any differences observed in intubation outcomes are more likely attributable to the performance characteristics of the adjustable bougie and CAEC rather than anatomical variation in stature.

"In the present study, the distribution of ASA (American Society of Anesthesiologists) physical status grades among participants showed that a higher proportion of ASA I patients were in the bougie group (40.0%) compared to the CAEC group (13.3%), while ASA II and III patients were more predominant in the CAEC group". Although the P value (0.06) was not statistically significant, this variation suggests that the CAEC group included more patients with higher perioperative risk. Similar to this, a study by Aziz et al. (2011) observed that patients with higher ASA grades were more likely to present with intubation challenges, potentially influencing the choice and efficacy of airway adjuncts (41). However, a contrasting study by Lascarrou et al. (2017) reported that when using video laryngoscopy, differences in ASA grading did not significantly affect first-pass success, suggesting the advantage of enhanced glottic visualization may compensate for underlying patient comorbidities (99). Thus, while ASA grade variations exist between groups in this study, the overall impact on intubation success using either the adjustable bougie or CAEC remains clinically relevant, particularly in real-world scenarios where patient comorbidities are common.

In the present study, Mallampati grading distribution revealed that most participants belonged to grades I and II in both the bougie and CAEC groups, with grade II being the most common. However, a slightly higher percentage of grade III airways "was observed in the bougie group (30.0%) compared to the CAEC group" (16.7%). Although the P value (0.437) indicates no significant difference, the presence of more challenging airways (grade III) in the bougie group suggests its potential effectiveness even in less favorable airway scenarios. A similar observation was reported by Driver et al. (2018), where bougie use was associated with higher first-attempt intubation success in patients with difficult airways, including higher Mallampati grades (74). "In contrast, a study by Yemam et al. (2021) found that" airway adjuncts like the CAEC did not show a significant advantage over traditional methods in patients with higher Mallampati scores when used with video laryngoscopy (100). These findings support the idea that a novel adjustable bougie may offer better adaptability in anatomically difficult airways, maintaining performance even in patients with reduced glottic visibility.

In this study, the Cormack-Lehane (CL) grading distribution revealed that a majority of participants had grade I and II airways, with grade I being the most common in both the bougie (43.3%) and CAEC (40.0%) groups. Interestingly, there was a higher percentage of grade III airways in the bougie group (36.7%) "compared to the CAEC group (33.3%), although this difference was not statistically significant (P = 0.830). This suggests that" despite a slightly higher proportion of grade III airways in the bougie group, both airway adjuncts performed similarly in terms of handling different airway grades. "Similar findings were noted in a study by Frerk et al. (2016)", which compared different airway devices and found that the bougie, when combined with video laryngoscopy, was effective across varying CL grades, including those with challenging airways (15). "In contrast, a study by Kheterpal et al. (2009)" suggested that devices like the CAEC might offer an edge in more difficult intubations, particularly in grade III airways, though the difference was not significant (11). This indicates that both the adjustable bougie and CAEC are effective tools for managing a range of airway grades, with minimal differences in performance across different CL classifications in the current study.

The mean intubation time for the bougie group (23.23 seconds) "was significantly lower than that of the CAEC group (26.50 seconds), with a P value of 0.001 indicating a statistically significant difference. This finding suggests that" the novel adjustable bougie may offer a faster intubation compared to the Cook's airway exchange catheter when used with C-MAC video laryngoscopy. Similar results were observed in studies by Von Hellmann et al. (2024), which showed that the bougie facilitated quicker intubations due to its superior maneuverability and real-time adjustability, allowing for more efficient passage through the airway (101). On the other hand, studies such as those by Law et al. (2013) have indicated that while the CAEC is a reliable adjunct for difficult airways, its slightly longer intubation time may be attributed to its less flexible design and the requirement for more adjustments during the procedure (102). These findings highlight that the bougie, with its enhanced flexibility, may improve the speed and success of intubation in cases where time is critical.

The "number of attempts required for successful intubation was significantly lower in the bougie group compared to the CAEC group, with 60% of the bougie group achieving intubation on the first attempt, versus only 33.3% in the CAEC group (P = 0.03). This difference is" statistically significant, suggesting that the adjustable bougie may improve the likelihood of first-attempt success in intubation procedures using C-MAC video laryngoscopy. These findings align with studies by Von Hellmann et al. (2024), which demonstrated that bougies, with their real-time adjustability and maneuverability, facilitate easier passage through the vocal cords, thereby reducing the need for multiple attempts (101). In contrast, the Cook's airway exchange catheter, while effective, often requires more attempts, particularly in difficult airway scenarios, due to its more rigid design, as conducted by a study in Maseri et al. (2024) (103). This difference "highlights the potential advantage of the bougie in reducing the risk of airway trauma and improving procedural efficiency, particularly in cases of predicted difficult intubation".

In this study, both the adjustable bougie and Cook's airway exchange catheter (CAEC) demonstrated a 100% success rate for intubation, with all patients achieving successful endotracheal tube placement. This indicates that both devices, when used with C-MAC video laryngoscopy, are highly effective in facilitating successful intubations, regardless of the adjunct device used. Similar "studies, such as those by Law et al. (2013) and Maseri et al. (2024)", have also reported high success rates with video laryngoscopy-assisted intubations, whether using bougies or airway exchange catheters (102,103). The findings are consistent with these studies, where both bougie and CAEC have shown to be reliable tools in ensuring successful intubation in a variety of airway conditions. While the 100% success rate in both groups is reassuring, it is important to consider that factors such as time to intubation and the number of attempts, which varied between groups, may provide further insights into the practical efficiency of each device in real-world clinical settings.

In this study, the occurrence of complications "was significantly lower in the bougie group compared to the CAEC group", with 63.3% of bougie group participants reporting no complications versus 23.3% in the CAEC group (p = 0.04). This suggests that the adjustable bougie may be associated with fewer adverse events during intubation when compared to the Cook's airway exchange catheter, which aligns with findings from similar studies. "For instance, a study by Rafael et al. (2024) found that" bougies generally resulted in fewer complications, such as airway trauma and bleeding, compared to other intubation adjuncts (104). In contrast, the CAEC group in this study experienced higher rates of bleeding (30%) and trauma to the airway (16.7%), "which is consistent with the findings of a study by McLean et al. (2013)", where rigid airway exchange catheters were linked to higher complications due to their less flexible design (105). The bougie's greater flexibility and maneuverability could explain its superior safety profile in this study, offering a smoother passage through the airway and reducing the likelihood of trauma or bleeding. However, both devices showed comparable incidences of mild sore throat and cough, indicating that these complications may be more related to the intubation procedure itself rather than the adjunct device used.

"LIMITATION"S:

"The study" was not blinded for the operator, introducing potential performance bias, and the variation in operator experience may have influenced the outcomes. Additionally, the focus was limited to short-term procedural outcomes without evaluating long-term complications such as persistent sore throat or airway trauma through objective means like fiberoptic examination. The study predominantly included patients with easier airway grades (Mallampati and Cormack-Lehane grades I and II), thus not fully assessing device performance in more challenging airway scenarios. Furthermore, the lack of detailed analysis of patient comorbidities and BMI-based subgroup evaluation may have masked factors influencing intubation difficulty. Lastly, as the novel adjustable bougie is a new device, a learning curve may have affected its performance compared to the more familiar Cook's airway exchange catheter.

CONCLUSION

The comparative evaluation of the novel adjustable bougie and Cook's Airway Exchange Catheter (CAEC) for intubation using C-MAC video laryngoscopy revealed that while both devices demonstrated a 100% success rate in achieving endotracheal intubation, the adjustable bougie showed clear advantages in terms of clinical performance and safety. The bougie group had significantly shorter intubation times, higher first-attempt success rates, and notably fewer complications such as airway trauma and bleeding. These benefits are likely attributable to the bougie's superior maneuverability and real-time adjustability, which may enhance navigation through anatomically challenging airways. Despite comparable patient demographics in terms of age, weight, height, and ASA classification, the bougie outperformed the CAEC in key procedural outcomes without compromising success. Overall, the novel adjustable bougie appears to be a more efficient and safer intubation adjunct compared to CAEC, especially in scenarios where rapid and atraumatic airway access is essential.

SUMMARY:

"The aim was to compare the efficacy and safety of a novel adjustable bougie versus the standard Cook's Airway Exchange Catheter (CAEC) using C-MAC video laryngoscopy". Patients were randomized into two groups of 30 each—Phase I (bougie group) and Phase II (CAEC group). Both groups had comparable demographics in terms of age, gender, weight, height, and ASA grading, allowing for balanced comparison. Though both devices

achieved a 100% intubation success rate, the bougie group showed significantly shorter intubation times (23.23 vs. 26.50 seconds, p=0.001), higher first-attempt success rates (60% vs. 33.3%, p=0.03), and fewer complications (63.3% complication-free vs. 23.3%, p=0.04) compared to the CAEC group. Additionally, despite having more participants with higher Mallampati and Cormack-Lehane grades, the bougie group maintained favorable outcomes, suggesting its superior performance in anatomically challenging airways. The findings indicate that the novel adjustable bougie may offer a faster, safer, and more effective alternative to the traditional CAEC during video laryngoscopy-guided intubation.

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MASTER CHART

PHASE I – BOUGIE GROUP

S.no	Age	Gender	Weight in Kg	Height in cm	ASA	Mallampati	CL grade	Intubation time in seconds	No. of attempts	Success	Complications
1	58	M	69	164	I	III	I	20	1	Y	1
2	39	F	80	170	I	II	I	22	2	Y	1
3	47	M	63	166	I	II	I	25	1	Y	1
4	36	F	69	160	II	I	III	26	1	Y	2
5	49	M	90	177	III	II	I	24	1	Y	1
6	55	M	75	174	II	II	II	22	2	Y	3
7	48	M	66	170	II	I	I	20	1	Y	1
8	52	M	59	173	I	III	III	28	2	Y	1
9	56	F	56	166	II	III	I	23	1	Y	1
10	56	F	58	161	I	III	II	26	1	Y	2
11	54	M	57	165	II	II	I	27	1	Y	1
12	48	M	58	173	III	II	III	26	1	Y	1
13	57	M	84	177	I	I	II	26	2	Y	2
14	59	M	77	178	III	II	I	24	1	Y	1
15	47	F	56	165	II	III	III	21	2	Y	1

16	53	F	67	170	III	II	I	22	1	Y	4
17	41	M	57	175	III	I	III	27	2	Y	1
18	55	M	78	176	III	II	III	25	1	Y	1
19	56	M	71	164	II	II	I	23	2	Y	3
20	46	F	69	178	II	III	III	19	1	Y	5
21	35	F	90	171	III	I	III	23	1	Y	2
22	49	M	70	161	I	III	III	20	2	Y	1
23	49	F	65	174	I	III	I	21	1	Y	5
24	57	F	85	172	II	II	I	24	1	Y	1
25	40	F	76	172	II	I	III	21	2	Y	1
26	40	F	81	175	I	III	III	24	2	Y	1
27	34	M	90	173	II	II	I	27	1	Y	3
28	44	M	88	168	I	I	II	21	1	Y	1
29	32	F	63	169	I	II	II	19	2	Y	1
30	49	F	77	165	I	I	II	21	2	Y	4

PHASE II – COOKS AIRWAY CATHETER

S.no	Age	Gender	Weight in Kg	Height in cm	ASA	Mallampati	CL grade	Intubation time in seconds	No. of attempts	Success	Complications
1	40	M	67	172	III	II	II	27	2	Y	5
2	51	F	84	161	II	I	II	18	1	Y	2
3	31	F	67	166	II	II	I	29	2	Y	1
4	58	M	63	180	II	III	I	22	2	Y	2
5	47	F	89	172	III	III	I	28	2	Y	4
6	49	M	68	172	I	II	I	24	1	Y	5
7	47	M	62	178	II	II	I	29	2	Y	1
8	50	M	75	164	III	I	II	25	1	Y	4
9	49	M	64	167	III	II	II	27	1	Y	4
10	46	M	82	176	II	II	III	34	2	Y	5
11	44	M	62	175	III	II	III	31	2	Y	3
12	60	F	85	164	II	I	I	22	2	Y	2
13	56	M	75	171	I	I	II	33	1	Y	1
14	53	M	75	161	II	I	III	31	2	Y	2
15	32	M	73	160	III	III	II	25	2	Y	1
16	37	M	76	171	II	II	III	23	2	Y	3
17	56	F	73	175	III	II	I	22	1	Y	5
18	46	F	77	175	II	I	I	23	2	Y	4
19	37	M	64	164	III	III	I	24	2	Y	1
20	39	M	80	167	III	II	I	22	2	Y	3
21	55	M	78	173	III	I	III	32	1	Y	2
22	54	M	62	163	II	II	II	22	2	Y	3
23	60	M	62	175	II	I	II	29	2	Y	5
24	41	M	81	173	II	I	III	25	1	Y	2
25	35	M	75	160	III	II	I	18	1	Y	1
26	53	F	71	162	III	III	III	18	2	Y	2
27	45	M	57	163	I	I	III	30	2	Y	1
28	48	M	66	162	I	II	III	35	2	Y	2
29	50	M	61	167	III	II	I	33	1	Y	3

30	31	F	71	160	III	I	III	34	2	Y	2

KEY TO MASTERCHART
Gender
1 - Male
2 – Female
Success
Y - Yes
Complications
1 - None
2 - Bleeding
3 - Cough
4 - Mild sore throat
5 - Trauma to airway