

# Rapid and safe removal of foreign bodies in the upper esophagus in children using an optimized Miller size 3 video laryngoscope blade

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## Abstract

**Background:** Foreign bodies lodged in the upper esophagus in children may result in life-threatening complications, especially with button batteries. Rapid removal is essential to prevent complications. Experts report that extraction with a suitable laryngoscope and a forceps is feasible under general anesthesia, but no further data had been available so far.

**Aims:** To study foreign body visualization and removal from the upper esophagus in children using a new optimized Miller size 3 blade video laryngoscope.

**Methods:** This prospective observational study was performed in three pediatric hospitals. The clinical observations were reported anonymously on an electronic spreadsheet after obtaining the informed consent from the parents or guardians. During the observational period from January 2019 to October 2020, all children with a foreign body lodged into the upper esophagus were eligible for participation and 22 cases were included. Main outcome measures were rates of successful removal and complications as well as duration of the procedure. Secondary outcome was subjective assessment regarding the quality of the visualization and the feasibility of the procedure.

**Results:** Success rate was 100% with no complications. Mean intervention and anesthesia times were  $5 \pm 4$  minutes and  $26 \pm 25$  minutes. Quality of visualization of the foreign body was judged as 'excellent' or 'good' in all cases and the feasibility of the procedure as 'without' or 'with little' effort in 95% of all cases.

**Conclusion:** The new Miller size 3 video laryngoscope enables rapid, easy, and reliable extraction of foreign bodies when they are located in the upper part of the esophagus. As early removal of esophageal foreign bodies, especially with button batteries, prevents life-threatening complications, we suggest this technique as the first choice of treatment.

## KEYWORDS

children, esophagoscopy, Foreign body ingestion

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## 1 | INTRODUCTION

Accidental ingestion of foreign bodies is a common pediatric emergency with close to 70,000 cases annually in the United States,<sup>1</sup> with most cases not leading to harm or even requiring treatment.<sup>2</sup> Coins are the most commonly ingested foreign body and like other blunt objects, the rate of impairment and complications in children is mainly influenced by anatomical location. Whereas gastric coins rarely lead to harm and do not need immediate intervention, coins lodged in the esophagus regularly cause pain and dysphagia. Laryngotracheal compression is possible, causing respiratory distress and stridor. Even in an asymptomatic child, coins and other blunt foreign bodies in the esophagus should be removed quickly, since the longer the foreign body is lodged, the risk of esophageal injuries increases.<sup>2</sup> In the majority of cases when foreign bodies become lodged in the esophagus, their location is at the level of upper esophageal sphincter or within the proximal third.<sup>3-6</sup>

Button batteries lodged in the esophagus are particularly dangerous. They present a true medical emergency and require removal without any delay.<sup>7</sup> A growing number of injuries in children<sup>8</sup> and even fatal cases<sup>9</sup> have been described during the last decade, attributable to a growing circulation of button batteries as well as their increased energy capacitance.<sup>10</sup> If a button battery is lodged in the esophagus,<sup>6</sup> the electrical current flow initiates a release of hydroxide radicals at the negative pole of the battery causing severe caustic damage<sup>11</sup> within the first two hours.<sup>12</sup> Esophageal perforation and strictures as well as tracheoesophageal fistulas may develop. Fatalities by fistulation into major blood vessels such as the aorta, subclavian, or thyroid artery leading to exsanguination are reported.<sup>13</sup> Therefore, all international recommendations emphasize the necessity for rapid removal of button batteries lodged in the esophagus.<sup>7,14,15</sup> Since a pediatric endoscopist is not always present, the mobilization of a specialized team or the necessity of transferring to a further institution may lead to critical delays in treatment.

Foreign bodies in the upper esophagus may be visualized with a well-sized laryngoscope and be extracted with a forceps of appropriate strength and length (eg, a Magill forceps).<sup>16-19</sup> Because this method had been used by individual experts for decades, it was integrated into the expert-based German guidelines regarding foreign body ingestions.<sup>15</sup> The use of a straight video laryngoscope blade is specifically recommended, as its wide-angle view and good illumination enables a better visualization and instrumentation compared with conventional laryngoscopes. This method does not require the availability of extensive pediatric endoscopy equipment and might be feasible for every anesthetist or other appropriately trained physician skilled in video laryngoscopy in children.

However, this technique occasionally is limited by the length of the laryngoscope blade and is not yet standard of care for the majority of children with foreign bodies lodged in the upper esophagus. In order to make the procedure as easy and reliable as possible, we collaborated with KARL STORZ SE & Co. KG company of Tuttlingen, Germany, to add a modified and optimized size 3 Miller blade to their STORZ C-MAC™ video laryngoscopy system.

### What is already known about the topic

- Foreign bodies lodged into the upper esophagus of children cause pain and dysphagia, and if not quickly removed lead to respiratory compromises and esophageal injuries. Lodged button batteries are particularly dangerous since their electrical current flow is causing severe caustic damage.

### What new information this study adds

- The extraction of foreign bodies out of the upper esophagus using a new Miller size 3 video laryngoscope and a forceps is feasible, fast, and safe.

This prospective observational trial was designed to describe the technique, its features, and success rate of foreign body removals from the upper esophagus in children while using a new optimized size 3 Miller STORZ C-MAC™ video laryngoscope blade. Main outcome measures were rates of successful removal and complications as well as duration of the procedure. Secondary outcome was subjective assessment regarding the quality of the visualization and the feasibility of the procedure.

## 2 | MATERIALS AND METHODS

All procedures performed in this study were in accordance with the ethical standards of the institutional Ethics Committee and with the 1964 Helsinki declaration and its later amendments. All medical products used were fully licensed for the intended use and patient groups. The multicenter trial was approved by the Ethics Committee of the University of Witten/Herdecke (Alfred-Herrhausen-Str. 50, D-58448 Witten, Germany; file reference Nr. 87/2018; Chairperson Prof. Dr. P. W. Gaidzik; December 1, 2018). According to this ethical approval, written informed consent was required from parents or guardians. Local ethics committees provided approval at each participating center. This observational study was reported in accordance with the STROBE statement.

### 2.1 | The optimized Miller-shaped video laryngoscope blade and description of the removal technique

While using a video laryngoscope for the foreign body removal from the upper esophagus, it should not be navigated along the tongue down to the vallecula like for the endotracheal intubation when a perfect visualization of the larynx is intended. On the contrary, the tip of the laryngoscope blade should be navigated along the posterior pharyngeal wall down to the origin of the esophagus. The epiglottis needs to be lifted with the tip of the blade to gain access to the esophageal inlet. As soon as the tip of the blade enters the upper

esophagus sphincter, the laryngoscope should be lifted in the direction of its handle to open the esophagus and to visualize the foreign body. This should be grasped with a stable forceps (eg, Magill forceps, modified Magill forceps, or a strong endoscopy forceps) while strictly avoiding grasping any tissue. The foreign body can be carefully extracted which occasionally requires increased forces. In difficult extractions, a 2-operator-4-hand technique may be useful for controlled handling of the laryngoscope and the forceps. After removal of the foreign body, a review using the same technique using the laryngoscope blade should be performed to check for local injuries.<sup>20</sup> If this cannot be judged properly due to a compromised visualization, a conventional endoscopy should be performed. If relevant lesions are visible or any impairment remains after the procedure, an endoscopy should be scheduled a few days later, depending on the nature of the foreign body and on the extent of the initial damage. The whole procedure can be done under endotracheal intubation and artificial ventilation or with bag-mask ventilation during intermittent apnea. Available blades are occasionally too short for the extraction of foreign bodies from the upper esophagus. Additionally, an optimal blade should be straight to enable an easy positioning into the upper esophagus. Moreover, a favorable blade should be as small as possible in order to provide enough free space to allow instrumentation in the oropharynx.

To accommodate those requirements, KARL STORZ added a modified miller-shaped size 3 blade (with 177 mm length) to their C-MAC™ video laryngoscope series. The classic miller-shaped blade has the profile of a 2/3 tube. By opening this profile to a 1/3 tube, the blade became narrower whereas the length has been maintained (Figure 1). This optimized blade was fully licensed by STORZ in accordance with the European Medical Device Directive (MDD; 93/42/EEC) as a reusable, sterilizable device.

## 2.2 | Study design, outcome measures, and statistical evaluation

This study was designed as a prospective observational trial with participation of three specialized pediatric hospitals. All children presenting at one of the participating institutions with a radiologically proven or suspected foreign body lodged in the upper esophagus were eligible for inclusion. The trial had no influence on the related decision-making process, the decision about the chosen technique or the modalities of anesthesia performed for the intervention. If the optimized Miller size 3 video laryngoscope and a forceps were used with the intention to remove a foreign body lodged into the upper esophagus, patients could be included. All participating institutions used a standardized electronic spreadsheet (EXCEL 365, Microsoft Corp., Redmond, WA, USA) for documentation of the procedure and transmitted the anonymized data to the study coordinator.

Main outcome measures were the rates of successful removal and complications (desaturation = pulse oximetry below 90%; blood pressure compromise = blood pressure decrease of more than 20%; laryngospasm/bronchospasm; pulmonary aspiration, any other complication), as well as the time required for the procedure and anesthesia. Duration of the intervention was defined as first touching the video laryngoscope with the intention to remove the foreign body until passage of the foreign body out of the oral cavity. Duration of anesthesia was defined as start of anesthesia induction until discharge from interventional room or theater. In addition, a subjective judgment by the interventionist about the feasibility of the procedure and the quality of visualization was queried, as described before<sup>21</sup> and defined in Table 3. Epidemiologic data included fasting status, time and day of presentation, and clinical impairment of swallowing and breathing by the foreign body ingested.

**FIGURE 1** Newly invented, optimized miller-shaped video laryngoscope blade size 3 (Picture by company KARL STORZ). A classic shaped Miller 3 blade and the modified model within a direct comparison. The optimized blade has a wider open profile of a 1/3 tube, whereas the profile of the classic model corresponds to a 2/3 tube



Since this trial did not set up a comparison arm but was solely an observational description of a single technique, no sample size calculation was reasonable. Solely descriptive data presentation was planned.

### 3 | RESULTS

Over 22 months (January 2019–October 2020), a total of 22 patients were included from three children's hospitals with foreign

bodies lodged in the upper esophagus (15 coins [68%], four different foodstuffs, one button battery, one medal, one necklace pendant). Average age was  $3.2 \pm 2.9$  years and almost all children were admitted outside regular working hours, not fasted and with dysphagia (Table 1). Most of the children had a radiograph before the intervention due to a radiopaque foreign body being suspected.

Foreign body removal was successful in all children, with no complications observed (Table 2). The duration of the foreign body removal was on average  $5.1 \pm 3.8$  minutes with a mean duration of

	Mean	SD	Min/Max
Age (years)	3.2	$\pm 2.9$	0.8/10.9
Weight (kg)	17.5	$\pm 11.2$	9.5/50.0
Clinical conditions	yes (n/%)	no (n/%)	
Witnessed ingestion	17/77.3%	5/22.7%	
Compromised swallowing	21/95.5%	1/4.5%	
Compromised breathing	4/18.2%	18/81.8%	
Outside regular working hours	20/90.9%	2/9.1%	
Not fasted	18/81.8%	2/18.2%	
X-ray before intervention	18/81.8%	2/18.2%	

TABLE 1 Demographic data and clinical conditions of the children introduced.

Number of cases (n) Center a = 11, center b = 10, center c = 1

max, maximum; min, minimum; SD, standard deviation.

TABLE 2 Success rate, rate of complications, rate of endotracheal intubations performed, and duration of the procedure and the anesthesia

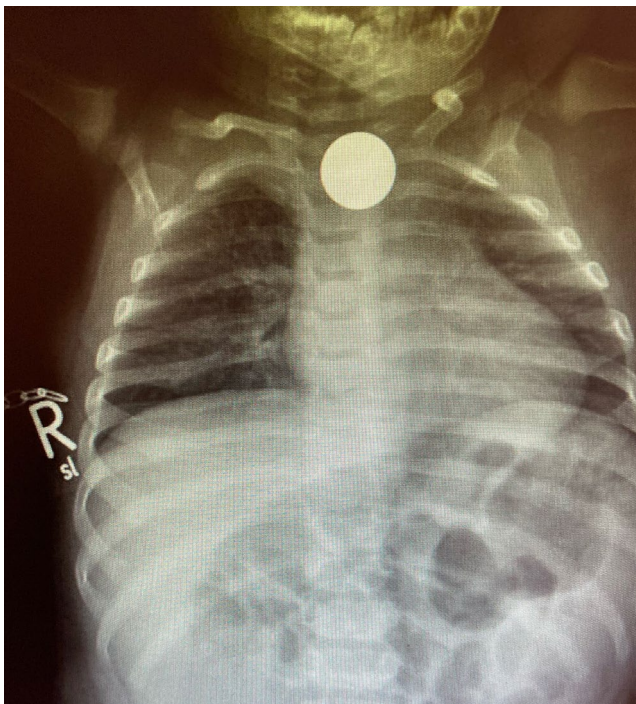
	Yes (n/%)	No (n/%)		
Success	22/100%	-		
Any complication <sup>a</sup>	-	22/100%		
Endotracheal intubation and NBD†	6/27.3%	16/72.7%		
Subgroup analysis center 1 (n = 11)	-	11/100%		
Subgroup analysis center 2 (n = 10)	5/50%	5/50%		
Subgroup analysis center 3 (n = 1)	1/100%	-		
	Mean	SD	Min/Max	t-test <sup>b</sup>
Duration of the intervention (min)	5.1	$\pm 3.8$	1/15	
Subgroup analysis center 1 (n = 11)	3.7	$\pm 2.0$	1/7	
Subgroup analysis center 2 (n = 10)	6.4	$\pm 4.9$	2/15	$p = 0.603^b$
Duration of the anesthesia (min)	25.7	$\pm 24.8$	10/120	
Subgroup analysis center 1 (n = 11)	14.5	$\pm 2.7$	10/20	
Subgroup analysis center 2 (n = 10)	34.5	$\pm 32.6$	10/120	$p = 0.057^b$

<sup>a</sup>Desaturation <90%, Drop of blood pressure >20%, laryngospasm/bronchospasm or any other complication observed; NBD =neuromuscular blocking drug; SD =standard deviation.

<sup>b</sup>Two-tailed Student *t* tests center 1 vs. center 2.

**TABLE 3** Subjective judgments of the quality of visualization of the foreign body and the feasibility of the removal procedure as a whole

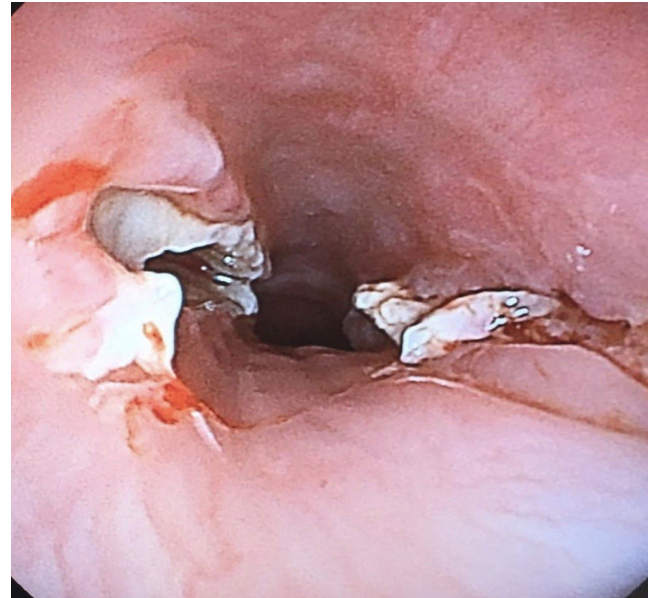
Quality of visualization	(n/%)
1 = excellent	17/77%
2 = good, but not perfect	5/23%
3 = difficult to use for this issue	-
4 = no visualization possible	-
Feasibility of the procedure	(n/%)
1 = without effort	12/55%
2 = with little effort	9/41%
3 = with great effort	1/5%
4 = unfeasible	-



**FIGURE 2** Coin lodged in the upper esophagus of a nine-month-old infant. Chest X-ray of a nine-month-old infant with a coin lodged in the upper esophagus for two days. The child was introduced to the hospital because of an increasing impairment of swallowing for two days, whereas no foreign body ingestion was observed

anesthesia of  $25.7 \pm 24.8$  minutes. Quality of the visualization of the foreign body was always judged as 'excellent' or 'good' and the feasibility of the procedure in 95% as 'without' or 'with little' effort (Table 3).

A comparison of the two main contributing children's hospitals revealed that at one center no patient, at the other 50% were endotracheally intubated during the intervention. Also, the duration of the procedure was 73% and the duration of anesthesia 138% longer



**FIGURE 3** Foreign body bed of a coin in the upper esophagus. Foreign body reactions of the esophagus due to an impacted coin that had been stuck in the upper esophagus of an infant for two days. Distinct granulation tissue development, swelling, and injuries of the mucous membrane are visible. Picture was captured with a pediatric gastroscope (Olympus EG740-N, Olympus Europa SE & Co. KG, Amsinckstraße 63, D-20097 Hamburg, Germany) after removal by the technique using the video laryngoscope. The infants' examination and esophagoscopy two weeks later revealed no impairments or residuals

in one center compared with one other (the differences were not significant, Table 2).

#### 4 | DISCUSSION

This multicenter prospective observational trial has confirmed that foreign bodies lodged in the upper esophagus of children can be removed quickly, easily, and safely using a newly introduced Miller size 3 video laryngoscope (C-MAC™ series of KARL STORZ). Although experienced clinicians had described this technique as feasible before using a conventional Miller blade,<sup>15,16</sup> handling, visualization, and instrumentation were markedly improved by the use of this optimized video laryngoscope blade. Furthermore, no trial had previously been published that analyzed success rates and feasibility of esophageal foreign body removal with any kind of laryngoscope blade. Button batteries are less frequently swallowed than coins, but the technique of removal is identical. Hence, transfer of these observations for lodged button batteries seems to be appropriate. Esophageally lodged coins are not as dangerous as button batteries, but early removal is also recommended since almost all children in our population experienced dysphagia and pain. Additionally, the risk of injuries increases with longer duration of coin lodgment (Figures 2 and 3).<sup>2</sup>

Without a doubt, general anesthesia is necessary for endoscopic foreign body removal from the upper esophagus. However, no clear recommendations on endotracheal intubation or other details are available.<sup>15,18</sup> Only two statements on the issue of anesthesia appear to be significant: It should be provided as fast as possible and by an anesthetist with pediatric expertise.<sup>10</sup> As we deliberately did not define a standardized anesthesia technique regarding drugs used and the instrumentation of the airway, we observed that in one center, general anesthesia was never accompanied by endotracheal intubation or usage of a neuromuscular blocking agent. This was in contrast to another Children's Hospital, where half of the cases were endotracheally intubated and solely in those patients, muscular blocking agents were regularly used. While some authors of case series report to use just deep sedation without intubation or usage of muscular blocking drugs,<sup>18,19</sup> others perform the procedures under endotracheal intubation.<sup>16</sup> However, at the hospital where endotracheal intubation with neuromuscular blockade was used more often, the average duration of the procedure was longer (difference not significant). The authors believe that the issue of anesthesia should be tailored to the individual clinical situation, be at the discretion of the responsible anesthetist and harmonized with the removal technique intended. Main goals in this regard are the avoidance of time delay and enabling high success rate for the benefit of patient safety.

As a limitation of this trial, we did not compare our described technique with any alternative. Since a foreign body lodged into the upper esophagus is an urgent emergency, rapid removal is imperative. All other endoscopic techniques are more time consuming and require a specialized pediatric endoscopic team. Therefore, no comparative trial with other endoscopic techniques was reasonable or even ethically justifiable. For the same ethical reasons, this trial did not seek to influence related decision-making or performance of healthcare provision in this emergency situation.

However, the fast and easy removal of the foreign body by this technique is also the greatest strength of the proposed concept. In some cases, if a specialized team is not available at the institution the child is admitted, a transfer to another hospital may become necessary. However, in the presence of a pediatrically competent anesthetist, every healthcare provider who is trained and skilled to perform a laryngoscopy can apply the described technique. By slightly modifying the laryngoscopy procedure as described above, the visualization of the upper esophagus is feasible and foreign bodies can be removed. This is—at least in the case of a button battery—a potentially life-saving measure. If the procedure failed, switch to another endoscopic technique or transfer to another hospital is necessary. However, if the technique is not attempted, delay would occur right from the start, so no worsening of the situation is caused by such an attempt.

Our descriptive analysis and confirmation that extraction of foreign bodies out of the upper esophagus using a Miller size 3 video laryngoscope is both feasible and fast should contribute to

dissemination of this technique. In cases of lodged button batteries, using this technique can prevent dangerous time delays and thereby potentially save children's lives.

## 5 | CONCLUSION

This study confirmed a convincing performance for removal of foreign bodies like coins or button batteries from the upper esophagus using a new optimized Miller size 3 video laryngoscope. Since this method enables fast removal, life-threatening complications can be avoided. Therefore, this method should be used as the first choice of treatment.

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Assistance with the study: There was no assistance with the article. All persons contributing to the work appear as authors.

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## CONFLICTS OF INTEREST

For all authors, none were declared.

## DATA AVAILABILITY STATEMENT

All data are available upon request. The data set will be archived for at least 10 years after publication.

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