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**ABOUT COVER**

Editorial Board Member of *World Journal of Meta-Analysis*, Sada Dwivedi, PhD, Professor, Department of Biostatistics, All India Institute of Medical Sciences, New Delhi 110029, India. [dwivedi7@aiims.edu](mailto:dwivedi7@aiims.edu)

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# Cap-assisted endoscopy for esophageal foreign bodies: A meta-analysis

Zahid Ijaz Tarar, Umer Farooq, Matthew L Bechtold, Yezaz A Ghouri

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**Zahid Ijaz Tarar**, Department of Internal Medicine, University of Missouri, Columbia, MO 65212, United States

**Umer Farooq**, Department of Medicine, Loyola University, Chicago, IL 60153, United States

**Matthew L Bechtold**, Department of Medicine, University of Missouri - Columbia, Columbia, MO 65212, United States

**Yezaz A Ghouri**, Department of Internal Medicine, Division of Gastroenterology and Hepatology, University of Missouri, Columbia, MO 65212, United States

**Corresponding author:** Matthew L Bechtold, AGAF, FACG, FASGE, MD, Professor, Department of Medicine, University of Missouri - Columbia, 5 Hospital Drive, Columbia, MO 65212, United States. [bechtoldm@health.missouri.edu](mailto:bechtoldm@health.missouri.edu)

## Abstract

### BACKGROUND

Esophageal foreign bodies are common around the world. Newer approaches, such as cap-assisted endoscopy, have been introduced as an alternative to conventional methods. Therefore, we performed a meta-analysis on cap-assisted endoscopy versus conventional endoscopy for removal of esophageal foreign bodies.

### AIM

To investigate the effectiveness of cap-assisted endoscopy with conventional endoscopy.

### METHODS

An extensive literature search was performed (December 2021). For esophageal foreign body removal, cap-assisted endoscopy was compared to conventional endoscopy for procedure time, technical success of the procedure, time of foreign body retrieval, *en bloc* removal, and adverse event rate using odds ratio and mean difference.

### RESULTS

Six studies met the inclusion criteria ( $n = 1305$ ). Higher odds of technical success ( $P = 0.002$ ) and *en bloc* removal ( $P < 0.01$ ) and lower odds of adverse events ( $P = 0.02$ ) and foreign body removal time ( $P < 0.01$ ) were observed with cap-assisted endoscopy as compared to conventional techniques.

## CONCLUSION

For esophageal foreign bodies, the technique of cap-assisted endoscopy demonstrated increased *en bloc* removal and technical success with decreased time and adverse events as compared to conventional techniques.

**Key Words:** Esophageal foreign body; Food bolus; Endoscopy; Snares; Forceps; Assisted devices; Cap-assisted endoscopy

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**Core Tip:** Esophageal foreign body impaction is very common worldwide. Many techniques have been used to treat these impactions. A newer technique of using a cap on the endoscope to assist the removal of the foreign body has been introduced. Therefore, we performed a meta-analysis. This meta-analysis showed that cap-assisted endoscopy has higher odds of technical success and *en bloc* removal as well as lower odds of adverse events and reduced procedure time for removal of impacted esophageal foreign bodies as compared to conventional techniques. With this information, cap-assisted endoscopy should be highly considered in removal of esophageal foreign bodies.

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## INTRODUCTION

Foreign body (FB) ingestion is a common gastroenterological emergency with an annual incidence of 120000 cases in the United States[1]. About 86.9% of ingested foreign bodies are lodged in the esophagus and, if left unresolved, it has been linked with the highest adverse event rate when compared to foreign bodies lodged in other parts of the gastrointestinal tract[2-4]. In majority of cases, the FB is ingested accidentally in adults while eating food, this includes impacted food bolus. In other cases, non-consumable objects are mainly ingested by individuals with an underline psychiatric disorder, social or developmental issues, alcohol abuse, or digestive diseases[5,6]. In many cases, when sharp foreign bodies, food boluses, or batteries are ingested, they may lead to complete esophageal obstruction and severe complications such as aspiration, perforation, or hemorrhage. In these cases, emergent assessment and management is warranted[2,7].

About 80%-90% of gastrointestinal foreign bodies pass spontaneously, while 10%-20% require endoscopic management and less than 1% of cases require surgery. Endoscopy has gained popularity as the preferred modality because it is not only effective in FB removal, it is also minimally invasive with low risk of adverse events[8]. Furthermore, endoscopy provides the added benefit of diagnosing other underlying gastrointestinal pathologies and obviates the need for surgical intervention[9].

A push technique can be used to mobilize an impacted FB and preferably push it distally into the stomach. Alternatively, endoscopy-assisted retrieval of the FB can be performed using special devices. Some of these devices include biopsy forceps, grasping forceps (rat-toothed or alligator type), Dormia baskets, snares, tripod graspers and retrieval nets (Roth's type). However, more recently, endoscopic mucosal resection cap has been added to endoscopes to help remove esophageal foreign bodies more effectively[10-12]. Traditional endoscopic techniques sometime encounter poor esophageal visualization due to its narrow lumen and contrary to this, studies have reported growing evidence of better visualization of esophagus with cap-assisted endoscopy as well higher technical success and shorter procedure time[13,14].

We performed a meta-analysis of published studies comparing the technical success rate of conventional endoscopy (snares, tripod graspers, forceps, Dormia baskets, retrieval nets) *vs* cap-assisted endoscopy in which a cap has been used in addition to the conventional devices mentioned above. Furthermore, we investigated the FB retrieval time, adverse events rate and *en bloc* removal rates in both groups.



## MATERIALS AND METHODS

### Data search and screening

We comprehensively performed an electronic literature search of MEDLINE/PubMed, EMBASE, Scopus, Reference Citation Analysis, and Web of Science databases; from inception to December 10, 2021. The meta-analysis was conducted in accordance with the preferred reporting items for systematic review and meta-analysis (PRISMA) statement. The search terms were (esophageal foreign body impaction or food impaction or gastrointestinal foreign body ingestion, dysphagia or throat pain or soreness or foreign body sensation) and (endoscopy or endoscopic management of esophageal foreign body or use of assisted device in retrieval of foreign bodies or conventional endoscopic technique or cap-assisted endoscopy or push technique for foreign body management, use of forceps or use of basket). We also manually searched the bibliographies of the included articles to find any studies that we may have missed during our initial literature search.

### Study selection

Study selection was performed by two reviewers (ZIT and UF). They independently screened the abstracts, titles, and full manuscripts to identify the studies eligible for inclusion. Any conflict was resolved through discussion between the two reviewers. We included the studies published only in English, comparing the effectiveness of cap-assisted endoscopy to conventional endoscopy for management of esophageal FB in adult patients (age  $\geq 18$  years). Outcomes of interest were FB retrieval time, technical success of the procedure, adverse events, and *en bloc* removal rate.

### Data extraction

Data was extracted by two reviewers (ZIT and UF). We extracted information about study design, country of study, study cohort characteristics, procedure performed, type of foreign bodies, rate of adverse events, time required for FB removal, difference in procedure timings, and procedure success rate. Once data was extracted, two reviewers (YG and MB) independently reviewed the extracted data sheet and final data sheet was prepared after discussion between the four reviewers.

### Quality assessment

Quality was assessed for non-randomized studies[4,14-16] using Cochrane risk of bias tool (Robin -I)[17] and randomized studies using Cochrane tool for risk of bias assessment[12,18,19].

### Statistical analysis

We used RevMan 5.3 (Review Manager, Version 5.3, Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2012) for statistical analysis. We calculated the mean difference and corresponding 95% confidence interval (CI) for continuous outcomes and pooled odds ratio (OR) with corresponding 95%CI for dichotomous outcomes. Random effects model was used to calculate the pooled odds ratio with 95%CI and  $P$  value  $< 0.05$  was deemed statistically significant. The  $I^2$  statistics and Cochran's Q test was used for heterogeneity and variance. Publication bias was assessed by funnel plots.

## RESULTS

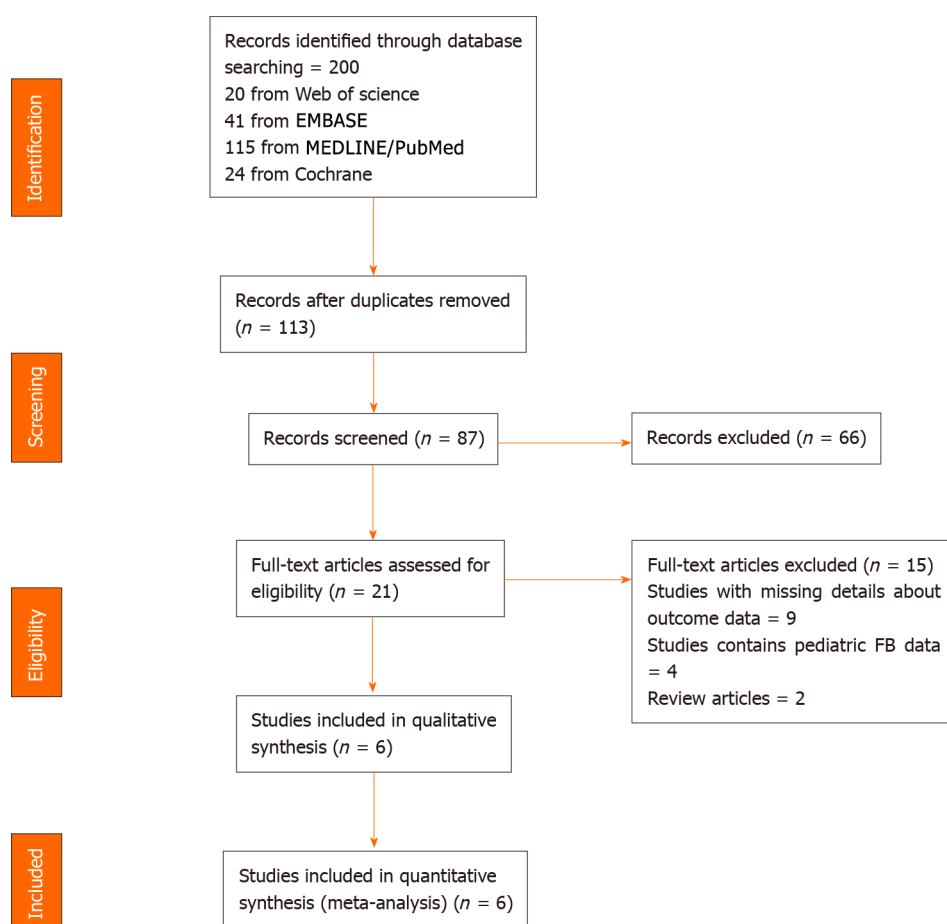
### Study selection and exclusion

On initial literature search, we shortlisted 200 studies, of which 113 were excluded due to overlap or duplication. On further assessment, 66 studies were excluded after reviewing their respective titles and abstracts. Twenty-one papers were considered potentially relevant for our analysis, so we reviewed them in detail, out of which six[4,12,14-16,19] were included in the final meta-analysis (Figure 1). We also searched the bibliographies of the reviewed full text articles but did not find any additional study that qualified for inclusion. All the six studies included in the final analysis were retrospective, comprising of 1305 patients (636 underwent cap-assisted endoscopy, 669 underwent conventional endoscopy) (Table 1). Three studies only included the patients with food bolus impaction while the other three studies reported patients with any type of esophageal FB. The type of cap utilized differed between the studies. Three studies used an 18.1 mm diameter cap attached to the endoscope with sticky tape[4,12,16], two studies used a 11.3 mm band ligation cap<sup>14,15</sup>, and one study used an Olympus cap but did not specify the size[19]. The technique differed slightly between the studies as well. For food bolus impactions, the cap-assisted technique used on only suction with very rare use of any additional equipment (forceps, snare, or net). For foreign bodies, especially sharp bones, the cap-assisted technique often used forceps or snares in addition to suction. Lastly, although food bolus impactions were the most studied type of impaction, other impactions such as fish/chicken bones, jujube pits, and sharp objects (keys, wire, etc.) were also included in some studies.

**Table 1 Characteristics of the included studies**

Ref.	Study type	Location	# of patients	Male %	Mean age conventional endoscopy	Mean age cap-assisted endoscopy	Type of FBs
Ooi <i>et al</i> [12], 2021	RCT	Australia	342	70.5	53.6 ± 14.7	54.7 ± 15.2	Food bolus
Fang <i>et al</i> [4], 2020	Retrospective Cohort	China	448	55.4	62.4 ± 18.2	62.8 ± 16.7	Jujube pit, fish bones, poultry bones, food bolus, other sharp objects
Wahba <i>et al</i> [15], 2019	Prospective Cohort	Egypt	216	46.2	52.9	51.7	Food bolus
Ooi <i>et al</i> [16], 2018	Retrospective Cohort	Australia	199	69.8	60.8 ± 19.8	57.5 ± 20.2	Food bolus
Zhang <i>et al</i> [19], 2013	RCT	China	70	58.6	48.9 (23-74)	47.6 (19-73)	Fish bone, chicken bones
Zhang <i>et al</i> [14], 2010	Retrospective cohort	China	30	NA	NA	NA	Fish bone, jujube pit, food bolus, coin or metal

RCT: Randomised controlled trial; FB: Foreign body; NA: Not available.

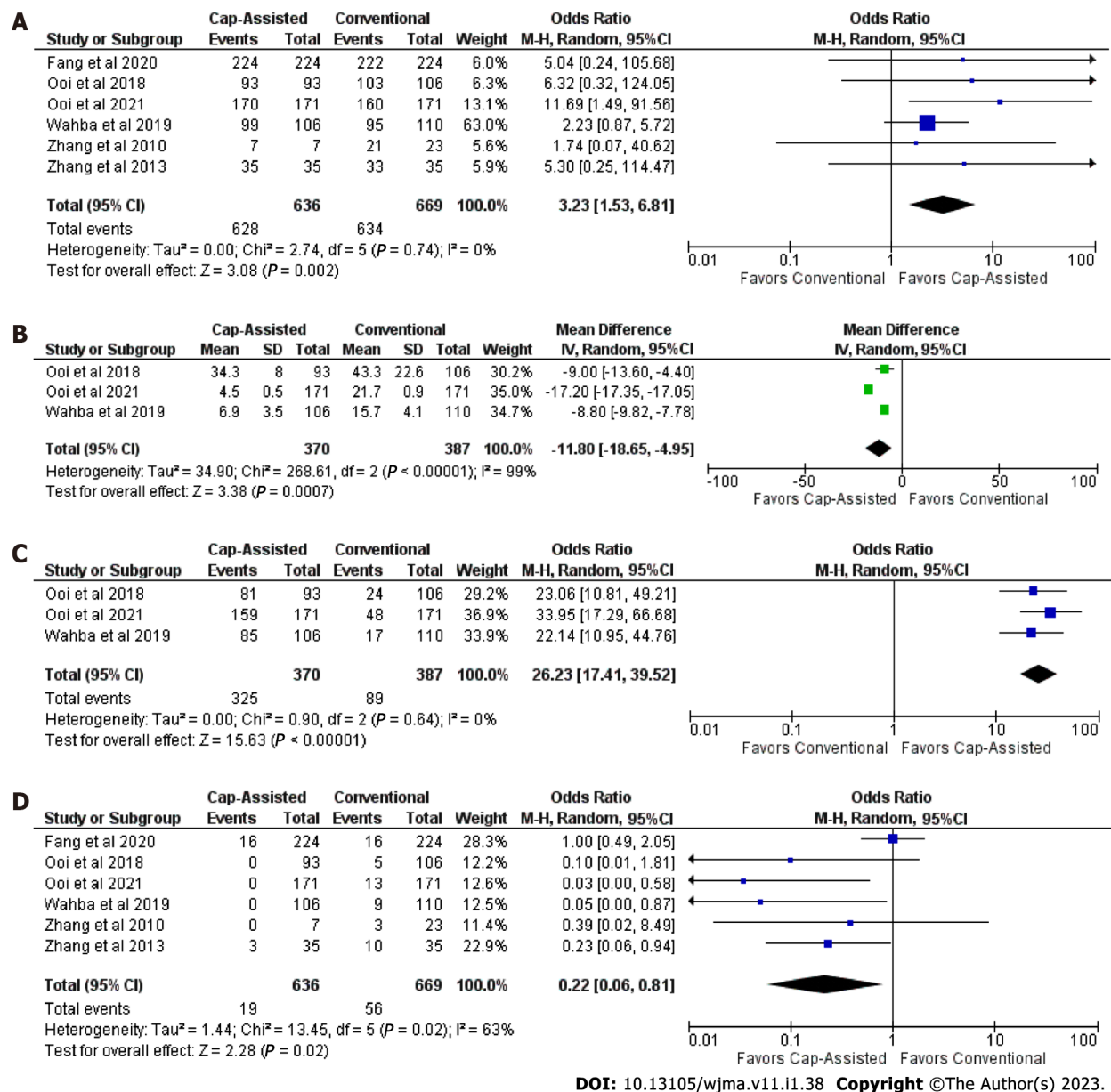


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**Figure 1** Flowchart showing details on the article search and selection. FB: Foreign body.

## Outcomes

**Technical success:** Six studies ( $n = 1305$ ) examined the technical success between cap-assisted endoscopy *vs* conventional endoscopy for esophageal FB removal [4,12,14-16,19]. Technical success was found in 628 of 636 with cap-assisted endoscopy but only in 634 of 669 with conventional endoscopy. Cap-assisted endoscopy demonstrated higher odds of technical success compared to conventional



**Figure 2 Forest plot.** A: Forest plot showing the technical success of cap-assisted endoscopy vs conventional endoscopy for esophageal foreign body removal; B: Forest plot showing the foreign body retrieval time of cap-assisted endoscopy vs conventional endoscopy for esophageal foreign body removal; C: Forest plot showing the *en bloc* removal of cap-assisted endoscopy vs conventional endoscopy for esophageal foreign body removal; D: Forest plot showing the adverse events of cap-assisted endoscopy vs conventional endoscopy for esophageal foreign body removal.

endoscopy (OR 3.23; 95%CI: 1.53-6.81;  $P = 0.002$ ;  $I^2 = 0\%$ ) (Figure 2A).

**Foreign body retrieval time:** Three studies ( $n = 757$ ) provided the information about mean difference in FB retrieval time[12,15,16]. Foreign body retrieval time was significantly lower in cap-assisted endoscopy (MD -11.80 min; 95%CI: -18.65 to -4.95);  $P < 0.01$ ;  $I^2 = 99\%$ ) (Figure 2B).

**En bloc removal:** Three studies ( $n = 757$ ) examined *en bloc* removal of esophageal FBs[12,15,16]. Cap-assisted endoscopy (325 of 370) was more effective in removing the FB as a single piece compared to conventional endoscopy (89 of 387). Cap-assisted endoscopy had a significantly higher pooled rate of removing FB in *en bloc* fashion as compared to conventional endoscopy (OR 26.23; 95%CI: 17.41-39.52;  $P < 0.01$ ;  $I^2 = 0\%$ ) (Figure 2).

**Adverse events:** Six studies ( $n = 1305$ ) reported adverse events between the two groups[4,12,14-16,19]. Cap-assisted endoscopy demonstrated adverse events in 19 of 636 and conventional endoscopy in 56 of 669 procedures. The odds for adverse events were found to be less in cases of cap-assisted endoscopy *vs* conventional endoscopy (OR 0.22; 95%CI: 0.06-0.81;  $P = 0.02$   $I^2 = 63\%$ ) (Figure 2D).



### Publication bias

Using funnel plots, no publication bias was deemed significant in any of the outcomes (Figure 3).

### Quality assessment

Using Cochrane risk of bias tool, all studies were determined to have low risk of bias (Tables 2 and 3).

## DISCUSSION

In the current analysis, we found that addition of a cap to the end of the endoscope in cases of esophageal foreign body impaction demonstrated significantly higher rates of technical success and *en bloc* removal with reduction in adverse events and time of foreign body retrieval as compared to conventional techniques. This is the first meta-analysis performed to compare the effectiveness of cap-assisted endoscopy when compared to conventional endoscopy.

In cases of esophageal foreign body impaction, 1 out of 5 requires endoscopic management[20]. Current European Society of Gastrointestinal Endoscopy recommendations are to apply gentle push technique initially to push FB into the stomach; however; if resistance is felt during pushing, a pull technique should be considered to extract the foreign body[7]. Traditionally, various endoscopic devices has been utilized, such as snares, forceps, tripod graspers, and net retrievers to remove FBs, but these methods are often time-consuming and, in most cases, the FB requires fragmentation before extraction [15]. Contrary to this, the addition of a cap allows better visualization of the narrow esophageal lumen and helps in *en bloc* removal of the FB by enlarging the suction area[14,21].

We found that cap-assisted endoscopy demonstrated better results for esophageal FB removal when compared to conventional endoscopy for all outcomes. Technical success of cap-assisted endoscopy was successful in 98.7% (628/636) of cases while conventional group was successful in only 94.76% (634/669) of cases. Ooi *et al*[12] postulated that the likely explanation for the lower success rate in conventional techniques was the failure to extract the esophageal FB in an *en bloc* manner which results in longer procedure times. Procedure times (recorded from the time of starting esophageal assessment with endoscopy to the extraction of FB) is shorter with the application of cap to the endoscope, likely due to the ability to remove the FB in *en bloc* fashion, which also causes less trauma to the surrounding tissue. Furthermore, with conventional techniques, the maneuver requires repeated removal and insertion of the attached device or endoscope which not only increases the retrieval time, but also leads to trauma of the surrounding tissue[14,16,19]. Cap-assisted endoscopy was successful in *en bloc* removal in 87.8% (325/370) of cases compared to 23% (89/387) of cases when conventional endoscopy was performed. *En bloc* retrieval is a major advantage of cap-assisted endoscopy due to strong suction applied to esophageal FB, which not only shortens the procedure time but also decreases the complication risk. Finally, adverse events in cap-assisted endoscopy were 2.98% (19/636), consisting of minor events such as mucosal tears and bleeding, while the conventional endoscopy were 8.37% (56/669). The risk of increased mucosal trauma and minor bleeding in conventional endoscopy group was likely due to the inability to remove the esophageal FB in *en bloc* fashion, which results in fragmentation and repeated insertion of the device.

This meta-analysis has several strengths. First, this is the first systematic review and meta-analysis that compares the efficacy of cap-assisted endoscopy with conventional endoscopy methods for esophageal FBs. Second, a thorough literature search was conducted and good quality studies were selected after establishing well-defined inclusion and exclusion criteria. Third, half of the outcomes (technical success and *en bloc* removal) demonstrated 0% heterogeneity. Fourth, no publication bias was identified. However, some limitations do exist. Firstly, only two of the studies were randomized controlled trials. Ideally, meta-analysis of randomized controlled trials is desired; however, the literature to-date lacks in this aspect. Furthermore, despite including retrospective studies, the quality assessment demonstrated low risk of bias. Secondly, half of the outcomes (FB retrieval time and adverse events) demonstrated significant heterogeneity. An exclusion sensitivity analysis was performed to evaluate the effect of heterogeneity on the results of these two outcomes. For FB retrieval, if Ooi *et al*[12] was removed, then the results were similar without heterogeneity (MD -8.81 min; 95%CI: -9.8 to -7.82;  $P < 0.01$ ;  $I^2 = 0\%$ ). For adverse events, if Fang *et al*[4] was excluded, then the results were similar without heterogeneity (OR 0.14; 95%CI: 0.05-0.4;  $P < 0.01$ ;  $I^2 = 0\%$ ). Therefore, heterogeneity seems to have minimal impact on the overall results.

## CONCLUSION

In conclusion, our study has many clinical implications. Cap-assisted endoscopy for esophageal FB removal demonstrates higher odds of technical success and *en bloc* removal while reducing procedure times and adverse events. Therefore, cap-assisted endoscopy should be considered for removal of impacted esophageal foreign bodies.

**Table 2** Quality assessment using cochrane risk of bias tool for non-randomized studies

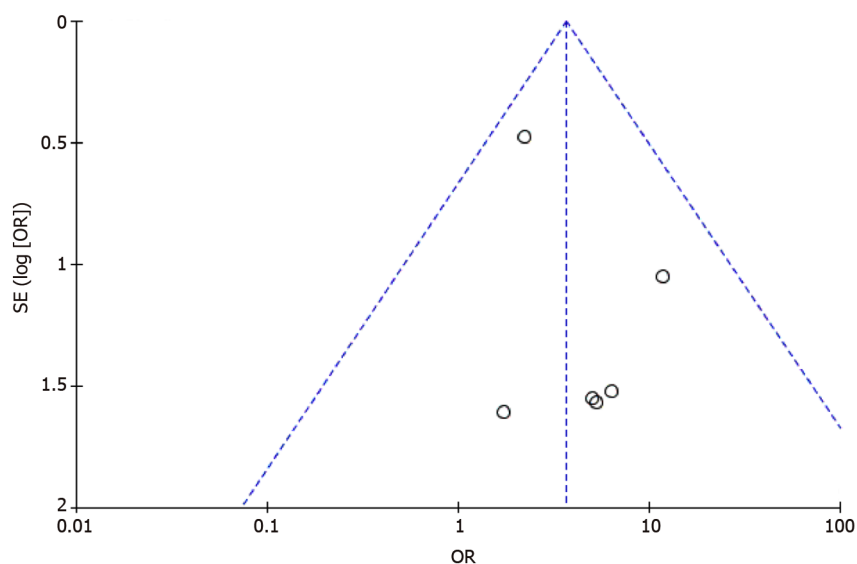
Non-randomized studies								
Ref.	Confounding	Selection of participants	Classification of interventions	Deviation from interventions	Missing outcome data	Measurement of outcome	Selection of reported results	Overall
Zhang <i>et al</i> [14], 2010	1	1	1	1	1	1	1	Low
Ooi <i>et al</i> [16], 2018	1	1	1	1	1	1	1	Low
Wahba <i>et al</i> [15], 2019	1	1	1	1	1	1	1	Low
Fang <i>et al</i> [4], 2020	1	1	1	1	1	1	1	Low

Risk of bias assessment: 0: No information; 1: Low; 2: Moderate; 3: Serious; 4: Critical.

**Table 3** Quality assessment using cochrane risk of bias tool for randomized studies

Randomized controlled trials							
Ref.	Random sequence generation	Allocation concealment	Blinding	Blinding outcome assessment	Incomplete outcome data	Selective reporting	Other bias
Zhang <i>et al</i> [19], 2013	Unclear	Unclear	Unclear	Unclear	Low	Low	Low
Ooi <i>et al</i> [12], 2021	Low	Low	High	Unclear	Low	Low	low

Risk of bias assessment: 0: No information; 1: Low; 2: Moderate; 3: Serious; 4: Critical.



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**Figure 3** Funnel plot showing no publication bias.

## ARTICLE HIGHLIGHTS

**Research background**

Cap-assisted endoscopy for removal of esophageal foreign bodies is a new technique.

**Research motivation**

With any new technique, studies need to be performed to truly evaluate the effectiveness and adverse events.

**Research objectives**

This meta-analysis examines cap-assisted endoscopy *vs* conventional endoscopy for removal of esophageal foreign bodies.

**Research methods**

An extensive literature search was conducted using multiple databases. Studies that compared cap-assisted endoscopy to conventional endoscopy for the removal of esophageal foreign bodies were included. Odds ratio or mean difference was used to analyze outcomes.

**Research results**

Cap-assisted endoscopy demonstrated higher odds of technical success ( $P = 0.002$ ) and *en bloc* removal ( $P < 0.01$ ) as compared to conventional techniques. Furthermore, cap-assisted endoscopy showed decreased odds of adverse events ( $P = 0.02$ ) and mean time of foreign body removal ( $P < 0.01$ ) as compared to conventional techniques.

**Research conclusions**

Cap-assisted endoscopy should be considered as a potential first-line option for impacted esophageal foreign bodies.

**Research perspectives**

Endoscopists may utilize cap-assisted endoscopy for removal of esophageal foreign bodies.

## FOOTNOTES

**Author contributions:** Tarar Z and Bechtold ML designed the meta-analysis; Tarar Z, Farooq U, and Bechtold ML acquired the data; Tarar Z, Bechtold ML, and Ghouri YA analyzed and interpreted the data; Tarar Z and Farooq U drafted the manuscript; Bechtold ML and Ghouri YA critically revised the manuscript; and Bechtold ML provided statistical expertise.

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**Country/Territory of origin:** United States

**ORCID number:** Zahid Ijaz Tarar 0000-0001-7562-7420; Matthew L Bechtold 0000-0002-0205-3400; Yezaz A Ghouri 0000-0002-8677-1871.

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