Removal of foreign body airway obstruction: a systematic review of interventions

Keith Couper[1,2]

Aysha Abu Hassan[1]

Vrinda Ohri[1]

Emma Patterson[1]

Ho Tsun Tang[1]

Robert Bingham[3]

Theresa Olasveengen[4]

Gavin D Perkins[1,2]

On behalf of the International Liaison Committee on Resuscitation Basic and Paediatric Life Support Task Force Collaborators.

1. Warwick Medical School, University of Warwick, Coventry, UK
2. Critical Care Unit, University Hospitals Birmingham NHS Foundation Trust, UK
3. Paediatric Anaesthetisia, Great Ormond Street Hospital for Children, London, UK
4. Department of Anaesthesiology, Oslo University Hospital and Institute of Clinical Medicine, University of Oslo, Oslo, Norway.

Corresponding author: Prof Gavin D Perkins, Warwick Clinical Trials Unit, Warwick Medical School, University of Warwick, Gibbet Hill Road, Coventry, CV4 7AL
Tel: 02476 150925. Email: g.d.perkins@warwick.ac.uk

Objective: To summarise in a systematic review the effectiveness of interventions to treat foreign body airway obstructions (FBAO).

Methods: We searched MEDLINE, EMBASE, and the Cochrane library from inception on 30th September 2019 for studies that described the effectiveness of interventions to treat FBAO in adults and children.

We included randomised controlled trials, observational studies and case series (≥5 cases) that described evidence of benefit. For evidence of harm/ complications, we included case reports. Two reviewers independently assessed study eligibility, extracted study data, and assessed risk of bias. Data are summarised in a narrative synthesis. The GRADE system is used to assess evidence certainty.

Results: We included 69 publications, comprising three cross-sectional studies (557 patients); eight case series (755 patients), and 59 were case reports (64 patients). One paper was included as a case series and cross-sectional study. For all interventions and associated outcomes, evidence certainty was very low. Early removal of FBAO by bystanders was associated with improved neurological survival (odds ratio 6.0, 95% confidence interval 1.5 to 23.4).

Identified evidence showed that key interventions (back blows, abdominal thrusts, chest thrusts/ compressions, Magill forceps, manual removal of obstructions from the mouth, suction-based airway clearance devices) are effective in relieving FBAO. We identified reports of harm in relation to back blows, abdominal thrusts, chest thrusts/ compressions, and blind finger sweeps.

Conclusions: Key interventions successfully relieve FBAO, but may be associated with important harms. Guidelines for FBAO management should balance the benefits and harms of interventions.

PROSPERO registration: CRD42019154784.

Foreign body airway obstruction is an important health problem that causes 250 deaths in the UK and 5200 deaths in the USA per year.[1, 2] In Japan, foreign body airway obstruction is the most common cause of accidental death.[3] It is responsible for two in every 1000 ambulance calls in London.[4] Individuals at increased risk include the young, elderly, and those with neurocognitive disabilities.[2, 4] Food is the most common cause of obstruction, and causes most deaths.[1]

Coughing is a physiological response to foreign body airway obstruction that generates high airway pressures and may be effective at removing obstructions.[5, 6] In individuals that have an ineffective cough, assistance from a bystander is likely to be needed, although case reports of self-delivered abdominal thrusts have been reported.[7, 8] A range of possible treatments have been reported including finger sweeps of the oral cavity, abdominal thrusts, chest thrusts, and back blows.

The International Liaison Committee on Resuscitation (ILCOR) last reviewed the evidence for foreign body airway obstruction in 2010.[9] The review noted the effectiveness of back blows, abdominal thrusts and chest thrusts, but highlighted that there was insufficient evidence to determine which strategy should be used first. Current European Resuscitation Council guidelines support a step-wise approach which advocates the sequential delivery of up to five back blows and five abdominal thrusts until the foreign body is removed in conscious patients with an ineffective cough.[10] In contrast, the American Heart Association does not support the use of back blows and recommend a strategy that includes only abdominal thrusts.[11]

A recent development in foreign body airway obstruction removal has been the creation of devices, such as the Dechoker (Dechoker LLC, Concord, North Carolina, USA) and LifeVac (LifeVac LLC, Nesconset, New York, USA), that use a vacuum to remove the obstruction from the airway. Given this development, the 10-year period since the last update, and ILCOR's commitment to ongoing evidence evaluation process, we undertook a systematic review supported by the Basic Life Support ILCOR task force to describe the benefits and harms associated with interventions for foreign body airway obstruction.[12]

Methods

We conducted a systematic review to identify and synthesise studies reporting the benefits and harms of immediate strategies for the removal of foreign body airway obstructions. Our review was registered with PROSPERO (CRD42019154784). The review protocol was developed in collaboration with ILCOR, and registered by ILCOR. This paper conforms to the PRISMA statement.[13]

We searched MEDLINE (OVID interface), Embase (OVID interface), and the Cochrane Central Register of Controlled Trials (CENTRAL) from inception to present on 30th September 2019. Search strategies, were developed in conjunction with an information scientist and included a combination of keywords and MESH terms. An example search strategy is included in the electronic supplement. Additional papers were identified through review of reference lists of previous ILCOR reviews and consultation with the ILCOR Basic Life Support Task Force.[9, 14]

Our population of interest was adults and children with foreign body airway obstruction in any setting. We included primary research studies that described the effect of key foreign body airway obstruction interventions compared with no intervention on key clinical outcomes. Our pre-defined outcomes were survival with good neurological outcomes, survival, return of spontaneous circulation, relief of airway obstruction, and harm. Using the GRADE (Grading of Recommendations, Assessment, Development and Evaluations) system, we allocated each outcome a level of

importance for decision-making.[15] Survival with good neurological outcomes and survival were categorised as critical. The remaining outcomes were categorised as important.

We included randomised controlled studies, non-randomized controlled trials, observational studies (interrupted time series, controlled before-and-after studies, cohort studies), and case series that reported at least five cases. For outcomes of harm, we also included individual case reports. The following study types were excluded: unpublished studies (e.g., conference abstracts), manikin and simulation studies, animal studies, laboratory studies, and cadaver studies. No written language limitations were applied.

Following search completion and removal of duplicates, two researchers (two of AH/VO/EP/HT) independently reviewed titles and abstracts, and excluded obviously irrelevant citations. Two reviewers (two of AH/VO/EP/HT)then independently assessed full-text papers against the review inclusion criteria. At both stages, unresolved discrepancies were resolved by a third reviewer (KC). Two authors (two of KC/AH/VO/EP/HT) independently extracted study data from included studies on to a pre-defined data extraction form. For each study, we extracted key data related to our review question including study setting, study design, population characteristics, outcome data, and interventions used to relieve the foreign body airway obstruction.

Study risk of bias was evaluated independently by two authors (two of KC/AH/VO/EP/HT) using the GRADE risk of bias tool for observational studies and the tool developed by Murad and colleagues for case reports and case series.[16, 17] Overall certainty of evidence for each outcome in relation to each intervention was assessed using the GRADE system.[18, 19]

For data analysis, we first assessed studies for clinical, methodological, and statistical heterogeneity. Where appropriate, we planned to meta-analyse data using either a fixed-effects or random-effects model, depending on statistical heterogeneity. In view of the findings of previous ILCOR reviews, it was anticipated that eligible studies were likely to be heterogeneous. In such circumstances, a narrative synthesis was planned.

Results

Through database searches and other sources, and subsequent removal of duplicates, we identified 1370 citations. We excluded 1168 citations at title/abstract screening. Review of 202 full-text papers identified 69 eligible papers.

Of these 69 papers, we included three cross-sectional studies (557 patients),[20-22] eight case series (755 patients), [8, 20, 23-28] and 59 case reports (64 patients).[29-87] One study was included as both a cross-sectional study and case series due to way in which data were presented for different outcomes.[20] All three cross-sectional studies were undertaken in Japan. Case series studies were undertaken across the USA, Europe, and Japan. Three case series included only paediatric patients.[23, 25, 28] Characteristics of included are summarised in table one (cross-sectional studies/ case series) and the electronic supplement (case reports). Risk of bias assessments are summarised in the electronic supplement.

Across all interventions and associated outcomes, where evidence was available, we assessed evidence certainty as very low (table two). This reflects the observational study design of all included studies, which was further downgraded for very serious risk of bias. Key areas of concern related to

selection bias and confounding. For some interventions and outcomes, evidence certainty was further downgraded to reflect the indirectness and imprecision of evidence.

For critical outcomes, we identified evidence for survival with good neurological outcome for three interventions (foreign body airway obstruction removal by bystander, chest thrusts/ compressions, Magill forceps) and for survival for five interventions (back blows, abdominal thrusts, finger sweep Magill forceps, suction-based airway clearance devices). Data on survival with good neurological outcomes was derived from cross-sectional studies and all interventions were associated with improved outcome. Estimates of effect size were often high with wide confidence intervals. One cross-sectional study also reported an association between use of Magill forceps and survival.

For all other interventions, where survival was reported as an outcome, data came from case series where survival was attributed to foreign body airway obstruction removal. It was often unclear how it was judged that the specific intervention was responsible for the patient's survival.

For important outcome of ROSC, we identified no evidence for any intervention.

The important outcome of relief of airway obstruction was described for all interventions, although the number of reported cases ranged from 10 events in nine patents (airway clearance devices) to 417 events (abdominal thrusts/ Magill forceps). Due to uncertainty in relation to the number of patients that received each intervention, we chose not to calculate the percentage success rate for interventions.

The important outcome of injuries/ complications was described in relation to back blows (4 reports), abdominal thrusts (52 reports), finger sweeps (10 reports), and chest thrusts/ compressions (5 reports). Seven reports described multiple interventions. Reports described patients aged 1-month to 93-years. Main sites of injury were vascular (n=17, 27%), gastro-oesophageal (n=17, 27%), and thoracic (n=12, 19%). Of the 61 patients where outcome was reported, 34% (n=21) died due to injuries, such as aortic dissection, gastric rupture, and splenic rupture.

Discussion

In this systematic review of interventions to remove foreign body airway obstruction, we included 69 papers. We found evidence that early bystander removal is associated with improved neurologically intact survival, and that all key interventions were effective in relieving airway obstructions. We also found evidence of harm for key interventions, which in some cases was associated with death. We assessed evidence certainty as very low for all outcomes and interventions.

Undertaking high-quality research in this area is challenging. Observational studies should reliably record all foreign body airway obstruction cases, ranging from those where the obstruction is rapidly relieved by coughing and no medical care is sought to cases where the patient sustains a cardiac arrest. Included studies used two main approaches to case identification, both of which may lead to ascertainment bias, namely: self-report of cases by clinicians and members of the public, and the analysis of healthcare records.[88]

Self-report of cases as a data source for case series likely favours extreme, interesting, or successful cases. For example, Heimlich's case series of 162 patients reported successful relief using abdominal thrusts in all cases.[8] In contrast, the success rate for abdominal thrusts in Redding's case series was only 74%.[24]

Analysis of healthcare records will exclude less severe foreign body airway obstruction cases where there is rapid relief and healthcare advice is not sought. Further challenges arise when either just hospital or just ambulance records are interrogated. Reliance on only hospital records excludes patients discharged by ambulance personnel at scene. In one paediatric study, these patients accounted for over 50% of patients seen by the ambulance service.[28] Similarly, sole use of EMS records will exclude patients where the foreign body airway obstruction occurs in hospital or where it is successfully removed pre-hospital, but a hospital review is subsequently sought due to injury concerns, as observed in some included case reports.[38, 66]

The relief of foreign body airway obstruction may involve the consecutive use of multiple interventions, including encouraging the patient to cough, back blows, and abdominal thrusts. In Redding's case series, over 50% of patients received more than one intervention.[24] Success in removing the foreign body airway obstruction was usually attributed to the last, or most aggressive, intervention. This means it is challenging to identify which treatments may have contributed to success or harm in a specific case. This has parallels with the carryover effect, which is a source of bias in crossover trials.[89]

The development of new suction-based airway clearance devices highlights the ongoing importance of foreign body airway obstruction to the clinical community and members of the public. A recent systematic review focussed only on these devices.[90] Despite broad study inclusion criteria, the review identified only small case series, manikin studies, and cadaver studies, which were limited to a single device type. No reports of harm were identified, but their limited use in clinical practice means it is too early to conclude that their use is harm free. The review recommended the need for further research before device use can be supported in practice.

This review adopted new ILCOR standards for evaluating evidence, which differ from the previous ILCOR foreign body airway obstruction reviews undertaken in 2005 and 2010.[9, 14] Firstly, this review adopted a review methodology that incorporated independent review by two people of study inclusion, risk of bias assessment, and data extraction. Secondly, we excluded simulation, cadaver, and animal research. These data can provide important information about the potential efficacy of treatment, such as the airway pressure generated by different interventions.[91] However, findings do not directly translate to the real-world setting where choking presentations (patient age, viscosity of obstruction, anatomical location of obstruction) are extremely heterogeneous.

Our review has a number of limitations. Firstly, the challenge of conducting research in this setting meant that there were only three studies with control groups, all of which were considered to be at serious risk of bias. Secondly, whilst case series provided evidence of effective relief of airway obstruction, data were not collected sufficiently robustly to enable us to calculate intervention success rates. Thirdly, anatomical differences between older adults, younger adults and children may influence the balance between benefit and harm for each intervention across age groups. For example, young children and frail older adults may be at greater risk of harm from abdominal thrusts. Limitations in the published evidence precluded an assessment of these differences. Fourthly, other strategies for relief of foreign body airway obstruction have been described in the literature, such as the table manoeuvre whereby the patient with foreign body airway obstruction is placed prone on a table and administered forceful blows between the shoulder blades.[92] Studies describing these strategies did not meet review eligibility criteria, for example case series with less than five cases, highlighting the need for further data on their effectiveness.

Future studies should aim for standardisation of reporting outcomes, drawing where possible on existing templates such as Utstein.[93, 94] Key variables include patient (age, gender, comorbidities), setting (out of hospital, in-hospital), patient status at start of treatment (conscious, unconscious, not breathing), intervention applied (cough, back blows, abdominal thrusts,), outcome (favourable neurological outcome, survival, ROSC, relief of obstruction). The planned Japanese MOCHI study will prospectively collect data on patients with foreign body airway obstruction that attend the emergency department, thereby improving our knowledge and understanding of the epidemiology and treatment of the most severe cases of foreign body airway obstruction.[3]

In conclusion, early bystander intervention following foreign body airway obstruction is associated with improved outcome. In this review, we identified that all included interventions were effective in relieving obstructions. The nature of the available evidence meant that we were unable to reliably compare the effectiveness of interventions.

Table and figure legends

Figure one: study identification flow diagram

Table one: summary of included studies

Table two: GRADE table

Funding

This research is supported by the National Institute for Health Research (NIHR) Applied Research Collaboration (ARC) West Midlands. Professor Perkins is supported as an NIHR senior investigator.

The opinions are those of the authors and not the NIHR, the NHS or the Department of Health and Social Care.

Conflicts of interest

KC, BB, TO and GDP have volunteer roles with the International Liaison Committee on Resuscitation. KC, TO and GDP have volunteer roles with the European Resuscitation Council. KC and GDP have volunteer roles with Resuscitation Council UK.

AA, VO, EP, and HT have no conflicts of interest to declare

Acknowledgements

We are grateful to the International Liaison Committee on Resuscitation for their support in developing the research question and support in delivering this review.

Besides the authors KC, AA, VO, EP, HT, BB, TO and GDP, the members of the International Liaison Committee on Resuscitation Basic and Paediatric Life Support Task Forces include: Suzanne Avis, Steven Brooks, Maaret Castren, Sung Phil Chung, Julie Considine, Peter Kudenchuk, Chika Nishiyama, Giuseppe Ristagno, Federico Semeraro, , Chris Smith, Michael Smyth, Peter Morley, Ian Maconochie, Richard Aickin, Dianne Atkins, Allan de Caen, Thomaz Bittencourt Couto, Anne-Marie Guerguerian, Vinay Nadkarni, Kee-Chong Ng, Gabrielle Nuthall, Yong-Kwang Gene Ong, Amelia Reis, Steve Schexnayder, Janice Tijssen, Patrick Van de Voorde, Mary Fran Hazinski

References

[1] Office for National Statistics. Number of choking deaths by place of occurrence and age, registered in England and Wales, 2014 to 2016. 2017. Accessed 23 May 2020. Available at https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/adhocs/007747numberofchokingdeathsbyplaceofoccurrenceandageregisteredinenglandandwales2014to2016

[2] Injury Facts. Preventable death and death rates per 100,000 population in the home and community by cause and age group, United States, 2017. Accessed 23 May 2020. Available at https://injuryfacts.nsc.org/home-and-community/home-and-community-overview/deaths-in-the-home-and-community-by-age-group-and-cause/

[3] Norii T, Igarashi Y, Sung-Ho K, et al. Protocol for a nationwide prospective, observational cohort study of foreign-body airway obstruction in Japan: the MOCHI registry. BMJ open. 2020;10:e039689

[4] Pavitt MJ, Nevett J, Swanton LL, et al. London ambulance source data on choking incidence for the calendar year 2016: an observational study. BMJ Open Respiratory Research. 2017;4:e000215.

[5] Man WD-C, Kyroussis D, Fleming TA, et al. Cough Gastric Pressure and Maximum Expiratory Mouth Pressure in Humans. American Journal of Respiratory and Critical Care Medicine. 2003;168:714-7.

[6] Smith JA, Aliverti A, Quaranta M, et al. Chest wall dynamics during voluntary and induced cough in healthy volunteers. The Journal of Physiology. 2012;590:563-74.

[7] Bertrand C, Fox M, Tartaglia J. The "do-it-yourself" Heimlich maneuver. New York State Journal of Medicine. 1991;91:408.

[8] Heimlich HJ. A life-saving maneuver to prevent food-choking. JAMA. 1975;234:398-401.

[9] Koster RW, Sayre MR, Botha M, Cave DM, Cudnik MT, Handley AJ, et al. Part 5: Adult basic life support: 2010 International consensus on cardiopulmonary resuscitation and emergency cardiovascular care science with treatment recommendations. Resuscitation. 2010;81:e48-e70.

[10] Perkins GD, Handley AJ, Koster RW, et al. European Resuscitation Council Guidelines for Resuscitation 2015: Section 2. Adult basic life support and automated external defibrillation. Resuscitation. 2015;95:81-99.

[11] Berg RA, Hemphill R, Abella BS, Aufderheide TP, Cave DM, Hazinski MF, et al. Part 5: adult basic life support: 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation. 2010;122:S685-705.

[12] Morley PT. Towards a more continuous evidence evaluation: A collaborative approach to review the resuscitation science. Resuscitation. 2017;118:A1-A2.

[13] Moher D, Liberati A, Tetzlaff J, Altman DG, Group P. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. Ann Intern Med. 2009;151:264-9.

[14] International Liaison Committee on Resuscitation. Part 2: Adult basic life support. Resuscitation. 2005;67:187-201.

[15] Guyatt GH, Oxman AD, Kunz R, Atkins D, Brozek J, Vist G, et al. GRADE guidelines: 2. Framing the question and deciding on important outcomes. Journal of clinical epidemiology. 2011;64:395-400.

[16] Guyatt GH, Oxman AD, Vist G, Kunz R, Brozek J, Alonso-Coello P, et al. GRADE guidelines: 4. Rating the quality of evidence--study limitations (risk of bias). Journal of clinical epidemiology. 2011;64:407-15.

[17] Murad MH, Sultan S, Haffar S, Bazerbachi F. Methodological quality and synthesis of case series and case reports. BMJ Evidence-Based Medicine. 2018;23:60-3.

[18] Guyatt G, Oxman AD, Akl EA, Kunz R, Vist G, Brozek J, et al. GRADE guidelines: 1. Introduction-GRADE evidence profiles and summary of findings tables. Journal of clinical epidemiology. 2011;64:383-94.

[19] GRADEpro GDT: GRADEpro Guideline Development Tool [Software]. McMaster University, 2015 (developed by Evidence Prime, Inc.). Available from gradepro.org.

[20] Igarashi Y, Yokobori S, Yoshino Y, Masuno T, Miyauchi M, Yokota H. Prehospital removal improves neurological outcomes in elderly patient with foreign body airway obstruction. American Journal of Emergency Medicine. 2017;35:1396-9.

[21] Sakai T, Kitamura T, Iwami T, Nishiyama C, Tanigawa-Sugihara K, Hayashida S, et al. Effectiveness of prehospital Magill forceps use for out-of-hospital cardiac arrest due to foreign body airway obstruction in Osaka City. Scandinavian journal of trauma, resuscitation and emergency medicine. 2014;22:53.

[22] Kinoshita K, Azuhata T, Kawano D, Kawahara Y. Relationships between pre-hospital characteristics and outcome in victims of foreign body airway obstruction during meals. Resuscitation. 2015;88:63-7.

[23] Boussuges S, Maitrerobert P, Bost M. Use of the Heimlich Maneuver on children in the Rhone-Alpes area. Archives Francaises de Pediatrie. 1985;42:733-6.

[24] Redding JS. The choking controversy: critique of evidence on the Heimlich maneuver. Crit Care Med. 1979;7:475-9.

[25] Rouillon I, Charrier JB, Devictor D, Portier F, Lebret IK, Attal P, et al. Lower respiratory tract foreign bodies: A retrospective review of morbidity, mortality and first aid management. International Journal of Pediatric Otorhinolaryngology. 2006;70:1949-55.

[26] Saperstein D, Pugliesi P, Ulteig C, Schreiber N. Successful Use of a Novel device called the LifeVac to Resuscitate Choking Victims. International Journal of Clinical Skills. 2018;12:No pagination.

[27] Soroudi A, Shipp HE, Stepanski BM, Ray LU, Murrin PA, Chan TC, et al. Adult foreign body airway obstruction in the prehospital setting. Prehospital Emergency Care. 2007;11:25-9.

[28] Vilke GM, Smith AM, Ray LU, Steen PJ, Murrin PA, Chan TC. Airway obstruction in children aged less than 5 years: the prehospital experience. Prehospital Emergency Care. 2004;8:196-9.

[29] Abder-Rahman HA. Infants choking following blind finger sweep. Jornal de Pediatria. 2009;85:273-5.

[30] Agia GA, Hurst DJ. Pneumomediastinum following the Heimlich maneuver. JACEP. 1979;8:473-5.

[31] Caro Aguilera P, Reiro Aranda R, Perez Ruiz E, Rodriguez Amuedo F, Perez Frias J. Haemoptysis after Heimlich manoeuvre. Anales de Pediatria. 2008;68:533-4.

[32] Ayerdi J, Gupta SK, Sampson LN, Deshmukh N. Acute abdominal aortic thrombosis following the Heimlich maneuver. Cardiovascular Surgery. 2002;10:154-6.

[33] Bintz M, Cogbill TH. Gastric rupture after the Heimlich maneuver. Journal of Trauma-Injury Infection & Critical Care. 1996;40:159-60.

[34] Bouayed S, u K, Teiga PS, Hallak B. Thoracocervicofacial Emphysema after Heimlich's Maneuvre. Case Reports in Otolaryngology Print. 2015;2015:427320.

[35] Cecchetto G, Viel G, Cecchetto A, Kusstatscher S, Montisci M. Fatal splenic rupture following Heimlich maneuver: case report and literature review. American Journal of Forensic Medicine & Pathology. 2011;32:169-71.

[36] Chao CM, Lai CC, Tan CK. Gastric perforation after Heimlich maneuver. American Journal of Medicine. 2012;125:e7-e8.

[37] Chapman JH, Menapace FJ, Howell RR. Ruptured aortic valve cusp: A complication of the Heimlich maneuver. Annals of Emergency Medicine. 1983;12:446-8.

[38] Chillag S, Krieg J, Bhargava R. The heimlich maneuver: Breaking down the complications. Southern Medical Journal. 2010;103:147-50.

[39] Cowan M, Bardole J, Dlesk A. Perforated stomach following the Heimlich maneuver. American Journal of Emergency Medicine. 1987;5:121-2.

[40] Croom DW. Rupture of stomach after attempted Heimlich maneuver. JAMA. 1983;250:2602-3.

[41] Desai SC, Chute DJ, Desai BC, Koloski ER. Traumatic dissection and rupture of the abdominal aorta as a complication of the Heimlich maneuver. Journal of Vascular Surgery. 2008;48:1325-7.

[42] Dupre MW, Silva E, Brotman S. Traumatic rupture of the stomach secondary to Heimlich maneuver. American Journal of Emergency Medicine. 1993;11:611-2.

[43] Entel RJ, Hakki AH. Bone scan after the Heimlich maneuver. Clinical Nuclear Medicine. 1996;21:251.

[44] Fearing NM, Harrison PB. Complications of the heimlich maneuver: case report and literature review. Journal of Trauma-Injury Infection & Critical Care. 2002;53:978-9.

[45] Feeney SN, Pegoli W, Gestring ML. Pancreatic transection as a complication of the Heimlich maneuver: case report and literature review. Journal of Trauma-Injury Infection & Critical Care. 2007;62:252-4.

[46] Fink JA, Klein RL. Complications of the Heimlich maneuver. Journal of Pediatric Surgery. 1989;24:486-7.

[47] Gjoni D, Mbamalu D, Banerjee A, James KK. An unusual complication of an attempt to open the airway in a choking child. British Journal of Hospital Medicine. 2009;70:595.

[48] Guinane J, Lee SM. Fatal acute aortic dissection after back blows and chest thrusts delivered for choking episode. Internal Medicine Journal. 2018;48:1272-3.

[49] Hartrey R, Bingham RM. Pharyngeal trauma as a result of blind finger sweeps in the choking child. Journal of accident & emergency medicine. 1995;12:52-4.

[50] Haynes DE, Haynes BE, Yong YV. Esophageal rupture complicating Heimlich maneuver. American Journal of Emergency Medicine. 1984;2:507-9.

[51] Heimlich HJ. Update on the Heimlich Maneuver. Emergency medical services. 1977;6:11-76.

[52] Herman A, Maiti A, Cherian SV, Estrada-Y-Martin RM. Heimlich Maneuver-Induced Diaphragmatic Rupture and Hiatal Hernia. American Journal of the Medical Sciences. 2018;355:e13.

[53] Kabbani M, Goodwin SR. Traumatic epiglottis following blind finger sweep to remove a pharyngeal foreign body. Clinical Pediatrics. 1995;34:495-7.

[54] Kirshner RL, Green RM. Acute thrombosis of abdominal aortic aneurysm subsequent to Heimlich maneuver: a case report. Journal of Vascular Surgery. 1985;2:594-6.

[55] Kosser A, Lehmkuhl L, Gutberlet M. Aortocaval fistula after applying the Heimlich maneuver - Diagnosis with multi-row detector CT. RoFo Fortschritte auf dem Gebiet der Rontgenstrahlen und der Bildgebenden Verfahren. 2009;181:1089-90.

[56] Koss SL, Karle WE, Dibelius G, Kamat A, Berzofsky C. Esophageal perforation as a complication of the Heimlich maneuver in a pediatric patient: A case report. Ear, Nose, & Throat Journal. 2018;97:E1-E3.

[57] Lee KY, Wu YL, Ho SW. Silent Aortic Dissection after the Heimlich Maneuver: A Case Report. Journal of Emergency Medicine. 2019;56:210-2.

[58] Lee SL, Kim SS, Shekherdimian S, Ledbetter DJ. Complications as a result of the Heimlich maneuver. Journal of Trauma: Injury, Infection and Critical Care. 2009;66:E34-E5.

[59] Lette J, Levasseur A, Labonte C, Eybalin MC, Cerino M. Thoracic bone imaging after the Heimlich maneuver. Clinical Nuclear Medicine. 1990;15:512.

[60] Lin PH, Bush RL, Lumsden AB. Proximal aortic stent-graft displacement with type I endoleak due to Heimlich maneuver. Journal of Vascular Surgery. 2003;38:380-2.

[61] Mack L, Forbes TL, Harris KA. Acute aortic thrombosis following incorrect application of the Heimlich maneuver. Annals of Vascular Surgery. 2002;16:130-3.

[62] Majumdar A, Sedman PC. Gastric rupture secondary to successful Heimlich manoeuvre. Postgraduate medical journal. 1998;74:609-10.

[63] Martin TJ, Bobba RK, Metzger R, et al. Acute abdominal aortic thrombosis as a complication of the Heimlich maneuver. Journal of the American Geriatrics Society. 2007;55:1146-7.

[64] Matharoo G, Kalia A, Phatak T, Bhattacharyya N. Diaphragmatic rupture with gastric volvulus after Heimlich Maneuver. European Journal of Pediatric Surgery. 2013;23:502-4.

[65] Meredith MJ, Liebowitz R. Rupture of the esophagus caused by the Heimlich maneuver. Annals of emergency medicine. 1986;15:106-7.

[66] Mori T, Inoue N. Nasopharyngeal foreign body triggered by a blind finger sweep. BMJ case reports. 2016:bcr2016216536.

[67] Nowitz A, Lewer BMF, Galletly DC. An interesting complication of the Heimlich manoeuvre. Resuscitation. 1998;39:129-31.

[68] Olenchock SA, Jr., Rowl, s DM, Reed JF, 3rd, Garzia FM, Zasik JM. Dysphagia after Heimlich maneuver. Chest. 2004;125:302-4.

[69] Otero Palleiro MM, Lopez CB, Pretel MCF, Fernandez JS. Hepatic rupture after Heimlich maneuver. Annals of Emergency Medicine. 2007;49:825-6.

[70] Passik CS, Ackermann DM, Piehler JM, Edwards WD. Traumatic rupture of Ionescu-Shiley aortic valve after the Heimlich maneuver. Archives of Pathology and Laboratory Medicine. 1987;111:469-70.

[71] Patterson DL, Brennan S, Cartwright T, Jolly W, Adlam JH, Waller BF. Traumatic rupture of an aortic ulcerative atherosclerotic plaque producing aortic dissection: A complication of interscapular back blows used to dislodge objects from the esophagus. Clinical Cardiology. 1993;16:741-4.

[72] Rakotoharinrasana H, Petit E, Dumas P, Vandermarcq P, Gil R, Neau J. Internal carotid artery dissection after Heimlich maneuver. Annales Francaises d'Anesthesie et de Reanimation. 2003;22:43-5.

[73] Razaboni RM, Brathwaite CEM, Dwyer Jr WA. Ruptured jejunum following Heimlich maneuver. Journal of Emergency Medicine. 1986;4:95-8.

[74] Roehm EF, Twiest MW, Williams RC. Abdominal aortic thrombosis in association with an attempted Heimlich maneuver. JAMA. 1983;249:1186-7.

[75] Sams JS, Nelson KR. Dangers of the Heimlich Maneuver for Esophageal Obstruction. New England Journal of Medicine. 1989;321:980-1.

[76] Skulberg A. Chest compression - An alternative to the Heimlich manoeuver? Resuscitation. 1992;24:91.

[77] Sridharan S, Amin MR, Branski RC. Vocal fold immobility after finger sweep self-extrusion of impacted food in a choking victim with resolution following laryngeal mask ventilation. Ear, Nose, & Throat Journal. 2016;95:33-5.

[78] Tashtoush B, Schroeder J, Memarpour R, et al. Food Particle Aspiration Associated with Hemorrhagic Shock: A Diagnostic Dilemma. Case Reports in Emergency Medicine. 2015;2015:275497.

[79] Truong T, Salire K, De Cicco I, Cherian S, Aisenberg G. Incarcerated diaphragmatic hernia following Heimlich maneuver. Baylor University Medical Center Proceedings. 2018;31:48-50.

[80] Tung PHM, Law S, Chu KM, Law WL, Wong J. Gastric rupture after Heimlich maneuver and cardiopulmonary resuscitation. Hepato-Gastroenterology. 2001;48:109-11.

[81] Ujjin V, Ratanasit S, Nagendran T. Diaphragmatic hernia as a complication of the Heimlich maneuver. International Surgery. 1984;69:175-6.

[82] Ulger H. Complications of the Heimlich maneuver: Isolated Sternum Fracture. Akademik Acil Tip Olgu Sunumlari Dergisi. 2016;7:15-6.

[83] Valero V. Mesenteric laceration complicating a Heimlich maneuver. Annals of emergency medicine. 1986;15:105-6.

[84] Van der Ham AC, Lange JF. Traumatic rupture of the stomach after Heimlich maneuver. Journal of Emergency Medicine. 1990;8:713-5.

[85] Visintine RE, Baick CH. Ruptured stomach after Heimlich maneuver. JAMA. 1975;234:415.

[86] Vunda A, ertuin L. Nasopharyngeal foreign body following a blind finger sweep. Journal of Pediatrics. 2012;160:353.

[87] Wolf DA. Heimlich trauma: A violent maneuver. American Journal of Forensic Medicine and Pathology. 2001;22:65-7.

[88] Delgado-Rodríguez M, Llorca J. Bias. Journal of Epidemiology and Community Health. 2004;58:635-41.

[89] Cummings P. Carryover bias in crossover trials. Archives of Pediatrics & Adolescent Medicine. 2010;164:703-5.

[90] Dunne CL, Peden AE, Queiroga AC, Gomez Gonzalez C, Valesco B, Szpilman D. A systematic review on the effectiveness of anti-choking suction devices and identification of research gaps. Resuscitation. 2020;153:219-26.g

[91] Langhelle A, Sunde K, Wik L, Steen PA. Airway pressure with chest compressions versus Heimlich manoeuvre in recently dead adults with complete airway obstruction. Resuscitation. 2000;44:105-8.

[92] Blain H, Bonnafous M, Grovalet N, Jonquet O, David M. The table maneuver: a procedure used with success in four cases of unconscious choking older subjects. American Journal of Medicine. 2010;123:1150.e7-9.

[93] Nolan JP, Berg RA, Andersen LW, et al. Cardiac Arrest and Cardiopulmonary Resuscitation Outcome Reports: Update of the Utstein Resuscitation Registry Template for In-Hospital Cardiac Arrest: A Consensus Report From a Task Force of the International Liaison Committee on Resuscitation. Resuscitation. 2019;144:166-77.

[94] Perkins GD, Jacobs IG, Nadkarni VM, et al. Cardiac Arrest and Cardiopulmonary Resuscitation Outcome Reports: Update of the Utstein Resuscitation Registry Templates for Out-of-Hospital Cardiac Arrest: A Statement for Healthcare Professionals From a Task Force of the International Liaison Committee on Resuscitation. Resuscitation. 2015;96:328-40.

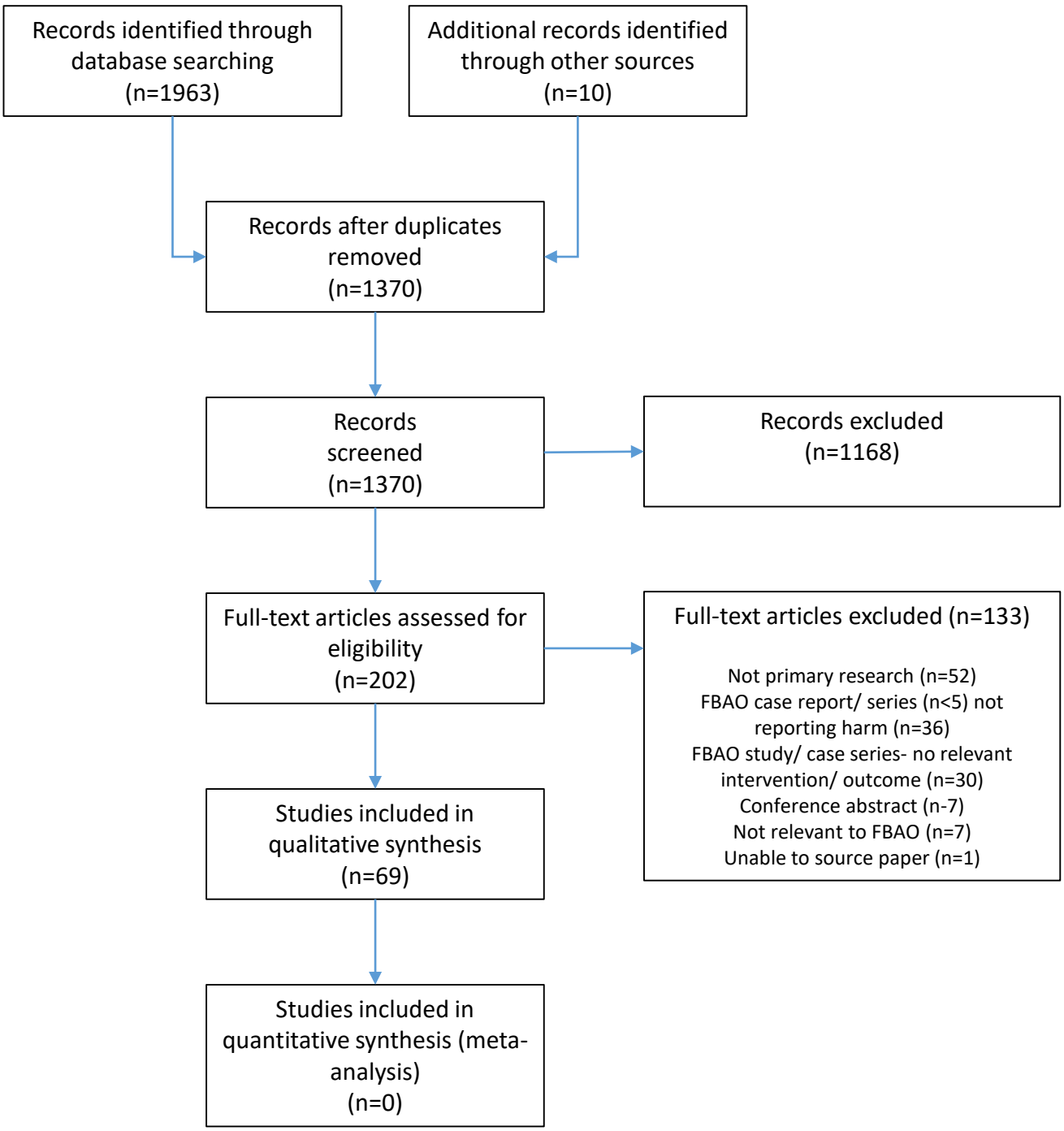
Records identified through database searching (n=1963)
Additional records identified through other sources (n=10)
Records after duplicates removed (n=1370)
Records screened (n=1370)
Records excluded (n=1168)
Full-text articles assessed for eligibility (n=202)
Full-text articles excluded (n=133)
Not primary research (n=52)
FBAO case report/ series (n<5) not reporting harm (n=36)
FBAO study/ case series- no relevant intervention/ outcome (n=30)
Conference abstract (n-7)
Not relevant to FBAO (n=7)
Unable to source paper (n=1)
Studies included in qualitative synthesis (n=69)
Studies included in quantitative synthesis (meta-analysis) (n=0)

Table one: summary of included studies

	Study name	Study setting	Population	Intervention	Comparator	Outcome
Cross-sectional studies						
	Igarashi 2017	Japan 2008-2014	155 adults with FBAO admitted to hospital	Successful FBAO removal by bystander	Removal by EMS/ physician on-scene or at hospital	Favourable neurological outcome
	Kinoshita 2015	Japan 2003-2013	162 adults with witnessed FBAO during meals who became unresponsive	Chest compressions	No chest compressions	Favourable neurological outcome
	Sakai 2014	Japan 2000-2007	240 bystander-witnessed OHCA due to FBAO in larynx/ pharynx	Magill Forcep use	No Magill forcep use	Favourable neurological outcome Survival
Case series						
	Boussuges 1985	France	27 children with FBAO	Abdominal thrusts	-	Relief of FBAO
	Heimlich 1975	Not reported	162 children and adults with FBAO (n=157) or drowning (n=5)	Abdominal thrusts	-	Survival Relief of FBAO
	Igarashi 2017	Japan 2008-2014	28 adults with FBAO admitted to hospital with FBAO removal	Back blows Abdominal thrust Magill forceps	-	Relief of FBAO
	Redding 1979	Not reported	225 cases of FBAO	Back blows Abdominal thrusts Chest thrusts Finger sweep	-	Relief of FBAO
	Rouillon 2006	France 1987-1999	6 children with FBAO admitted to paediatric intensive care unit	Magill forceps	-	Relief of FBAO
	Saperstein 2018	Europe/ USA	10 adults with FBAO- 8 with neurological disability	LifeVac	-	Survival Relief of FBAO
	Soroudi 2007	USA 2003-2005	115 adults with FBAO attended by EMS with recorded intervention	Abdominal thrust Magill forceps	-	Relief of FBAO
	Vilke 2004	USA 1999	182 children (≤5 years) with FBAO attended by EMS	Back blows Abdominal thrust Finger sweep	-	Survival Relief of FBAO
FBAO- Foreign body airway obstruction; EMS- Emergency Medical Service						

Table two: GRADE table

	Outcome	No. of studies	Certainty of evidence assessment						No. of patients		Odds ratio (95% CI)	Certainty	Importance
			Study design	Risk of Bias	Inconsistency	Indirectness	Imprecision	Other	Intervention	Control			
FBAO removal by bystander													
	Survival with GNO	1	Cross-sectional	very serious[a]	not serious	not serious	not serious	none	14/19 (73.7%)	7/22 (31.8%)	6.00 (1.54 to 23.36)	⊕◯◯◯ VERY LOW	CRITICAL
	Survival	No evidence											CRITICAL
	ROSC	No evidence											IMPORTANT
Back blows													
	Survival with GNO	No evidence											CRITICAL
	Survival	1	Case series	very serious[a]	not serious	serious [b]	not serious	none	13/-			⊕◯◯◯ VERY LOW	CRITICAL
	ROSC	No evidence											IMPORTANT
	Relief of airway obstruction	3	Case series	very serious[a]	not serious	serious [b]	not serious	none	75/-			⊕◯◯◯ VERY LOW	IMPORTANT
	Injuries/ complications	4	Case report	very serious [c]	not serious	not serious	not serious	none	4/-			⊕◯◯◯ VERY LOW	IMPORTANT
Abdominal thrusts													
	Survival with GNO	No evidence											CRITICAL
	Survival	2	Case series	very serious [a]	not serious	not serious	not serious	none	189/-			⊕◯◯◯ VERY LOW	CRITICAL
	ROSC	No evidence											IMPORTANT
	Relief of airway obstruction	6	Case series	very serious [a]	not serious	not serious	not serious	none	417/-			⊕◯◯◯ VERY LOW	IMPORTANT
	Injuries/ complications	49	Case report	very serious [c]	not serious	not serious	not serious	none	52/-			⊕◯◯◯ VERY LOW	IMPORTANT
Finger sweep													
	Survival with GNO	No evidence											CRITICAL
	Survival	1	Case series	very serious [a]	not serious	serious [b]	not serious	none	6/-			⊕◯◯◯ VERY LOW	CRITICAL
	ROSC	No evidence											IMPORTANT
	Relief of airway obstruction	2	Case series	very serious [a]	not serious	serious [b]	not serious	none	36/-			⊕◯◯◯ VERY LOW	IMPORTANT
	Injuries/ complication	8	Case report	very serious [c]	not serious	not serious	not serious	none	10/-			⊕◯◯◯ VERY LOW	IMPORTANT
Chest thrusts/ compressions													

	Outcome	No. of studies	Certainty of evidence assessment						No. of patients		Odds ratio (95% CI)	Certainty	Importance
			Study design	Risk of Bias	Inconsistency	Indirectness	Imprecision	Other	Intervention	Control			
	Survival with GNO	1	Cross-sectional	very serious [a]	not serious	not serious	very serious [d]	none	24/35 (68.6%)	36/103 (35.0%)	10.60 (2.47 to 65.06)	⊕◯◯◯ VERY LOW	CRITICAL
	Survival	No evidence											CRITICAL
	ROSC	No evidence											IMPORTANT
	Relief of airway obstruction	1	Case series	very serious [e]	not serious	not serious	not serious	none	28/-			⊕◯◯◯ VERY LOW	IMPORTANT
	Injuries/ complications	4	Case report	very serious [c]	not serious	not serious	not serious	none	5/-			⊕◯◯◯ VERY LOW	IMPORTANT
Magill forceps													
	Survival with GNO	1	Cross-sectional	very serious [a]	not serious	serious [f]	serious [d]	none	24/146 (16.4%)	4/94 (4.3%)	3.96 (1.21 to 13.00)	⊕◯◯◯ VERY LOW	CRITICAL
	Survival	1	Cross-sectional	very serious [a]	not serious	serious [f]	serious [d]	none	39/146 (26.7%)	16/94 (17.0%)	not stated	⊕◯◯◯ VERY LOW	CRITICAL
	ROSC	No evidence											IMPORTANT
	Relief of airway obstruction	4	Case series	very serious [e]	not serious	not serious	not serious	none	417/-			⊕◯◯◯ VERY LOW	IMPORTANT
	Injuries/ complications	No evidence											IMPORTANT
Airway clearance devices													
	Survival with GNO	No evidence											CRITICAL
	Survival	1	Case series	very serious [e]	not serious	not serious	not serious	none	9/-			⊕◯◯◯ VERY LOW	CRITICAL
	ROSC	No evidence											IMPORTANT
	Relief of airway obstruction	1	Case series	very serious [e]	not serious	not serious	not serious	none	10/-[†]			⊕◯◯◯ VERY LOW	IMPORTANT
	Injuries/ complication	No evidence											IMPORTANT

ROSC- Return of spontaneous circulation; GNO- Good neurological outcome; CI: Confidence interval.

a. Very serious risk of bias due to confounding; b. Single study undertaken in paediatric population; c. Data from case reports; d. Extremely wide confidence interval; e. Evidence from case series; f. Study only included patients with OHCA due to FBAO in pharynx or larynx

†Ten events in nine patients

Removal of foreign body airway obstruction: a systematic review of interventions- Supplementary material

Contents:

MEDLINE Search strategy

Database: Ovid MEDLINE(R) and Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Daily and Versions(R): 1946 to current

1 exp Airway Obstruction/th [Therapy]
2 exp Foreign Bodies/
3 1 and 2
4 (Foreign body adj3 air* adj3 obstruct*).tw,kf.
5 (Foreign bodies adj3 air* adj3 obstruct*).tw,kf.
6 (Foreign object* adj3 air* adj3 obstruct*).tw,kf.
7 (Foreign body adj3 air* adj3 remov*).tw,kf.
8 (Foreign bodies adj3 air* adj3 remov*).tw,kf.
9 (Foreign object* adj3 air* adj3 remov*).tw,kf.
10 back slap*.tw,kf.
11 back blow*.tw,kf.
12 chest thrust*.tw,kf.
13 abdominal thrust*.tw,kf.
14 (heimlich maneuver or heimlich manoeuvre).tw,kf.
15 Heimlich Maneuver/
16 manual suction device*.tw,kf.
17 de-choker.tw,kf.
18 dechoker.tw,kf.
19 lifewand.tw,kf.
20 lifevac.tw,kf.
21 anti-choking.tw,kf.
22 table maneuver.tw,kf.
23 table manoeuvre.tw,kf.
24 finger sweep.mp.
25 Magill forcep*.mp.
26 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25
27 ((airway* or airflow or aspiration* or inhale* or inhalation* or respiratory or asphyxiat*) adj3 (obstruct* or closure or occulusion* or impaction or foreign body or foreign bodies or foreign object* or food or bolus)).tw,kf.
28 (choking or choke).tw,kf.
29 first aid.tw,kf. or first aid/
30 27 or 28
31 29 and 30
32 26 or 31
33 32 not (animals/ not human/)
34 limit 33 to (comment or editorial)
35 33 not 34

Table S1: Case report data extraction

Study	Age†	Sex	Obstruction type	Intervention(s)	Injury type	Outcome
Abder-Rahman 2009	11-month	Male	Non-food	Blind finger sweep	Dislodge object	Died
Abder-Rahman 2009	1-month	Male	Unknown	Blind finger sweep	Dislodge object	Died
Abder-Rahman 2009	1	Unknown	Food: non-meat	Blind finger sweep	Dislodge object	Died
Agia 1979	19	Male	Food: non-meat	Abdominal thrusts	Thoracic	Survived
Aguilera 2008	7	Male	Food: meat	Abdominal thrusts	Thoracic	Survived
Ayerdi 2002	70	Male	Food: meat	Abdominal thrusts	Vascular	Survived
Bintz 1996	65	Female	Food: meat	Abdominal thrusts	Gastric/ oesophageal	Survived
Bintz 1996	80	Male	Food: non-meat	Abdominal thrusts	Gastric/ oesophageal	Died
Bouayed 2015	45	Female	Food: meat	Abdominal thrusts	Thoracic	Survived
Cecchetto 2011	83	Male	Food: meat	Abdominal thrusts	Abdominal	Died
Chao 2012	59	Female	Food: unknown	Abdominal thrusts	Gastric/ oesophageal	Survived
Chapman 1983	86	Male	Food: unknown	Abdominal thrusts	Vascular	Died
Chillag 2010	80	Female	Food: unknown	Abdominal thrusts	Thoracic	Survived
Cowan 1987	74	Male	Food: meat	Abdominal thrusts	Gastric/ oesophageal	Survived
Croom 1983	39	Male	Food: unknown	Abdominal thrusts	Gastric/ oesophageal	Died
Desai 2008	78	Female	Food: unknown	Abdominal thrusts	Vascular	Died
Dupre 1993	93	Male	Food: unknown	Abdominal thrusts	Gastric/ oesophageal	Survived
Entel 1995	79	Female	Food: unknown	Abdominal thrusts	Thoracic	Survived
Fearing 2002	74	Female	Food: meat	Abdominal thrusts	Gastric/ oesophageal	Survived
Feeney 2007	11	Male	Unknown	Abdominal thrusts	Abdominal	Survived
Fink 1989	3	Male	Non-food	Abdominal thrusts	Thoracic	Survived
Gjoni 2009	3	Male	Food: non-meat	Blind finger sweep	Injury to naso-pharynx	Survived
Guinane 2018	85	Male	Food: non-meat	Back blows; chest thrust	Vascular	Died
Hartrey 1995	9-week	Female	Non-food	Blind finger sweep	Injury to naso-pharynx	Survived
Haynes 1984	61	Female	Unknown	Abdominal thrusts	Gastric/ oesophageal	Survived
Heimlich 1977	-	-	Food: unknown	Blind finger sweep	Injury to naso-pharynx	Unknown
Herman 2018	85	Female	Food: meat	Abdominal thrusts	Abdominal	Survived
Kabbani 1995	8-month	Female	Non-food	Blind finger sweep	Injury to naso-pharynx	Survived
Kirshner 1985	69	Male	Food: meat	Abdominal thrusts	Vascular	Died
Koss 2018	16	Male	Food: non-meat	Abdominal thrusts	Gastric/ oesophageal	Survived
Kosser 2009	73	Male	Food: unknown	Abdominal thrusts	Vascular	Died
Lee 2009	3	Male	Food: non-meat	Abdominal thrusts	Abdominal	Survived
Lee 2019	67	Male	Food: meat	Abdominal thrusts	Vascular	Survived
Lette 1990	72	Female	Food: meat	Abdominal thrusts	Thoracic	Survived
Lin 2003	63	Male	Food: meat	Abdominal thrusts	Vascular	Survived
Mack 2002	80	Female	Food: non-meat	Abdominal thrusts; chest compressions	Vascular	Died
Mack 2002	84	Male	Food: meat	Abdominal thrusts	Vascular	Died
Majumdar 1998	57	Female	Food: non-meat	Abdominal thrusts	Gastric/ oesophageal	Died
Martin 2007	81	Male	Unknown	Abdominal thrusts	Vascular	Died
Matharoo 2013	10	Female	Non-food	Abdominal thrusts	Thoracic	Survived

Meredith 1986	62	Male	Food: unknown	Abdominal thrusts	Gastric/ oesophageal	Survived
Mori 2016	1	Male	Non-food	Blind finger sweep	Dislodge object	Survived
Nowitz 1998	7	Male	Non-food	Back blows; abdominal thrusts	Thoracic	Survived
Olenchock 2004	56	Male	Food: non-meat	Abdominal thrusts	Thoracic	Survived
Palleiro 2007	88	Male	Food: meat	Abdominal thrusts	Abdominal	Survived
Passik 1987	74	Female	Unknown	Abdominal thrusts	Vascular	Survived
Patterson 1993	84	Female	Non-food	Back blows	Vascular	Died
Rakotoharinandrasana 2003	46	Female	Food: non-meat	Back blows; abdominal thrusts	Vascular	Survived
Razaboni 1986+A6	22	Male	Non-food	Abdominal thrusts	Abdominal	Survived
Roehm	62	Male	Food: meat	Abdominal thrusts	Vascular	Died
Sams 1989	-	Female	Food: unknown	Abdominal thrusts	Gastric/ oesophageal	Unknown
Skulberg 1992	-	Female	Food: meat	Abdominal thrusts; chest compressions	Gastric/ oesophageal	Survived
Sridharan 2016	57	Female	Food: meat	Blind finger sweep	Injury to naso-pharynx	Survived
Tashtoush 2015	84	Male	Unknown	Abdominal thrusts	Abdominal	Survived
Truong 2018	85	Female	Food: unknown	Abdominal thrusts	Abdominal	Survived
Tung 2001	64	Female	Food: unknown	Abdominal thrusts; chest compressions	Gastric/ oesophageal	Survived
Tung 2001	73	Male	Food: non-meat	Abdominal thrusts; chest compressions	Gastric/ oesophageal	Survived
Ujjin 1984	-	Male	Unknown	Abdominal thrusts	Thoracic	Died
Ulger 2016	33	Female	Unknown	Abdominal thrusts	Thoracic	Survived
Valero 1986	76	Male	Non-food	Abdominal thrusts	Vascular	Died
Van der Ham 1990	76	Female	Food: unknown	Abdominal thrusts	Gastric/ oesophageal	Died
Visintine 1975	74	Male	Food: meat	Abdominal thrusts	Gastric/ oesophageal	Survived
Vunda 2012	9-months	Female	Non-food	Blind finger sweep	Dislodge object	Unknown
Wolf 2001	51	Male	Food: non-meat	Abdominal thrusts	Vascular	Died
†- Years unless stated						

Table S2: Risk of bias of cross-sectional studies

	Development of eligibility criteria	Measurement of exposure and outcome	Control of confounding	Incomplete follow-up
Igarashi 2017†	Low	Unclear	High	Low
Kinoshita 2015	Low	Unclear	High	Low
Sakai 2014	Unclear	Unclear	High	Low
†Outcome of survival with good neurological outcome				

Table S3: Risk of bias of case series

	Domain							
	Selection	**Ascertainment**		**Causality**				**Reporting**
Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
Boussuges 1985	Unclear	No	Yes	No	N/A	N/A	Unclear	No
Heimlich 1975	No	No	Yes	No	N/A	N/A	No	No
Igarashi 2017†	Yes	No	Yes	No	N/A	N/A	Yes	No
Redding 1979	No	No	Yes	No	N/A	N/A	Unclear	No
Rouillon 2006	Yes	No	Yes	No	N/A	N/A	Yes	No
Saperstein 2018	Unclear	Yes	Yes	No	N/A	N/A	Unclear	Unclear
Soroudi 2007	Yes	No	Yes	No	N/A	N/A	No	No
Vilke 2004	Yes	No	Yes	No	N/A	N/A	No	No

†Outcome of FBAO removal

1. Does the patient(s) represent(s) the whole experience of the investigator (centre) or is the selection method unclear to the extent that other patients with similar presentation may not have been reported?
2. Was the exposure adequately ascertained?
3. Was the outcome adequately ascertained?
4. Were other alternative causes that may explain the observation ruled out?
5. Was there a challenge/rechallenge phenomenon?
6. Was there a dose–response effect?
7. Was follow-up long enough for outcomes to occur?
8. Is the case(s) described with sufficient details to allow other investigators to replicate the research or to allow practitioners make inferences related to their own practice?

Table S4: Risk of bias of case reports

	Domain							
	Selection	Ascertainment		Causality				Reporting
Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
Abder-Rahman 2009	Yes	Yes	Yes	No	N/A	N/A	Yes	Yes
Agia 1979	No	Yes	Yes	No	N/A	N/A	Yes	No
Aguilera 2008	No	Yes	Yes	No	N/A	N/A	Yes	No
Ayerdi 2002	No	No	Yes	No	N/A	N/A	Yes	No
Bintz 1996	No	No	Yes	Yes	N/A	N/A	Yes	No
Bouayed 2015	No	Yes	Yes	Yes	N/A	N/A	Yes	Yes
Cecchetto 2011	No	Yes	Yes	Yes	N/A	N/A	Yes	Yes
Chao 2012	No	Yes	Yes	No	N/A	N/A	Yes	No
Chapman 1983	No	Yes	Yes	No	N/A	N/A	Yes	Yes
Chillag 2010	No	No	Yes	No	N/A	N/A	No	No
Cowan 1987	No	Yes	Yes	No	N/A	N/A	Yes	No
Croom 1983	No	Yes	Yes	No	N/A	N/A	Yes	No
Desai 2008	No	No	Yes	No	N/A	N/A	Yes	No
Dupre 1993	No	Yes	Yes	No	N/A	N/A	Yes	No
Entel 1995	No	No	Yes	No	N/A	N/A	No	No
Fearing 2002	No	No	Yes	No	N/A	N/A	Yes	No
Feeney 2007	No	Yes	Yes	No	N/A	N/A	Yes	No
Fink 1989	No	Yes	Yes	No	N/A	N/A	Yes	No
Gjoni 2009	No	Yes	Yes	No	N/A	N/A	Yes	Yes
Guinane 2018	No	No	Yes	No	N/A	N/A	Yes	No
Hartrey 1995	No	Yes	Yes	No	N/A	N/A	Yes	Yes
Haynes 1984	No	Yes	Yes	No	N/A	N/A	Yes	Yes
Heimlich 1977	No	No	No	No	N/A	N/A	No	No
Herman 2018	No	No	Yes	No	N/A	N/A	Yes	No
Kabbani 1995	No	Yes	Yes	Yes	N/A	N/A	Yes	Yes
Kirshner 1985	No	Yes	Yes	No	N/A	N/A	Yes	No
Koss 2018	No	Yes	Yes	No	N/A	N/A	Yes	Yes
Kosser 2009	No	No	Yes	No	N/A	N/A	Yes	Yes
Lee 2009	No	Yes	Yes	No	N/A	N/A	Yes	No
Lee 2019	No	No	Yes	No	N/A	N/A	Yes	Yes

	Domain							
	Selection	Ascertainment		Causality				Reporting
Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
Lette 1990	No	No	Yes	No	N/A	N/A	Yes	No
Lin 2003	No	No	Yes	No	N/A	N/A	Yes	No
Mack 2002	No	No	Yes	No	N/A	N/A	Yes	No
Majumdar 1998	No	No	Yes	No	N/A	N/A	Yes	No
Martin 2007	No	No	Yes	No	N/A	N/A	Yes	No
Matharoo 2013	No	Yes	Yes	Yes	N/A	N/A	Yes	Yes
Meredith 1986	No	Ye	Yes	No	N/A	N/A	Yes	Yes
Mori 2016	No	Yes	Yes	Yes	N/A	N/A	Yes	Yes
Nowitz 1998	No	Yes	Yes	No	N/A	N/A	Yes	Yes
Olenchock 2004	No	No	Yes	No	N/A	N/A	Yes	No
Palleiro 2007	No	No	Yes	No	N/A	N/A	Yes	No
Passik 1987	No	No	Yes	No	N/A	N/A	Yes	No
Patterson 1993	No	Yes	Yes	No	N/A	N/A	Yes	No
Rakotoharinandrasana 2003	No	Yes	Yes	No	N/A	N/A	Yes	Yes
Razaboni 1986	No	No	Yes	No	N/A	N/A	Yes	No
Roehm 1983	No	Yes	Yes	No	N/A	N/A	Yes	No
Sams 1989	No	No	No	No	N/A	N/A	No	No
Skulberg 1992	No	No	Yes	No	N/A	N/A	Yes	No
Sridharan 2016	No	Yes	Yes	No	N/A	N/A	No	No
Tashtoush 2015	No	No	Yes	No	N/A	N/A	Yes	Yes
Truong 2018	No	No	Yes	No	N/A	N/A	Yes	No
Tung 2001	No	No	Yes	No	N/A	N/A	Yes	No
Ujjin 1984	No	No	Yes	No	N/A	N/A	Yes	No
Ulger 2016	No	No	Yes	No	N/A	N/A	No	No
Valero 1986	No	Yes	Yes	No	N/A	N/A	Yes	Yes
Van der Ham 1990	No	No	Yes	No	N/A	N/A	Yes	No
Visintine 1975	No	No	Yes	No	N/A	N/A	Yes	No
Vunda 2012	No	Yes	Yes	Yes	N/A	N/A	No	Yes
Wolf 2001	No	No	Yes	No	N/A	N/A	Yes	No
1. Does the patient(s) represent(s) the whole experience of the investigator (centre) or is the selection method unclear to the extent that other patients with similar presentation may not have been reported?								

	Domain							
	Selection	**Ascertainment**		**Causality**				**Reporting**
Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
2. Was the exposure adequately ascertained? 3. Was the outcome adequately ascertained? 4. Were other alternative causes that may explain the observation ruled out? 5. Was there a challenge/rechallenge phenomenon? 6. Was there a dose–response effect? 7. Was follow-up long enough for outcomes to occur? 8. Is the case(s) described with sufficient details to allow other investigators to replicate the research or to allow practitioners make inferences related to their own practice?								