

Original Article

Peri-operative glucagon-like peptide-1 receptor agonist use and outcomes: a national prospective multicentre cohort study

Thomas E. Potter,  John N. Cronin,  Justin Kua,  Sophie Bloomfield,  Mayur Murali,  Frances Beatty, Andrew McKechnie,  Danny J. N. Wong  and Kariem El-Boghdadly,  on behalf of the GLIMPSE Resident Research Networks and Collaborators*

Summary

Introduction Peri-operative glucagon-like peptide-1 receptor agonist (GLP-1 RA) use is associated with delayed gastric emptying. It is unclear what proportion of patients having anaesthetic care are receiving GLP-1 RAs; what strategies are used in their peri-operative management; and whether the incidence of pulmonary aspiration and/or regurgitation is greater in this population.

Methods We performed a national prospective multicentre cohort study of adults undergoing elective or emergency procedures under the care of an anaesthetist. Patients were screened for GLP-1 RA use in the 3 months before the index procedure. Data were collected on patient, procedure, anaesthesia and outcomes, including pulmonary aspiration and regurgitation. The primary outcome was the proportion of patients receiving GLP-1 RAs. Secondary outcomes described the pre-operative management of GLP-1 RAs; anaesthesia and airway management in patients receiving GLP-1 RAs; and the incidence of pulmonary aspiration and/or regurgitation.

Results Of 47,039 patients from 119 sites across the UK, 1348 (2.9%) reported receiving GLP-1 RAs. Peri-operative management was variable regarding drug cessation, anaesthesia and airway management. The incidence (95%CI) of pulmonary aspiration and/or regurgitation in the non-GLP-1 RA cohort was 57/45,691 (0.12% (0.09–0.16%)) and in the GLP-1 RA cohort was 19/1348 (1.41% (0.85–2.19%)); odds ratio (95%CI) 11.39 (6.47–20.05), $p < 0.001$. In patients receiving GLP-1 RAs, pulmonary aspiration and/or regurgitation occurred most frequently during emergence from anaesthesia.

Discussion In this national study, 1 in 36 patients undergoing anaesthesia care received GLP-1 RAs, and their peri-operative management was variable. A range of airway management techniques aiming to reduce pulmonary aspiration risk were observed but, despite this, the incidence of pulmonary aspiration and/or regurgitation was 1 in 71 in people receiving GLP-1 RAs.

For full author affiliations, see end of article

Plain Language Summary is available on the journal website.

Correspondence to: Kariem El-Boghdadly

Email: kariem.el-boghdadly@kcl.ac.uk

Accepted: 28 August 2026

Keywords: gastric regurgitation; glucagon-like peptide-1 receptor agonist; pulmonary aspiration

*GLIMPSE Resident Research Networks Collaborators are listed in online Supporting Information Appendix S1.

X: [@t_Potter_1](#); [@john_n_cronin](#); [@justin_kua](#); [@MuraliMayur](#); [@admckdoc](#); [@dannyjnwong](#); [@elboghdadly](#); [@PeriopResearch](#)

Introduction

Glucagon-like peptide-1 receptor agonists (GLP-1 RAs) and dual GLP-1 RA/glucose-dependent insulinotropic polypeptide receptor agonists (hereafter pooled with GLP-1 RAs) are used for the treatment of diabetes and obesity. They have been shown to reduce cardiovascular and renal complications, as well as all-cause mortality in people with and without diabetes [1–4]. Their use is likely to increase as their potential indications expand, including the treatment of obstructive sleep apnoea; heart failure; Parkinson's disease; and Alzheimer's disease [5–7]. In the UK, GLP-1 RAs are recommended by the National Institute of Health and Care Excellence (NICE) for management of both type 2 diabetes and obesity, provided criteria are met [8,9]. Given their effectiveness for weight loss, GLP-1 RAs are obtained increasingly through non-physician or specialist prescription routes, such as online pharmacies [10,11]. Consequently, people undergoing surgery may not readily report their use, and standard approaches to medicines reconciliation might not include them on admission for surgery. Therefore, the proportion of people undergoing surgery who receive GLP-1 RAs remains unclear.

Case reports highlight episodes of pulmonary aspiration or regurgitation in patients receiving GLP-1 RAs despite adequate fasting times; however, these patients frequently have other risk factors for aspiration, and it is therefore unclear to what extent GLP-1 RAs contribute to this risk [12–15]. Ultrasound, endoscopy and various other techniques indicate that GLP-1 RA use is associated with higher volumes of residual gastric content despite adherence to appropriate or extended fasting times, as well as drug withholding [16–18]. While increased gastric volumes are a concern, they are not always associated with pulmonary aspiration. For example, a recent meta-analysis reported an increased risk of residual gastric contents but not of pulmonary aspiration, though the certainty of the evidence was low [19]. Studies reporting risks of pulmonary aspiration and/or regurgitation are largely confined to retrospective database analyses with methodological limitations and high risk of reporting bias [20,21]. This lack of high-quality prospective data has resulted in variability in clinical practice guidelines on peri-operative management of GLP-1 RAs [19,22–24].

Data on the scale of peri-operative use of GLP-1 RAs and the anaesthesia-related implications are required to inform future guidance. We therefore conducted a prospective, national, multicentre service evaluation, aiming to determine the proportion of people receiving GLP-1 RAs; describe drug prescription and utilisation;

report current peri-operative management; and quantify pulmonary aspiration risks.

Methods

The GLP-1 receptor agonist Management in the Peri-operative Setting (GLIMPSE) project was a prospective observational cohort study conducted in NHS hospitals in England, Wales and Scotland, and Health and Social Care hospitals in Northern Ireland (hereafter described collectively as NHS hospitals). The study met the criteria for a service evaluation according to the NHS Health Research Authority tool and relevant devolved authorities [25], and therefore formal ethical approval was not required. The study was approved prospectively by the Caldicott Guardian at the lead site, and all participating hospital sites were required to register the study as a service evaluation before data collection commencing, as done in previous studies [26]. We report our findings according to the STROBE guidelines [27].

Individual hospital sites were invited to participate via anaesthesia resident research networks throughout the UK, as well as through the Society of Obesity and Bariatric Anaesthesia. Individual sites were permitted to choose their own data collection period, defined as any consecutive 14-day period starting from 07.30 on a Monday between 29 September and 26 December 2025.

All adults (aged ≥ 18 y) undergoing elective or emergency surgery under the care of an anaesthetist were eligible, with the exception of patients undergoing obstetric procedures and those in whom airway management commenced at a location other than the procedure location (e.g. ICU transfers). Pregnant patients undergoing non-obstetric procedures were eligible for inclusion. Local investigators identified patients receiving GLP-1 RAs by screening drug histories in medical notes, and the anaesthetists with clinical responsibility for the case, were asked to verify GLP-1 RA status as per routine clinical practice. Anaesthetists were also asked to report any episode of regurgitation or aspiration regardless of GLP-1 RA exposure. Eligible patients were divided into cohorts based on: whether they had received GLP-1 RAs (either oral or injection) within 3 months of the index procedure; and/or had experienced a clinically detectable episode of peri-operative pulmonary aspiration and/or regurgitation of gastric contents. In patients who had not received GLP-1 RAs in the previous 3 months or in those with no peri-operative regurgitation or pulmonary aspiration, no further data were collected.

Patient data were collected in predefined categories to ensure they were not identifiable and included: sex; age;

BMI; ASA physical status; pre-operative exposure to GLP-1 RAs within the preceding 3 months; source of prescription; drug name; route of administration; dosing frequency; current dose; and any dose increase in the preceding 3 months. The duration of any pre-operative cessation of GLP-1 RAs was collected, if relevant. Procedural data collected included surgical speciality; start time; and surgical complexity as defined by NICE [28]. Surgical urgency was defined as per the UK National Confidential Enquiry into Patient Outcome and Death [29]. Data were also collected on any anaesthetic interventions undertaken to assess or mitigate the risk of pulmonary aspiration, including use of pre-operative gastric ultrasound; cricoid force; head-up position; prokinetic medication; gastric tube; and rapid sequence induction and intubation. A complete list of all collected data is provided in online Supporting Information Appendix S2.

The primary outcome was the proportion of patients receiving GLP-1 RAs. Secondary outcomes described the pre-operative management of GLP-1 RAs; anaesthesia and airway management in patients receiving GLP-1 RAs; and the incidence of pulmonary aspiration and/or regurgitation. Outcome data collected included cancellation of surgery due to GLP-1 use pre-operatively; regurgitation of gastric contents (defined as the observed passage of gastric contents into the oropharynx); and pulmonary aspiration (defined as clinical, radiological and/or bronchoscopic evidence of gastric contents in the trachea and/or lungs). The timing of regurgitation or pulmonary aspiration was categorised according to the phase of anaesthesia management during the peri-operative period: induction; maintenance; or emergence. Other outcomes included unplanned admission to a ward or ICU; tracheal re-intubation immediately following the procedure; and death within 48 h where pulmonary aspiration was deemed by local investigators to have contributed to death.

Included patients were defined as those who received GLP-1 RAs in the 3 months prior to the index procedure and/or experienced intra-operative regurgitation and/or pulmonary aspiration and therefore required data collection and follow-up for 48 h after surgery. Follow-up involved a review of medical notes to identify postoperative pulmonary complications. Postoperative pulmonary complications were classified according to the Standardised Endpoints for Peri-operative Medicine (StEP) criteria and included: atelectasis; pneumonia; acute respiratory distress syndrome; and pulmonary aspiration [30]. The severity of postoperative pulmonary complications was graded according to oxygen requirements as: none; mild; moderate; or severe.

Local investigating teams at each site uploaded data onto a secure data capture server (REDCap v16.0.15, Vanderbilt University, TN, USA) hosted at the lead site. These included data collected on each patient receiving GLP-1 RAs, as well as those who had a peri-operative pulmonary aspiration and/or regurgitation event. In addition, each hospital site reported the total number of patients screened for inclusion and the number of potentially eligible patients who were not screened due to logistical difficulties at that site. Local investigators were encouraged to ensure all data were complete wherever possible; however, this was not always feasible within the context of a service evaluation and therefore proportions may not sum to 100% due to missing data.

The sample size was calculated a priori based on an expected incidence of 3% of the population being on a GLP-1 RA, extrapolated from published results suggesting increasing year-on-year incidence of these medications with 2.9% reported in 2024 [31] and a precision of 5% (i.e. 0.15%). This suggested we would need to screen 49,685 patients to report the primary outcome with 5% error. We estimated that institutions would report 30 patients per day for 2 weeks, meaning we required approximately 120 sites. Data from sites that screened < 75% of potentially eligible patients at their institutions were excluded to reduce the risk of selection bias, as described previously [26].

The primary outcome was modelled as a binomial outcome stratified by site as a random-effects variable to account for any inter-site variation in use of GLP-1 RAs (e.g. single-speciality sites dedicated to bariatric surgery). Binomial confidence intervals were reported for the incidence of pulmonary aspiration/regurgitation events. Association between GLP-1 RA use and pulmonary aspiration/regurgitation events were modelled as a generalised linear mixed-effects logistic regression with GLP-1 RA use as a fixed effect and hospital site as a random effect. Sites with zero events were handled via partial pooling. To reduce the risk of sparse event bias, a sensitivity analysis was performed using Firth's penalised logistic regression with site as a fixed effect. All analyses were performed using R (version 4.5.3, R Foundation for Statistical Computing, Vienna, Austria).

Results

A total of 52,053 eligible patients were identified from 131 sites. Data from 12 sites were excluded due to low screening rates, leaving 48,592 eligible patients from 119 sites. The remaining sites screened 47,039 patients (i.e. reviewed medical notes for GLP-1 RA), giving a screening rate of 96.8%.

Out of 47,039 patients screened, 1348 (2.9%) reported receiving pre-operative GLP-1 RAs (Fig. 1). After controlling for inter-site variability in usage, the overall incidence (95% CI) of GLP-1 RA use was 2.77% (2.52–3.05%), ranging between 0.4% and 7.8% across individual institutions (see online Supporting Information Figure S1). Patient and surgical characteristics are reported in Table 1 and online Supporting Information Table S1.

The majority of patients receiving GLP-1 RAs were taking either tirzepatide (942/1348; 69.9%) or semaglutide (353/1348; 26.2%) (Table 2). In total, 20/1348 patients (1.5%) reported receiving daily oral GLP-1 RAs, and 1309/1348 (97.1%) received weekly injectable medications. Data were not available for the remaining 19 patients. The variety of GLP-1 RA drug regimens is summarised in Table 2. Most patients taking semaglutide or tirzepatide were taking doses in the lower half of the dose titration range (online Supporting Information Table S2). Most patients obtained their prescription for a GLP-1 RA from sources other than their GP or a hospital specialist.

In the 3 months before anaesthesia, two patients reported switching from semaglutide to tirzepatide, and five reported switching from tirzepatide to semaglutide. For this analysis, these patients were grouped according to the drug they were taking immediately before surgery.

A total of 405/1348 patients (30.0%) were asked to stop taking their GLP-1 RA before surgery, the majority of whom withheld it between 8 and 14 days (Fig. 2). In some patients, the drug was omitted for > 28 days, but there were insufficient data to understand the indication for this. While

there was substantial variability in the anaesthetic and airway management of patients receiving GLP-1 RAs (Tables 3 and 4), most underwent general anaesthesia with tracheal intubation.

One patient had surgery deferred due to reporting the use of GLP-1 RAs on the day of surgery. Another patient deferred themselves after being counselled about increased peri-operative risk. The anaesthetic team reported a change in practice directly due to GLP-1 RAs for two patients. In one patient, the anaesthetist performed post-induction ventilation with a supraglottic airway device rather than a facemask before tracheal intubation. In the second, the anaesthetist reported that instead of directly placing a double-lumen tube, as would be their standard practice for the procedure, they instead placed a single-lumen tracheal tube immediately following induction, followed by a planned change to a double-lumen tube.

Peri-operative pulmonary aspiration and/or regurgitation occurred in 76 out of 47,039 (0.2%) patients within the entire cohort. The incidence (95%CI) in the non-GLP-1 RA cohort was 57 out of 45,691 patients (0.12% (0.09–0.16%)) and in the GLP-1 RA cohort was 19 out of 1348 patients (1.41% (0.85–2.19%)). The odds ratio (95%CI) for pulmonary aspiration and/or regurgitation in the GLP-1 RA cohort was 11.39 (6.47–20.05); $p < 0.001$. Site-level random-effects variance was 0.78 (log-odds) with an overdispersion ratio of 1.16 ($p = 0.256$), consistent with absence of overdispersion. In a sensitivity analysis using Firth's penalised logistic regression, the estimated odds

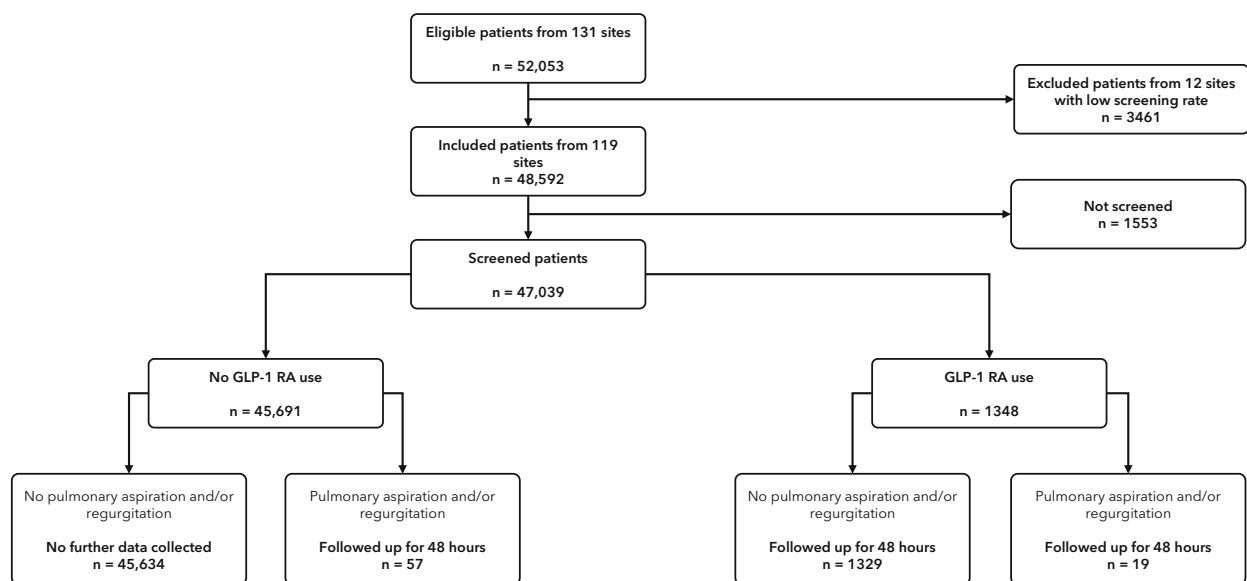


Figure 1 Patient flow chart.

Table 1 Patient and surgical characteristics. Values are number (proportion).

	Without GLP-1 RA Pulmonary aspiration and/or regurgitation n = 57	With GLP-1 RA No pulmonary aspiration and/or regurgitation n = 1329	Pulmonary aspiration and/or regurgitation n = 19
Age; y			
18–29	6 (10.5%)	71 (5.3%)	1 (5.3%)
30–39	11 (19.3%)	186 (14.0%)	1 (5.3%)
40–59	18 (31.6%)	639 (48.1%)	11 (57.9%)
60–79	17 (29.8%)	417 (31.4%)	6 (31.6%)
≥ 80	5 (8.8%)	13 (1.0%)	0
Missing	0	3 (0.2%)	0
Sex; female	27 (47.4%)	917 (69.0%)	15 (78.9%)
ASA physical status			
1	3 (5.3%)	57 (4.3%)	0
2	27 (47.4%)	725 (54.6%)	12 (63.2%)
3	19 (33.3%)	510 (38.4%)	7 (36.8%)
4	6 (10.5%)	35 (2.6%)	0
5	1 (1.8%)	0	0
Missing	1 (1.8%)	2 (0.2%)	0
BMI; kg.m ⁻²			
< 18.5	0	0	0
18.5–24.9	12 (21.1%)	91 (6.8%)	3 (15.8%)
25–29.9	14 (24.6%)	319 (24.0%)	6 (31.6%)
30–34.9	18 (31.6%)	411 (30.9%)	4 (21.1%)
35–39.9	7 (12.3%)	266 (20.0%)	4 (21.1%)
≥ 40	5 (8.8%)	231 (17.4%)	2 (10.5%)
Missing	1 (1.8%)	11 (0.8%)	0
Surgical urgency			
Elective	20 (35.1%)	973 (73.2%)	15 (78.9%)
Expedited	6 (10.5%)	135 (10.2%)	0
Urgent	19 (33.3%)	153 (11.5%)	4 (21.1%)
Emergency	12 (21.1%)	68 (5.1%)	0
Surgical complexity			
Minor	17 (29.8%)	379 (28.5%)	4 (21.1%)
Intermediate	23 (40.4%)	594 (44.7%)	10 (52.6%)
Major	17 (29.8%)	348 (26.2%)	5 (26.3%)
Missing	0	8 (0.6%)	0
Day of the week			
Weekday	49 (86.0%)	1231 (92.6%)	17 (89.5%)
Weekend	8 (14.0%)	98 (7.4%)	2 (10.5%)
Anaesthesia start time			
In hours*	44 (77.2%)	1198 (90.1%)	16 (84.2%)
Out of hours**	13 (22.8%)	131 (9.9%)	3 (15.8%)

*07:30 and 17:59, Monday–Friday.

**All other times.

ratio was 11.4 (7.61–17.1), supportive of the lack of sparse event bias in the data.

There were two reports of pulmonary aspiration of 1348 patients receiving a GLP-1 RA. In the non-GLP-1 RA cohort,

there were 16 reports of pulmonary aspiration in 45,691 patients (see online Supporting Information Appendix S3). Full details on timing, severity and management of pulmonary aspiration and/or regurgitation events are

Table 2 Characteristics of GLP-1 RAs received pre-operatively. Only doses for semaglutide and tirzepatide are provided given the low rates of use of other medications in this class. Values are number (proportion).

n = 1348	
Drug	
Albiglutide	1 (0.1%)
Dulaglutide	34 (2.5%)
Exenatide	3 (0.2%)
Liraglutide	11 (0.8%)
Retatrutide	3 (0.2%)
Semaglutide	353 (26.2%)
Tirzepatide	942 (69.9%)
Missing	1 (0.1%)
Administration frequency	
Once daily	127 (9.4%)
Once weekly	1189 (88.2%)
Missing	32 (2.4%)
Indication	
Weight loss	794 (58.9%)
Diabetes	315 (23.4%)
Weight loss and diabetes	176 (13.1%)
Missing	63 (4.7%)
Duration of treatment; months	
< 1	44 (3.3%)
1–3	187 (13.9%)
3–6	303 (22.5%)
6–12	305 (22.6%)
> 12	218 (16.2%)
Missing	291 (21.6%)
Dose increase in last 3 months	
Yes	304 (22.6%)
No	690 (51.2%)
Missing	354 (26.3%)
Source of prescription	
General practitioner	470 (34.9%)
Hospital specialist	92 (6.8%)
Other	555 (41.2%)
Missing	231 (17.1%)

provided in Table 5. Emergence was the most common time for patients on GLP-1 RAs to aspirate or regurgitate (10/19). There were no additional cases of pulmonary aspiration identified at follow-up of patients on GLP-1 RAs. There was one reported death due to pulmonary aspiration of the 48,592 included; this patient had no prior GLP-1 RA exposure.

Discussion

In this national prospective multicentre observational study, 1 in 36 patients undergoing anaesthesia were receiving GLP-1 RAs. Of these, > 40% procured it via non-GP or specialist prescription sources, with the most common indication being for weight management. Peri-operative management varied widely. The incidence of pulmonary aspiration and/or regurgitation in people receiving GLP-1 RAs was 1 in 71, reported most commonly during emergence of anaesthesia.

Our results indicate wide variation in practice regarding the peri-operative cessation of GLP-1 RAs. Nearly one-third of patients had been advised to hold their GLP-1 medication pre-operatively, with the majority of these being omitted for 8–14 days, consistent with a request to stop the drug for 1 week. This observed practice contrasts with the multidisciplinary consensus statement from the Association of Anaesthetists, which recommends continuing GLP-1 RAs throughout the peri-operative period [24]. Since tirzepatide and semaglutide have an elimination half-life of 5 and 7 days, respectively, cessation of 25 and 35 days (five half-lives) would be required to effectively eliminate the drug. It is unclear, however, how long these medications need to be held pre-operatively to reduce the risk of residual gastric contents. Increased gastric volumes have been observed despite withholding semaglutide for up to 3 weeks [32]. It is possible the observed practice relates to the initial guidance issued by the American Society of Anesthesiologists, which recommended a 1-week cessation for weekly preparations, but has since been revised [33]. While holding GLP-1 RAs for 1 week may not reduce the risk of pulmonary aspiration, it may increase the risk of peri-operative hyperglycaemia, and a theoretical loss of cardioprotective benefits with metabolic 'rebound' in weight may be seen with prolonged GLP-1 RA discontinuation [34].

Our data show that tracheal intubation was the most common airway technique among patients receiving GLP-1 RAs who required general anaesthesia (> 80%), a proportion higher than reported in other studies of people with obesity (50–60%) [35]. Thus, despite retrospective data previously suggesting no increased risk of pulmonary aspiration [19], clinicians still appear to favour tracheal intubation in this cohort of patients. It is unclear how multiple risk factors for pulmonary aspiration (obesity, diabetes, GLP-1 RAs) influence decision-making [36].

In addition to tracheal intubation, we observed other pulmonary aspiration mitigation techniques. Use of head-up positioning was employed commonly. The use of a

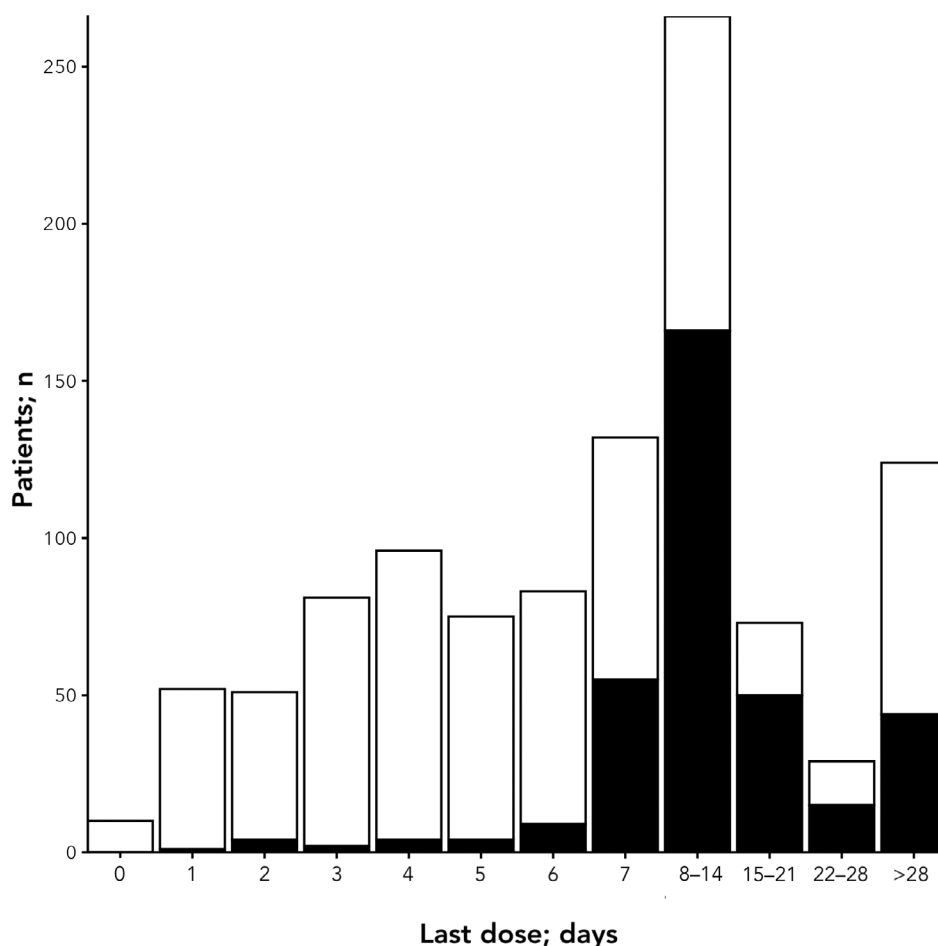


Figure 2 Time between last dose of a weekly preparation of a GLP-1 RAs and surgery, grouped into whether the patient was requested by clinical staff to hold the medication pre-operatively (black bars) or not (white bars). Data were unavailable for 9 patients where the medication was intentionally held pre-operatively; 103 patients where it was not; and 16 patients where it was unknown whether or not the medication was intentionally held pre-operatively.

gastric tube was uncommon, but when they were inserted, it was typically following induction of anaesthesia and presumably reflects an attempt to reduce the risk of pulmonary aspiration on emergence of anaesthesia without subjecting an awake patient to a gastric tube. Despite the potential advantages of point-of-care gastric ultrasound in risk assessing patients [18], it was infrequently utilised, which may represent a skills gap for anaesthetists and a potential area for improvement [37]. Rapid sequence induction and intubation (RSI) was reported in a quarter of patients receiving GLP-1 RA and showed varied practice. For example, total intravenous anaesthesia (TIVA) was commonly used for RSIs despite the safety of this technique being debated [38–40]. Our data did not have sufficient granularity to determine if a reported ‘TIVA RSI’ involved a manual bolus for induction before commencing a TIVA anaesthetic or relied on TIVA pumps to induce anaesthesia.

Cricoid force was applied in 65% of patients receiving RSI, underscoring the uncertainty and variability in clinician perception and evidence base [41]. Overall, our data suggest that clinicians regarded patients receiving GLP-1 RAs as having a higher risk of pulmonary aspiration, but the interventions used to reduce this risk were variable.

Historical studies suggest the baseline risk of pulmonary aspiration in the general population to be 1 in 3200 [42], while the rate of fatal aspiration was 1 in 350,000 in the 4th National Audit Project of the Royal College of Anaesthetists (NAP4) [43]. More recent observational data suggest a higher pulmonary aspiration rate of approximately 1 in 1500 [26]. The 7th National Audit Project (NAP7) activity survey analysis of serious complications during non-obstetric anaesthesia, combined pulmonary aspiration and regurgitation events and reported a rate of approximately 1 in 660 [35]. Our data reporting aspiration

Table 3 Anaesthetic management of patients receiving GLP-1 RAs. Values are number (proportion).

GLP-1 RA patients		n = 1348
Anaesthesia		
General		1065 (79.0%)
Regional		68 (5.0%)
General with regional		65 (4.8%)
Sedation		59 (4.4%)
Regional with sedation		86 (6.4%)
Missing		5 (0.4%)
Time since last solids; h		
< 6		12 (0.9%)
6–12		566 (42.0%)
12–18		573 (42.5%)
18–24		130 (9.6%)
> 24		53 (3.9%)
Missing		14 (1.0%)
Time since last clear fluid; h		
< 2		394 (29.2%)
2–6		567 (42.1%)
6–12		270 (20.0%)
12–24		99 (7.3%)
> 24		7 (0.5%)
Missing		11 (0.8%)
Use of gastric ultrasound		
Yes		17 (1.3%)
No		1319 (97.8%)
Missing		12 (0.9%)
Sedation only		n = 145
Deepest level of sedation*		
Minimal		69 (47.6%)
Moderate		54 (37.2%)
Deep		20 (13.8%)
Missing		2 (1.4%)

*Minimal, normal response to verbal stimulation; moderate, purposeful response to verbal or tactile stimulation; deep, purposeful response to repeated or painful stimulation, airway intervention may be required.

and/or regurgitation events in patients not receiving GLP-1 RAs show a rate of 1 in 802 (57 of 45,691), which is consistent with NAP7 data. Conversely, patients receiving GLP-1 RAs had an event rate of approximately 1 in 71 (19 of 1348). These differences appear to be clinically relevant and contrast with other published data [19].

This event rate is present despite clinicians tending to select airway management options that may mitigate the risks of pulmonary aspiration and regurgitation. However,

Table 4 Anaesthetic management of patients receiving GLP-1 RAs undergoing general anaesthesia. Values are number (proportion).

GLP-1 RA patients undergoing general anaesthesia		n = 1130
Use of prokinetics		
Use of prokinetics		34 (3.0%)
Use of antacids		
Use of antacids		136 (12.0%)
Head-up positioning		
Head-up positioning		893 (79.0%)
Pre-oxygenation		
Pre-oxygenation		1090 (96.5%)
Anaesthesia induction technique		
Intravenous		800 (70.8%)
RSI (non-TIVA)		174 (15.4%)
RSI (TIVA)		127 (11.2%)
Inhalational		20 (1.8%)
Awake tracheal intubation		9 (0.8%)
Apnoeic oxygenation		
Apnoeic oxygenation		95 (8.4%)
Post-induction mask ventilation		
Post-induction mask ventilation		472 (41.8%)
Airway device used		
Facemask (sole device)		9 (0.8%)
SAD (1st generation)		21 (1.9%)
SAD (2nd generation)		152 (13.5%)
Tracheal tube		916 (81.1%)
SAD (1st generation) and tracheal tube		2 (0.2%)
SAD (2nd generation) and tracheal tube		5 (0.4%)
Missing		25 (2.2%)
Patients with a tracheal tube		n = 923
Method of visualising glottis		
Direct laryngoscopy		316 (34.2%)
Videolaryngoscopy		485 (52.5%)
Direct and videolaryngoscopy		10 (1.1%)
Missing		112 (12.1%)
Patients having RSI		n = 301
Use of cricoid force		197 (65.4%)

RSI, rapid sequence induction and intubation; TIVA, total intravenous anaesthesia; SAD, supraglottic airway device.

although our results suggest that GLP-1 RAs are associated with an 11-fold increase in the incidence of pulmonary aspiration or regurgitation, causality cannot be determined, and this association may be due to unmeasured confounding. For example, obesity and diabetes are known risk factors for pulmonary aspiration and are over-represented in people receiving GLP-1 RAs in our cohort. Furthermore, our data may underestimate the incidence of pulmonary aspiration and regurgitation in patients who were not receiving GLP-1 RAs. Interestingly, the increased risk of peri-operative aspiration or

Table 5 Peri-operative pulmonary aspiration/regurgitation events, grouped by presence/absence of pre-operative GLP-1 RAs. Postoperative pulmonary complications were identified at 48-h follow-up according to the StEP criteria [30], and therefore the rates of confirmed pulmonary aspiration as per StEP criteria are lower than those observed clinically. Values are number (proportion).

	All pulmonary aspiration and/or regurgitation n = 76	Without GLP-1 RA n = 57	With GLP-1 RA n = 19
Regurgitation of gastric contents			
Yes	71 (93.4%)	52 (91.2%)	19 (100.0%)
No	5 (6.6%)	5 (8.8%)	0
Pulmonary aspiration			
Yes	18 (23.7%)	16 (28.1%)	2 (10.5%)
No	58 (76.3%)	41 (71.9%)	17 (89.5%)
Timing of aspiration and/or regurgitation			
Induction	19 (25.0%)	16 (28.1%)	3 (15.8%)
Maintenance	28 (36.8%)	23 (40.4%)	5 (26.3%)
Emergence	27 (35.5%)	17 (29.8%)	10 (52.6%)
Missing	2 (2.6%)	1 (1.8%)	1 (5.3%)
Identification of pulmonary aspiration			
Laryngoscopy	6 (7.9%)	5 (8.8%)	1 (5.3%)
Clinically	14 (18.4%)	13 (22.8%)	1 (5.3%)
Bronchoscopy	3 (3.9%)	3 (5.3%)	0
Radiography	3 (3.9%)	2 (3.5%)	1 (5.3%)
Missing*	59 (77.6%)	42 (73.7%)	17 (89.5%)
Trachea re-intubated immediately post-procedure			
Yes	7 (9.2%)	7 (12.3%)	0
No	69 (90.8%)	50 (87.7%)	19 (100%)
Postoperative pulmonary complications			
Pulmonary atelectasis	8 (10.5%)	6 (10.5%)	2 (10.5%)
Pneumonia	3 (3.9%)	3 (5.3%)	0
Pulmonary aspiration**	13 (17.1%)	11 (19.3%)	2 (10.5%)
None*	57 (75.0%)	41 (71.9%)	16 (84.2%)
Severity			
Mild	10 (13.2%)	8 (14.0%)	2 (10.5%)
Moderate	1 (1.3%)	1 (1.8%)	0
Severe	4 (5.3%)	4 (7.0%)	0
Missing	61 (80.3%)	44 (77.2%)	17 (89.5%)
Unplanned admission			
Level 0/1 care	10 (13.2%)	8 (14.0%)	2 (10.5%)
Level 2/3 care	5 (6.6%)	5 (8.8%)	0
None/missing	61 (80.3%)	44 (77.2%)	17 (89.5%)
Death in follow-up period			
Yes	1 (1.3%)	1 (1.8%)	0
No	74 (97.4%)	56 (98.2%)	18 (94.7%)
Missing	1 (1.3%)	0	1 (5.3%)

*Due to multiple choice questions some patients may be present in multiple groups.

**Confirmed at follow-up.

regurgitation associated with GLP-1 RAs observed in our study is similar to the increased risk seen in patients immediately following bariatric surgery [44] rather than the smaller or negligible risk increase seen in patients with obesity [45, 42].

Notably, the majority of regurgitation and/or aspiration events only involved regurgitation. There were two cases of pulmonary aspiration of 1348 patients receiving GLP-1 RAs, giving an aspiration event rate of 1 in 674. It is possible that the pulmonary aspiration mitigation strategies commonly observed in this cohort were responsible for this discrepancy by preventing pulmonary soiling despite regurgitation being present, although we did not have sufficient granularity of data to confirm or refute this. Interestingly, > 50% of pulmonary aspiration and regurgitation events in the GLP-1 RA group occurred at emergence, underscoring the need for a safe tracheal extubation plan, rather than solely focusing on securing the airway at induction of anaesthesia. There may be a role for future guidance in describing techniques to mitigate emergence complications in people receiving GLP-1 RAs.

This study has limitations. We did not collect data on patients who were not receiving GLP-1 RAs and did not have pulmonary aspiration or regurgitation due to the impracticalities of collecting these data with the available resources. As a result, we were unable to account for confounding when reporting data on pulmonary aspiration. Secondly, our study methodology partly relied on anaesthetists who were not directly involved in the study to assess patients for GLP-1 RA use pre-operatively and report this to local investigators. It is possible that patients who were on GLP-1 RAs but not identified during the pre-operative notes screening process were not included, and our results may underestimate the proportion of patients on these medications. We attempted to mitigate this by reminding clinicians to check for GLP-1 RA use with patients, as should be expected for standard care. Another consequence of relying on anaesthetists who were not involved in the study was the potential for underreporting of pulmonary aspiration and regurgitation events, particularly since there may be a reluctance to disclose this complication. That said, the reported incidence in the cohort who did not receive GLP-1 RAs was similar to recent observational studies [35]. We had variation in the number of study collaborators at each site. While we attempted to ensure data quality by excluding sites with low screening rates, it is possible that sites with an insufficient number of collaborators may have struggled to collect all the data accurately. However, due to the complexities of differing

case mix, number of remote sites, local rota differences and study leave policies, it was inappropriate to make assumptions regarding the ability of local teams to collect data. Anaesthetists were aware of the GLP-1 RA status of patients and this may have introduced an observer bias whereby there was more vigilance for gastric regurgitation in this group leading to higher reporting of regurgitation relative to the non GLP-1 RA group. Lastly, a prerequisite for patient eligibility was for an anaesthetist to provide care to facilitate surgery. We are aware of a small number of cases in which the anaesthetic plan changed in light of GLP-1 RA use, from anaesthetist-delivered care to proceeding under local anaesthesia without the involvement of an anaesthetist. As a result, we were unable to include those cases, and this may underestimate the proportion of patients receiving GLP-1 RAs presenting for surgery. However, it is likely that very few patients would have been in this scenario, and thus the impact on our results would be minimal.

In conclusion, this prospective observational study reported that 1 in 36 patients undergoing anaesthesia care receive GLP-1 RAs and their peri-operative management is variable. A range of airway management techniques consistent with reducing aspiration risk were observed, and despite this, the incidence of pulmonary aspiration and/or regurgitation was 1 in 71 in patients receiving GLP-1 RAs; this occurred most commonly during emergence from anaesthesia. These data warrant further prospective studies to determine interventions that may mitigate risks of pulmonary aspiration and improve patient outcomes.

Author affiliations

Thomas E. Potter,¹ John N. Cronin,^{1,2} Justin Kua,^{1,3} Sophie Bloomfield,¹ Mayur Murali,⁴ Frances Beatty,¹ Andrew McKechnie,⁵ Danny J. N. Wong,^{6,7} and Kariem El-Boghdady,^{1,2} on behalf of the GLIMPSE Resident Research Networks and Collaborators

1 Department of Anaesthesia and Perioperative Medicine, Guy's and St Thomas' NHS Foundation Trust, London, UK
2 Centre for Human and Applied Physiological Sciences, King's College London, London, UK
3 Department of Anesthesiology, St. Paul's Hospital, Providence Health Care, Vancouver, BC, Canada
4 Division of Anaesthetics, Pain Medicine and Intensive Care, Imperial College London, London, UK
5 Lewisham and Greenwich NHS Trust, London, UK
6 Department of Anaesthesiology, Singapore General Hospital, Singapore
7 Duke-NUS Medical School, National University of Singapore, Singapore

Acknowledgements

We wish to thank Professor Ketan Dhatariya and Professor Matthew D. Wiles for protocol review and feedback. KE or his institution have received funding from GE Health Care and Fisher and Paykel Healthcare. KE and DW are Editors of *Anaesthesia*. MM has received funding from Asthma and Lung UK and HCA International. Statistical code is available upon reasonable request, but data are not available for sharing. No other external funding competing interests declared.

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Supporting Information

Additional supporting information may be found online via the journal website.

Figure S1. GLP-1 RA use as a proportion of patients at each site.

Table S1. Surgical specialties of included patients.

Table S2. Dosing of GLP-1 RAs.

Appendix S1. GLIMPSE Resident Research Networks and collaborators.

Appendix S2. Data collected and definitions.

Appendix S3. Pulmonary aspiration analysis.