Review article

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Management of leaks following one-anastomosis gastric bypass: an updated systematic review and meta-analysis of 44 318 patients

Mohammad Kermansaravi, MD[a,b,*], Radwan Kassir, MD, PhD[e,f], Rohollah Valizadeh, PhD[c,d], Chetan Parmar, MS, DNB, FRCS[g], Amir Hossein Davarpanah Jazi, MD[d], Shahab Shahabi Shahmiri, MD, MPH[c], Marine Benois, MD[f]

Introduction: One-anastomosis gastric bypass (OAGB) complication, such as leakage, can be dangerous and should be managed properly, yet little data exist in the literature regarding the management of leaks after OAGB, and there are no guidelines to date.
Methods: The authors performed a systematic review and meta-analysis of the literature and 46 studies, examining 44 318 patients were included.
Results: There were 410 leaks reported in 44 318 patients of OAGB published in the literature, which represents a prevalence of 1% of leaks after OAGB. The surgical strategy was very variable among all the different studies; 62.1% of patients with leaks had to undergo another surgery due to the leak. The most commonly performed procedure was peritoneal washout and drainage (with or without T-tube placement) in 30.8% of patients, followed by conversion to Roux-en-Y gastric bypass in 9.6% of patients. Medical treatment with antibiotics, with or without total parenteral nutrition alone, was conducted in 13.6% of patients. Among the patients with the leak, the mortality rate related to the leak was 1.95%, and the mortality due to the leak in the population of OAGB was 0.02%.
Conclusion: The management of leaks following OAGB requires a multidisciplinary approach. OAGB is a safe operation with a low leak risk rate, and the leaks can be managed successfully if detected in a timely fashion.

Keywords: bariatric, leak, one-anastomosis gastric bypass, weight loss

Introduction

A growing number of surgeons are performing one-anastomosis gastric bypass (OAGB) around the world. OAGB is an International Federation for the Surgery of Obesity and Metabolic Disorders (IFSO) recognized bariatric surgical procedure since 2018 and has recently been endorsed by the American Society for Metabolic & Bariatric Surgery (ASMBS)[1,2]. OAGB is also the third most common bariatric operation after sleeve and Roux-en-Y gastric bypass (RYGB). This procedure has gained popularity during the last decade as it combines several advantages; a relatively short operating time duration and learning curve compared to RYGB, a high efficiency in the treatment of obesity and its associated medical problems, and a simple possibility of reversal to normal anatomy[3].

Despite these advantages, OAGB complications such as leakage can be dangerous and should be managed properly. The leak rate after OAGB has been reported in less than 1% of patients, but leak diagnosis should be done as soon as possible to prevent diffuse peritonitis and subsequent sepsis[4]. Different approaches for both diagnosis and treatment of leak after OAGB exists and

HIGHLIGHTS

- Four hundred ten leaks were reported out of 44 318 cases of one-anastomosis gastric bypass (OAGB) published in the literature, which represents a prevalence of 1% of leaks after OAGB.
- In all, 62.1% of patients with leaks had to undergo another surgery due to a leak after OAGB.
- Medical treatment alone was conducted in 13.6% of patients.
- The mortality rate related to leaks was 1.95% and the mortality due to leaks in the general population of OAGB was 0.02%.

[a]Division of Minimally Invasive and Bariatric Surgery, Department of Surgery, Minimally Invasive Surgery Research Center, Rasool-E Akram Hospital, School of Medicine, Iran University of Medical Sciences, [b]Center of Excellence of European Branch of International Federation for Surgery of Obesity, Hazrat-E Rasool Hospital, [c]Division of Minimally Invasive and Bariatric Surgery, Minimally Invasive Surgery Research Center, Iran University of Medical Sciences, Tehran, [d]Urmia University of Medical Sciences, Urmia, Iran, [e]Diabete Athérothrombose Thérapies Réunion Océan Indien, INSERM, UMR 1188, Université de La Réunion, [f]Department of Digestive Surgery Unit, University Hospital of la Réunion – Félix Guyon Hospital, Saint-Denis, La Réunion, France and [g]Department of Surgery, Whittington Hospital, London, UK

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*Corresponding author. Address: Department of Surgery, Division of Minimally Invasive and Bariatric Surgery, Minimally Invasive Surgery Research Center, Rasool-E Akram Hospital, School of Medicine, Iran University of Medical Sciences, PO Box: 1445613113, Tehran, Iran. Tel: +982166507055; fax: +982166501113. E-mail: mkermansaravi@yahoo.com (M. Kermansaravi).

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should be selected depending on the patient's hemodynamic condition, surgeon's experience, and many other factors.

Only little data exist in the literature regarding the management of leaks after OAGB, and to date, there are no published guidelines. The aim of this systematic review and meta-analysis is to give an update on the different strategies available and to guide surgeons for optimal management of leaks following OAGB.

Materials and methods

This work has been reported in line with the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) criteria[5]. We also assessed the level of compliance with AMSTAR (A MeaSurement Tool to Assess systematic Reviews) 2 in this work[6]. This systematic review and meta-analysis were registered in the Prospective Register of Systematic Reviews (PROSPERO) (# CRD42021247913) and researchregistry.com (#researchregistry8285).

Search

A systematic review of the literature was made by searching through PubMed, Embase, and Scopus databases by 1 January 2022. We identified all articles describing the occurrence of leaks after OAGB using keywords: 'one anastomosis gastric bypass' or 'one-anastomosis gastric bypass' or 'OAGB' or 'Single anastomosis' or 'Omega loop' or 'mini gastric-bypass' or 'mini gastric bypass' or 'MGB' AND 'leak' or 'peritonitis' or 'perforation' or 'abscess' or 'collection' or 'fistula' or 'complication' or 'reoperation' or 'sepsis' or 'septic' or 'conversion' or 'revision'. The references of the articles were manually reviewed for additional relevant papers. Duplicate studies were removed. We did not take into account if OAGB was a primary or a revisional surgery for the analysis, as this specificity was not always well described in articles.

Statistical analysis

The main measure of the effect/effect size was prevalence (ratio of cases to the total population). Cochrane's test (Q test) (showing significant heterogeneity in the meta-analysis) and I^2 (showing the amount of heterogeneity, ranging from 0 to 100%.) were used to assess the heterogeneity among the studies. The random-effects model was used for the continuous and frequency outcome under study. Random-effects meta-analysis was performed to estimate the main index, which was the pooled prevalence, at the 95% CI. A forest plot was used to present the pooled prevalence. Publication bias was assessed using Begg's test. The analysis was performed using Stats version 13. Averages of quantitative variables were only reported according to the articles. In the meta-analysis process, we weighted each study by N (sample size). For descriptive purposes, tables and figures were used.

Data extraction

Data on the included articles, including author, year, type of study, patients' numbers (F/M), age, follow-up, mortality, leak management, limb size, BMI, and complications such as leakage, perforation, and peritonitis were retrieved by two independent investigators. The differences observed in this process were corrected by a third investigator independent from the other two. The Newcastle–Ottawa Scale was used for the qualitative assessment of studies[7].

Results

A total of 46 studies examining 44 318 patients were included in this meta-analysis (Fig. 1).

A total of 415 articles were found in PubMed, 1238 in Embase, and 28 in Scopus. Some articles were found twice in separate databases. Among these articles, after the first screening, we only retained 58 articles. Non-English articles were then excluded, as well as articles that were not relevant to our search. PRISMA guidelines were followed for systematic review.

Study characteristics of the patients included in the meta-analysis are presented in Table 1.

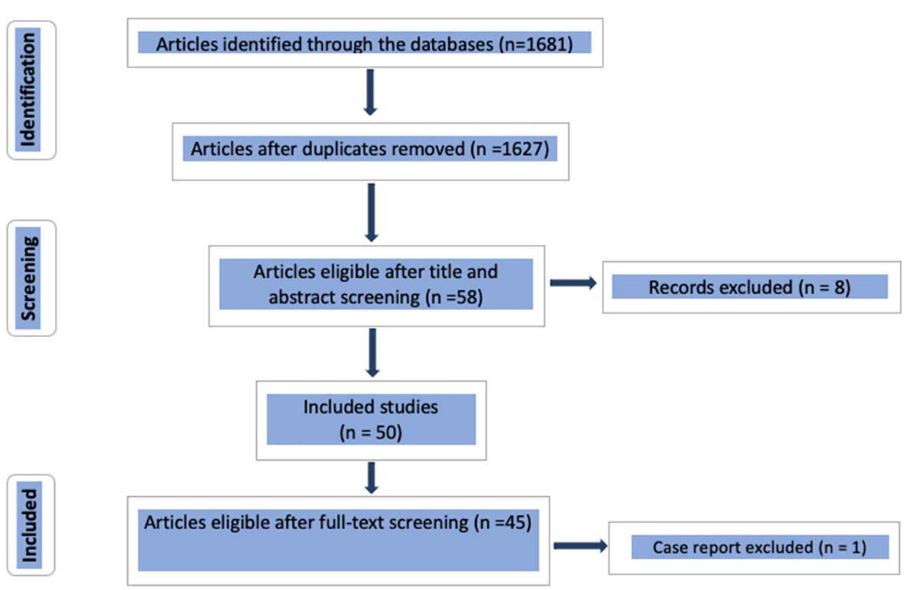

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

Table 1

Main characteristics of the included studies in the systematic review.

First author, year, reference	Study type	Mean follow-up, (range)	*N*	Female% (*M*)	Mean age (years) (range)	Mean BMI, kg/m^2 (range)	Primary or revision	Length BP limb[8]	Duration (min)
Scavone *et al.*, 2020[9]	Retro	60 months	953	71.7% (684)	41.8	49.4	Both	180–240	100 ± 16 (primary) 118 ± 22 (revision)
Bashah *et al.*, 2020[10]	Retro	3.8 ± 1.4 years	49	85.7% (42)	37.83 ± 9.36	43.6 ± 7.4	Revision	150–200	N/A
Lessing *et al.*, 2020[11]	Retro	2 years	57	63.1% (36)	47.7 ± 10.8	42.8 ± 7.0	Revision	N/A	N/A
Neuberg *et al.*, 2020[12]	Retro	92 months (76–111)	163	N/A	41 ± 11.4	41.2 ± 6.5	Both	150	N/A
Liagre *et al.*, 2019[13]	Retro	90 days	2780	85% (39)	45 (26–64)	41.5 (31–55)	Both	N/A	N/A
Sohrabi Maralani *et al.*, 2021[14]	Retro	5 years	N/A	N/A	39.73 ± 11.50	44.79 ± 6.07	N/A	N/A	N/A
Debs *et al.*, 2020[15]	Retro	55 months (8–144)	77	81.8% (63)	45.3 ± 14.8	40.1 (29–57)	Revision only	150	42.0 ± 8.0
Younis *et al.*, 2020[16]	Retro	6 months	9	44.4% (4)	41 ± 11 (23–57)	44 ± 8	Both	N/A	N/A
Musella *et al.*, 2017[17]	Retro	5 years	2678	70.4% (1885)	42.2 ± 3.8	45.39 ± 3.63	Both	165–260	86.6 ± 36.5 (primary) 109.3 ± 24.8 (revision)
Lessing *et al.*, 2017[18]	Retro	12 months	407	62.4% (254)	4 1.8 ± 1 2.05	41.7 ± 5.77	Both	200	N/A
Nevo *et al.*, 2021[19]	Retro	21 months	21	76% (16)	43.2 ± 12.1	39.7 ± 5.9	Revision only	200	N/A
Musella *et al.*, 2019[20]	Retro	20.8 months (6–156)	196	N/A	46.1 ± 10.5	45.1 ± 7	Revision only	226	N/A
Noun *et al.*, 2018[21]	Prosp	12 months	21	52.3% (11)	39 ± 12 (18–65)	42.9 ± 6.5	Revision only	N/A	N/A
Nagliati *et al.*, 2019[22]	Prosp	2 years	8	N/A	N/A	N/A	Both	N/A	N/A
Poublon *et al.*, 2020[23]	Retro	3 years	185	75.5% (139)	46 ± 9.0	40.9 (36–45)	Revision only	150–250	72 (56–95)
Meydan *et al.*, 2017[24]	Retro	6 months	154	72.1% (111)	47.06	41.76	Both	150–200	N/A
Bolckmans *et al.*, 2019[25]	Prosp	9 years	526	89.3% (25)	N/A	N/A	Primary only	200	N/A
Alkhalifah *et al.*, 2018[26]	Retro	10 years	1731	70% (1212)	33.8 ± 10.4	40.4 ± 7.7	Primary only	150–250	124.6 ± 38.8
Chansaenroj *et al.*, 2017[27]	Retro	N/A	26	61.5% (16)	35.9 ± 8.8	39.3 ± 8.9	Revision only	N/A	180.2 ± 58.7
Apers *et al.*, 2018[28]	Prosp	3 years	287	85.4% (245)	44 (19–69)	42 (32–76)	Primary only	150–250	50 (25-120)
Almalki *et al.*, 2018[29]	Retro	5 years	81	74% (60)	38.7 ± 9.8	37.8 ± 9.6	Revision only	N/A	167.7 ± 55.8
Genser *et al.*, 2016[30]	Retro	8 years and 9 months	2321	N/A	41 (26–63)	N/A	Both	N/A	N/A
de la Cruz *et al.*, 2020[31]	Retro	3 years	42	N/A	N/A	43.4 ± 9.2	Revision only	200	N/A
Parmar *et al.*, 2018[32]	Retro	6 months to 12 years	12 807	N/A	41.2	46.6	N/A	N/A	123 ± 39
Soong *et al.*, 2019[33]	Retro	12 months	940	62.3% (586)	40.6	40	Primary only	400	142
Navarrete *et al.*, 2018[34]	Prosp	12 months	100	64% (64)	40.5 ± 12.4	44.8 ± 12.1	Primary only	N/A	69 ± 4.62
Lo *et al.*, 2020[35]	Retro	12 months	73	61% (39)	40.8	42.5	Primary only	N/A	117
Parmar *et al.*, 2020[36]	Retro	32.7 months (6–84)	376	67.7% (254)	44.3	29.2	N/A	120	89.5 (49–150)
Khalaj *et al.*, 2020[37]	Retro	12 months	548	85% (457)	39.5	46	Primary only	160–200	71.8
Salama *et al.*, 2016[38]	Prosp	12 months	39	N/A	38.7	39.7	Revision only	180	145 ± 29 (125–235)
Taha *et al.* 2017[39]	Retro	6–36 months	1520	62.7% (953)	37.2 ± 11.4	46.8 ± 6.6	Both	150–300	57
AlSabah *et al.*, 2018[40]	Retro	12 months	31	89.7% (28)	41.4 ± 10.2	42.6 ± 5.8	Revision only	175–200	118.2 ± 53.1
Pujol Rafols *et al.*, 2018[41]	Retro	12–60 months	191	89.5% (171)	40.6 ± 11.2	39.8 ± 6.9	Revision only	150–250	N/A
Beaupel *et al.*, 2017[4]	Retro	24.5 (4–108)	17	76.5% (13)	48 (23–62)	51 (38–70)	Both	150–200	N/A
Carbajo *et al.*, 2005[42]	Retro	2 years	209	82% (172)	41 (14–66)	48 (39–86)	Both	200	93 (70–150)
Noun *et al.*, 2012[43]	Retro	60 months	1000	66.1% (661)	33.15	42.5	Both	150	89 (primary) 144 (revision)
Piazza *et al.*, 2015[44]	Retro	5 years	48	82%	38	43.4	Revision only	180–240	N/A
Chevallier *et al.*, 2015[45]	Retro	7 years	1000	71.2% (712)	41.8	45.7	Both	200	N/A
Ghosh *et al.*, 2017[46]	Retro	12 months	74	91% (67)	48.3	46	Revision only	150	72.7
Abdallah *et al.*, 2022[47]	Retro	12 months	80	77.5% (62)	41	50.9	Primary only	200 (170–300)	N/A
Plamper *et al.*, 2017[48]	Retro	N/A	169	71.6% (121)	N/A	54.1%	Primary only	N/A	N/A
Parmar *et al.*, 2016[49]	Retro	2 years	125	68.8% (86)	45	48.1	Primary only	N/A	92.4
Bruzzi *et al.*, 2015[50]	Retro	5 years	126	79% (99)	50 ± 10	47	Revision only	N/A	110

Table 1

(Continued)

First author, year, reference	Study type	Mean follow-up, (range)	N	Female% (N)	Mean age (years) (range)	Mean BMI, kg/m^2 (range)	Primary or revision	Length BP limb[8]	Duration (min)
Disse *et al.*, 2014[51]	Retro	21.4 months	20	N/A	49.5	40.1	Primary only	N/A	105
Johnson *et al.*, 2007[8]	Retro	N/A	32	N/A	N/A	N/A	Primary only	N/A	N/A
Beargeat *et al.*, 2017[52]	Retro	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Piazza *et al.*, 2011[53]	Retro	2	197	75% (148)	37.9	52.9	N/A	N/A	120
Noun *et al.*, 2007[54]	Retro	N/A	126	N/A	N/A	N/A	N/A	N/A	N/A
Kular *et al.*, 2014[55]	Retro	6 years	1054	67.5% (712)	38.4	43.2	N/A	200	52
Musella *et al.*, 2014[56]	Retro	12–60 months	974	51.2% (499)	39.4	48 ± 4.58	Both	224.6 ± 23.2	95 ± 51.6
Wang *et al.*, 2005[57]	Retro	Up to 36 months	423	79% (336)	30.8	44.2	Both	200	95 ± 41.5
Docimo *et al.*, 2022[58]	Retro	1 month	279	81.7% (228)	46.1 (11.04)	44.5 ± 7.7	Primary	N/A	N/A
Rayman *et al.*, 2021[59]	Retro review	25.5 months (8–60)	144	74.3% (107)	42.4 ± 10.5	40.6 ± 5.9	Revision only	N/A	N/A
Rutledge and Walsh, 2005[60]	Prosp	38.7 months (1.0–74.4)	2410	85% (2049)	39 (14–78)	46 ± 7 (34–74)	Both	N/A	37.5
Almuhanna *et al.*, 2021[61]	Retro	N/A	2223	70.2% (1560)	35.3 ± 11.4 (14–71)	40.2 ± 11.9	N/A	N/A	N/A
Goel *et al.*, 2021[62]	Retro	3 years	3187	53.8% (1712)	43.3 ± 12.2	44.5 ± 7.9	Both	N/A	N/A
Garcia-Caballero *et al.*, 2005[63]	Case report	N/A	1	1	36	43	Primary only	N/A	N/A

BP limb, biliopancreatic limb, Retro, retrospective study ; Prosp, prospective study.

Study characteristics regarding the management of leaks are presented in Table 2.

Descriptive characteristics

Table 3 shows a mean procedure time of 98.45 ± 35.93 min, a mean age of 41.34 ± 4.21 years, a mean BMI of 43.7 ± 4.2 kg/m^2, and a median hospital stay of 3.63 days.

Regarding the time of leak after OAGB, we found a rate of ‘acute’ leaks (within 7 days) of 33.3% ($N = 6$) and ‘early’ leaks (1–6 weeks) of 66.7% ($N = 12$), while there are no reports about ‘late’ leaks (6–12 weeks) ($N = 0$).

Leak prevalence

There were 410 leaks reported in a total of 44 318 cases of OAGB published in the literature. Hence, the pooled estimation of a meta-analysis of prevalence studies reported a prevalence of 1% (or 0.01 with 73.75% I^2), that is one out of every 100 surgeries of OAGB experience leakage (Fig. 2).

Two studies, including Johnson *et al.*[8] and Younis *et al.*[16], were deleted from leak prevalence analysis because they reported leak as a reason for revision surgery and endoscopic management among their revision and endoscopic procedures, not amongst all revisional OAGB patients.

We did not find a ‘cutoff’ year regarding the leak rate; the leak rate was stable, for instance, there were no more leaks before or after a precise year, and the leak rate did not drop after a precise year. This was to understand whether the leak rate was more in the earlier years when probably more surgeons were in their learning curve of this operation.

Leak prevalence across primary and revision studies

The pooled estimation of a meta-analysis of prevalence studies reported a prevalence of 1% (or 0.01 with 2.98% I^2) for revision studies and 1% (or 0.01 with 0% I^2) for primary studies, that is one out of every 100 surgeries of OAGB experience leakage in the two types of studies. The following figure shows a non-significant difference between the two types of studies (primary vs. revision/secondary studies) ($P = 0.57$), but visually and clinically, the prevalence of leak is higher in the revision studies, and we can see the range of 1–8% prevalence in the revision studies while in the primary studies, there is only 1% prevalence of leak (Fig. 3).

Leak diagnosis

Computed tomography scan (CT scan) with or without oral contrast was the most commonly used technique to diagnose leaks, as it was used in 47% of studies. Diagnostic laparoscopy (intraoperative finding) was done in 32% of cases. The use of upper gastrointestinal oral contrast series was reported in 21% of studies, ‘endoscopy’ and ‘clinical presentation’ were reported in 15% of studies (Fig. 4).

Leak management

Several treatment options were reported: medical treatment only, percutaneous drainage, endoscopic treatment using stent or pigtails, or glue and surgical treatment. Very few articles justified the choice-making process and the decisions of one option or the other.

Table 2

Leak-related data of the included studies in the meta-analysis.

First author, year, reference	Leak rate	Diagnosis	Time after OAGB	Leak management	Reoperation (due to leak)	Death after leak
Scavone *et al.*, 2020[9]	5 of 953 (0.5%)	CT scan Oral contrast series	First week	N/A	N/A	0%
Bashah *et al.*, 2020[10]	1 of 49 (2%)	N/A	'shortly'	Surgery: conversion to RYGB	1 (100%)	0%
Lessing *et al.*, 2020[11]	2 of 57 (3.51%)	N/A	N/A	N/A	N/A	0%
Neuberg *et al.*, 2020[12]	1 of 163 (0.61%)	N/A	'early'	N/A	N/A	0%
Liagre *et al.*, 2019[13]	46 of 2780 (1.7%)	Oral CT scan Endoscopic findings Intraoperative	10 days (1–42)	Medical (*N*=9): fasting, total parenteral nutrition, and antimicrobial therapy Interventional/endoscopy (*N*=23): percutaneous drainage and/or endoscopy Surgery: laparoscopy: washout and drainage (+T-tube placement in 5 cases) (*N*=13); conversion to RYGB (*N*=1)	14 (30%)	0%
Sohrabi Maralani *et al.*, 2021[14]	1 of 805 (0.1%)	N/A	N/A	N/A	1 (100%)	100% (1)
Debs *et al.*, 2020[15]	1 of 77 (1.3%)	N/A	N/A	Surgery (*N*=1): Kehr tube and drainage	1 (100%)	0%
Younis *et al.*, 2020[16]	N/A	CT scan	Less than 4 weeks	Interventional/endoscopy: all had fully covered stents (*N*=9) Surgery: laparotomy RYGB conversion (*N*=2) Laparotomy after 2 weeks of treatment due to stent migration and ileum perforation	2 (22%)	11% (1)
Musella *et al.*, 2017[17]	13 of 2251 (0.6%)	N/A	N/A	Surgery *depending on the leak site* Anastomotic leak (*N*=5): -laparoscopic revision/Braun anastomosis (*N*=2) -laparoscopic repair (*N*=1) -laparoscopic reversal surgery (*N*=1) -conservative treatment/laparotomy (*N*=1) Gastric pouch leak (*N*=7): -laparoscopic repair (*N*=5) -conservative treatment (*N*=1) -revision/laparotomy (*N*=1) Gastric remnant leak: -laparoscopic repair (*N*=1)	11 of 13 (84.6%)	1 (7.7%)
Lessing *et al.*, 2017[18]	7 of 407 (1.7%)	N/A	6.5 days (2–14)	Medical: fasting, total parenteral nutrition, and antimicrobial therapy (*N*=3) Surgery: laparoscopic drainage (*N*=3), laparoscopic drainage after failed percutaneous drainage (*N*=1)	3 of 407 (0.73%)	0%
Nevo *et al.*, 2021[19]	1 of 21 (4.7%)	N/A	N/A	Interventional (*N*=1): percutaneous drainage	0%	0%
Musella *et al.*, 2019[20]	1 of 196 (0.5%)	N/A	N/A	N/A	N/A	N/A
Nagliati *et al.*, 2019[22]	1 of 8 (12.5%)	Intraoperative	1 day	Surgery (*N*=1): no details	1 (12.5%)	N/A
Poublon *et al.*, 2020[23]	1 of 185 (0.5%)	N/A	N/A	N/A	N/A	0%
Meydan *et al.*, 2017[24]	1 of 154 (0.65%)	Clinical presentation: septic shock	4 days	Surgery (*N*=1): laparoscopic conversion to RYGB	1 (100%)	N/A
Bolckmans *et al.*, 2019[25]	5 of 526 (0.95%)	N/A	N/A	Surgery (*N*=5): laparoscopic conversion to RYGB	5 (100%)	N/A
Alkhalifah *et al.*, 2018[26]	20 of 1731 (1.15%)	N/A	N/A	N/A	N/A	N/A
Chansaenroj *et al.*, 2017[27]	2 of 26 (7.7%)	N/A	N/A	Surgery (*N*=2): laparoscopic exploration, repair and drainage	2 (100%)	0%
Apers *et al.*, 2018[28]	4 of 287 (1.4%)	N/A	N/A	Medical (*N*=2): feeding tube Surgery (*N*=2): laparoscopy (no details)	2 (50%)	N/A
Almalki *et al.*, 2018[29]	5 of 81 (6.2%)	N/A	N/A	N/A	N/A	N/A
Genser *et al.*, 2016[30]	35 of 2321 (1.5%)	Systematic oral contrast series (*N*=4) Oral CT scan (*N*=4) Intraoperative (*N*=27)	9 days (97%) (0–28)	Surgery (*N*=35): all had washout and drainage: -laparoscopy (*N*=33) -laparotomy (*N*=2) Interventional/endoscopy (*N*=2): in addition to surgery in patients with large staple lines breakdown needing endoscopic stenting	35 (100%)	0%
de la Cruz *et al.*, 2020[31]	1 of 42 (2.4%)	N/A	N/A	Surgery (*N*=1): laparoscopy (no details)	1 (100%)	N/A
Parmar and Mahawar, 2018[32]	123 of 12 807 (0.96%)	N/A	N/A	N/A	N/A	N/A
Soong *et al.*, 2019[33]	5 of 940 (0.5%)	N/A	N/A	N/A	N/A	N/A

Table 2

(*Continued*)

First author, year, reference	Leak rate	Diagnosis	Time after OAGB	Leak management	Reoperation (due to leak)	Death after leak
Parmar *et al.*, 2020[36]	1 of 376 (0.3%)	< 30 days	N/A	Surgery: conversion to RYGB	1 (100%)	N/A
Khalaj *et al.*, 2020[37]	3 of 548 (0.5%)	Oral CT scan	< 30 days	Interventional (*N*= 2): drainage and intravenous antibiotics Surgery (*N*= 1): urgent peritoneal lavage and antimicrobial therapy	1 (33%)	1 (0.18%)
Salama and Sabry, 2016[38]	1 of 39 (2.6%)	N/A	2 days	Surgery (*N*= 1): direct suture of the injured bowel	1 (100%)	0
Taha *et al.*, 2017[39]	2 of 1520 (0.1%)	N/A	2 days	Surgery (*N*= 2): -conversion to RYGB (*N*= 1) -repair of the defect (*N*= 1)	2 (100%)	0
AlSabah *et al.*, 2018[40]	2 of 31 (6.45%)	CT scan	N/A	Interventional/endoscopy (*N*= 2): -stent (*N*= 1) -percutaneous drainage (*N*= 1)	0%	0%
Pujol Rafols *et al.*, 2018[41]	5 of 191 (2.6%)	N/A	N/A	N/A	N/A	0%
Beaupel *et al.*, 2017[4]	10 of 1430: study conducted among 17 patients with leakage after OAGB – but 10 had undergone an initial OAGB in the center, which leads to a leak rate of 0.7% (10/1430)	Oral CT scan (88%) Intraoperative	4 days (1–28)	Surgery (*N*= 14): -conversion to RYGB (*N*= 4): leak of the GT or the GJA: conversion was performed lavage, drainage, and treatment of the perforation (T-tube intubation *N*= 2, suture *N*= 1, anastomosis resection and refection *N*= 1)	14 (100%)	0%
Carbajo *et al.*, 2005[42]	4 of 209 (1.9%)	Oral contrast series	1 day	Medical: conservative management (no details)	0%	0%
Noun *et al.*, 2012[43]	5 of 1000 (0.5%)	Oral contrast series	1 week (2 leaks) 2 weeks (3 leaks)	Medical/interventional: -cutaneous fistula that healed with conservative management more than 2 weeks after surgery (*N*= 3) -percutaneous drainage (*N*= 3) Surgery: suturing of the GT and drainage (*N*= 1) -conversion to RYGB after failed percutaneous drainage (*N*= 1)	2 (40%)	0%
Chevallier *et al.*, 2015[45]	6 of 1000 (0.6%)	N/A	'early'	Surgery (*N*= 6) (no details)	6 (100%)	0%
Ghosh *et al.*, 2017[46]	1 of 74 (1.35%)	N/A	'early'	Interventional (*N*= 1): percutaneous drainage	0%	0%
Plamper *et al.*, 2017[48]	1 of 169 (0.6%)	N/A	'early'	N/A	N/A	0%
Bruzzi *et al.*, 2015[50]	1 of 126 (0.79%)	Intraoperative	N/A	Surgery (laparotomy), no details	1 (100%)	0%
Johnson *et al.*, 2007[8]	N/A	N/A	N/A	Surgery (*N*= 3): -conversion to RYGB (*N*= 2)	3 (100%)	0%
Kular *et al.*, 2014[55]	2 of 1054 (0.2%)	N/A	2	Surgery (laparotomy), repair (no details)	2 (100%)	0%
Musella *et al.*, 2014[56]	10 of 974 (1%)	N/A	1–12 days	Surgery (*N*= 6) (no detail)	6 (60%)	1 (0.001%)
Wang *et al.*, 2005[57]	9 of 423 (2.1%)	N/A	N/A	Medical (*N*= 6): total parenteral nutrition for minor leakage (*N*= 6) Surgery (*N*= 3): reoperation for drainage	3 (33%)	1 (0.23%)
Docimo *et al.*, 2022[58]	3 of 279 (1.1%)	N/A	N/A	Surgery (*N*= 1) (no details)	1 (33%)	N/A
Rayman *et al.*, 2021[59]	2 of 144 (1.4%)	N/A	N/A	N/A	N/A	N/A
Rutledge and Walsh, 2005[60]	26 of 2410 (1.1%)	Intraoperative	N/A	Surgery: (no details) Laparoscopic re-exploration and repair	N/A	No
Almuhanna *et al.*, 2021[61]	19 of 2223 (0.85%)	N/A	N/A	N/A	N/A	2 (0.09%)
Goel *et al.*, 2021[62]	7 of 3187 (0.2%)	CT scan Oral contrast series Ultrasounds	N/A	Medical/interventional: pigtail, drainage Surgery: laparoscopy (no details)	N/A	No
Garcia-Caballero et al., 2005[63]	1 case report	Oral contrast series	N/A	Medical/interventional: total parenteral nutrition, endoscopic fibrin glue	N/A	No

CT scan, computed tomography scan; oral CT scan, orally ingested computed tomography scan; GJ anastomosis, gastrojejunal anastomosis; GT, gastric tube; reoperation, number of patients with a leak who needed a reoperation and percentage; OAGB, one-anastomosis gastric bypass; RYGB, Roux-en-Y gastric bypass.

Table 3

Mean and SD of main quantitative variables.

Variable	Minimum	Maximum	Mean	SD
Procedure time, min	38	180	98.45	35.93
Mean age, year	31	50	41.34	4.21
BMI, kg/m^2	29	54	43.67	4.19
Hospital stay, day, median (interquartile range)		3.63 (2–5.53)		

Among the 410 leaks reported, clear numbers and statistics regarding precisely how leaks were treated were available in only 198 patients.

Surgical management

The surgical strategy was very variable among all the different studies.

Among these 198 patients, 123 (62.1%) of them had to undergo another surgery because of a leak. The most commonly used procedure was a peritoneal washout and drainage (with or without T-tube placement) in 61 (30.8%) patients, followed by conversion to RYGB in 19 (9.6%) patients. Other surgical options include repair of the anastomosis and drainage in 14 (7.1%) patients and surgical reversal of the OAGB in 1 patient. No details were given regarding the kind of surgery performed in 32 (16.2%) patients.

Conservative management

Medical treatment with antibiotics with or without total parenteral nutrition alone was conducted in 27 (13.6%) patients. In addition to medical treatment, percutaneous drainage was reported in 9 (4.6%) patients. Endoscopic treatment without surgery was the chosen option in 33 (16.7%) patients.

Mortality

In this meta-analysis, out of 410 with a leak, 8 patients died: the mortality rate related to the leak was 1.95%. Hence, the mortality due to leaks was 8 out of 44 318 patients (0.02%).

Discussion

This study gives an updated insight into the state of the literature, with an average rate of leaks of 1%, and there is no statistically significant difference in leak rates between primary and revisional OAGB in the presence of an experienced surgical team. The occurrence of a leak often leads to another surgical procedure, as roughly 60% of patients actually require a surgical exploration.

In this review, leak diagnosis was most often made after an oral contrast CT scan. It is important to keep in mind that a leak

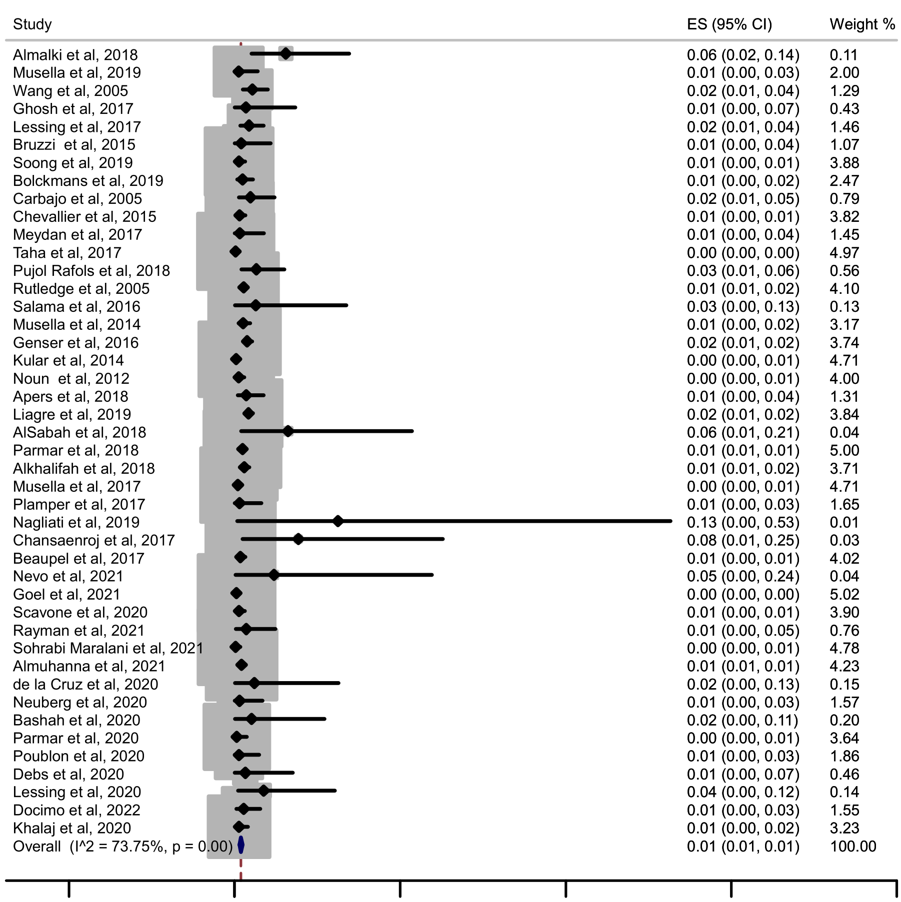

Figure 2. Forest plot showing the prevalence of leaks among the different studies included in the meta-analysis. ES, effect size.

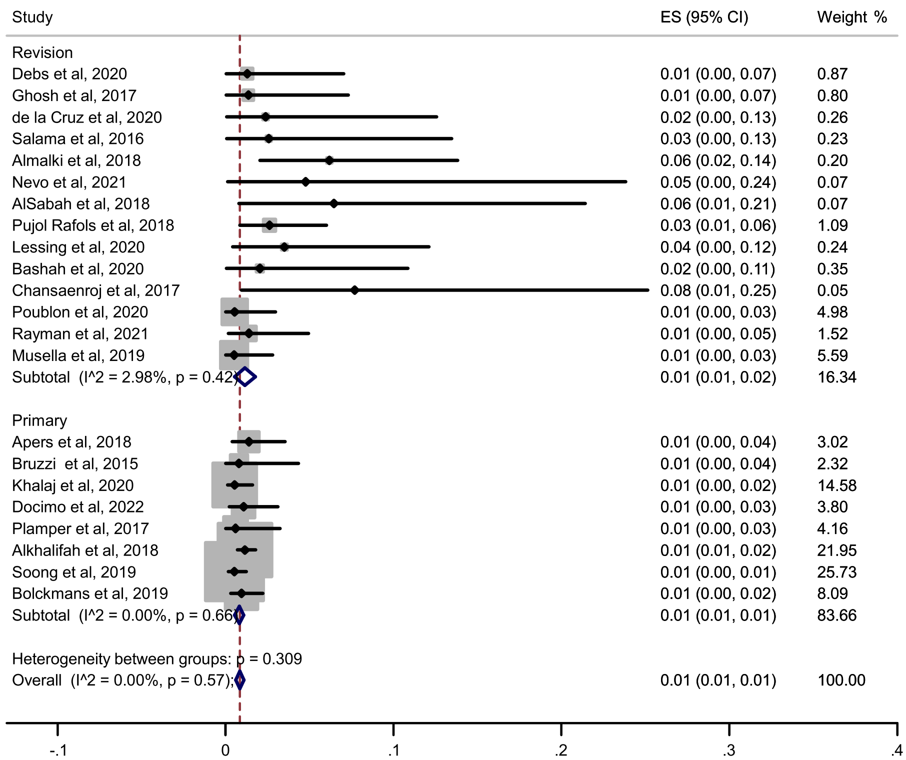

Figure 3. Forest plot showing the prevalence of leak across only primary and revision studies. ES, effect size.

following an OAGB is an emergency, and therefore patients' clinical presentation should always be taken into account before any radiological or complementary diagnostic exam. When a leak is suspected, no further investigations preceding a surgical exploration should be performed if the patient is unstable and/or shows signs of severe sepsis. A tachycardia over 120 beats per minute (bpm) in the first postoperative days is a strong element to schedule a surgical exploration without any delay or further examination[64] to decrease mortality and subsequent morbidities. Caiazzo *et al.*[65] showed that in most cases, mortality after bariatric surgery is the consequence of delays in the management of leaks, resulting in the constitution of diffuse peritonitis. This 'surgical' attitude was also the one adopted by Genser *et al.*[30], who recommend an 'aggressive' management of leaks, systematically involving a surgical exploration when a leak is suspected in order to obtain a rapid recovery and a decreased risk of mortality, at the cost of increased morbidity. In all cases, surgery must always be adapted to the clinical situation; therefore, in the presence of septic shock with the need for catecholamines, the procedure should be as quick as possible, and a simple lavage and drainage can be performed in such critical patients. The addition of a feeding jejunostomy in the efferent limb can be an interesting option in complicated situations in order to avoid long-lasting parenteral nutrition.

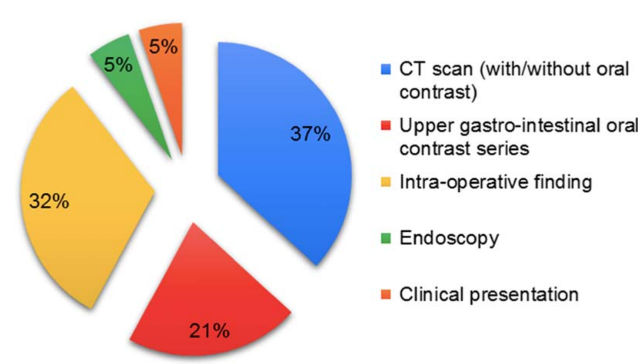

Figure 4. Diagnostic approach of leak after OAGB. CT, computed tomography; OAGB, one-anastomosis gastric bypass.

Most leaks following OAGB cannot be assimilated to leaks occurring after laparoscopic sleeve gastrectomy or RYGB. Indeed, leaks after OAGB raise concerns, as the most common leak site is the gastrojejunal anastomosis (GJA). Unlike after GJA leaks following RYGB, where the leak stays isolated from the bile, after OAGB, the GJA leak is a high-flow leak, exposed to a strong concentration of bile flowing from an afferent limb to the leak site. This is why in such a situation, especially if the surgery is recent and when the leak episode is well tolerated, many bariatric surgeons recommend directly converting to the RYGB condition in order to isolate the bile flow from the GJA. If the leak is not of the GJA but still takes place in the lower part of the gastric pouch, conversion to the RYGB by dividing the pouch above the leak site is also a good and safe option.

Conversion to RYGB exhibits good results in the literature. The IFSO Worldwide One Anastomosis Gastric Bypass Survey showed that conversion of OAGB to RYGB for leak management is the most common bariatric surgical procedure among bariatric surgeons[66]. Blockmans *et al.*[25] reported control of the sepsis and a complete treatment of the leak in five out of five early leaks after OAGB. Similar good results were observed by Poghosyan *et al.*[67] and Beaupel *et al.*[4,] who also experimented with uncomplicated conversion to RYGB in the treatment of leaks.

In the case of conversion to RYGB, it has been suggested that the gastric pouch could be shortened to avoid the fashion of a big or/and broad gastric pouch that causes acid reflux and anastomotic ulcers[68]. Conversion to RYGB is a procedure requiring high surgical skills and, therefore, cannot always be performed by all general surgeons during an emergency. This should be done within expert units by experienced surgeons.

If the leak is located at the top of the gastric pouch, below the cardia (proximal staple line), conversion to RYGB should be avoided as it rarely allows a sufficient gastric length to fashion a new gastric pouch. We suggest in such a situation simply place a surgical drain near the leak orifice if surgery is performed and/or proceed to an endoscopic placement of a gastric stent or pigtail, depending on the leak size.

Endoscopic management of a leak can play an important role in suitable conditions and at the right time to prevent a second surgical approach. The value of endoscopy in the treatment of leaks, alone or combined with surgery, is now indubitable but data regarding specifically endoscopic management of leaks after OAGB are still scarce in the literature. Liagre *et al.* proposed endoscopy for patients with failure of medical treatment alone and/or in association with percutaneous drainage of an abscess with a leak orifice clearly identified on a CT scan and/or in the presence of digestive fluid leaking through the abdominal drain left in place after surgical exploration. They also suggested that if the leak orifice on the digestive side was less than 1 cm in diameter, a double pigtail drain could be used to obtain an intraluminal drainage of the collection[13]. Endoscopic treatment can be chosen for leaks occurring after the first postoperative week in patients with no major signs of sepsis. In 2020, Younis *et al.* reported a median time between surgery and endoscopy of 12 days. In their study, fully covered stents were placed for a median duration of 26 days. All patients with anastomotic leaks had a favorable outcome, whereas this treatment succeeded in only one patient with a staple line leak. Despite this attitude, two patients developed a late fistula needing additional drainage procedures (including pigtail), and another patient had an emergency laparotomy due to a stent migration with perforation of the ileum[16]. Endoscopy can also be a second-line treatment, as was described by Beaupel *et al.*[4] in their 2017 study when they used stents for two patients in second intention as a treatment of persistent leaks after surgical treatment, obtaining closure of the leak orifice within 4 weeks.

Endoscopic stenting can also add to surgical procedures in large gastric tube staple line failure to decrease the gastric tube content spillage and accelerate the recovery time, as has been reported by Gesner *et al.*[30], although it was not recommended by them because of the risk of stent migration that may lead to obstruction and perforation.

The recent experts' consensus about patient selection in OAGB recommended this procedure as a suitable revisional procedure for weight regain after primary restrictive bariatric procedures[2]. This systematic review and meta-analysis also confirms the results of two previously published meta-analyses about the safety of revisional OAGB in the subject of leakage, which is the most common major complication after revisional OAGB[69,70].

A suggested algorithm regarding the management of patients with a suspicion of the leak, according to the included papers in this meta-analysis, is shown in Figure 5.

Despite our efforts, this review has several weaknesses. Most of the studies included in this review did not mention or elaborate on

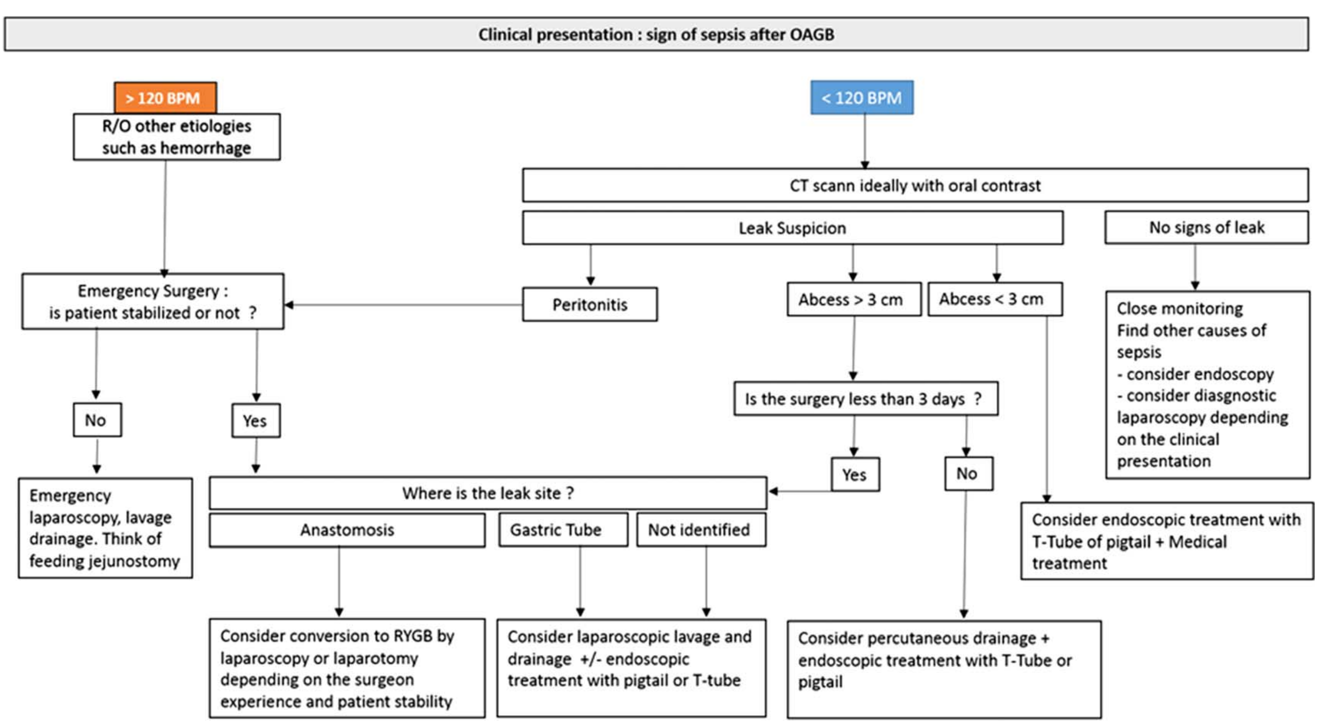

Figure 5. Suggested algorithm regarding the management of patients with a suspicion of the leak. CT, computed tomography; R/O, rule out; RYGB, Roux-en-Y gastric bypass.

how precisely leaks were managed. We could only extract this data from less than half of the reviewed articles. Therefore, there is probably a publication bias in this aspect. The statistical validity of such pooling of heterogeneous data cannot be perfect. This work is only meant to be indicative for surgeons and is here to guide them, as every case is unique. Despite all these shortcomings, this is a significant paper documenting how OAGB leaks are managed today by a significant number of surgical groups from around the world.

Conclusion

The management of leaks following OAGB requires a multidisciplinary team approach. OAGB is a safe operation with a low leak rate, and the leaks can be managed successfully if detected in a timely fashion. There is no significant difference between leak incidence after primary and revisional OAGB and correct surgical technique, and increasing the surgical team experience can decrease the leak rates after OAGB. With the increasing popularity of this technique, it is a necessity that the management of leaks following OAGB is clarified, and this question should be addressed in international guidelines in the near future.

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Author contribution

M.K.: conceived the idea for the topic, data gathering, consulting, and writing; R.K.: consulting and reviewing; R.V.: statistics and methodology; C.P.: data gathering, consulting, and reviewing; A. H.D.: data gathering, consulting, and reviewing. S.S.S.: data gathering, consulting, and reviewing; M.B.: organization leadership, data gathering, consulting, and writing.

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