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ORIGINAL CONTRIBUTIONS

Effects of Perioperative Cannabis Use on Bariatric Surgical Outcomes: a Systematic Review

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Abstract

Purpose While cannabis is the most commonly used non-prescription drug in the USA and has established effects on weight, its implication for bariatric surgery has not been formally evaluated. We aimed to review the current literature on perioperative cannabis use in patients undergoing bariatric surgery.

Materials and Methods Our systematic search of MEDLINE and Embase until March 2020 returned 169 citations. Screening and abstraction of results were performed in duplicate, and qualitative synthesis of the data was performed. Primary outcomes were cannabis use characteristics, weight loss outcomes, and 30-day postoperative morbidity. Study quality was assessed through the MINORS risk-of-bias tool.

Results Six observational studies with a total of 1167 patients (78.6% female, median follow-up 12 months [3–38.4 months]) were included. A total of 9.9% of patients ($n = 116/1167$) used cannabis in the perioperative period. Compared with non-users, 1-year weight loss was significantly higher in a study evaluating 8 preoperative cannabis users ($n = 8/239$, $p = 0.002$); however, there were no differences in single-study data on 90-day total weight loss ($n = 434$, $p = 0.89$) nor 2-year excess BMI loss ($n = 146$, $p = 0.631$). There was no difference in 30-day minor (RR 0.91, 95%CI 0.49–1.71, $p = 0.77$) or major morbidity (RR 0.75, 95%CI 0.31–1.79; $p = 0.50$).

Conclusion There are only uncontrolled studies to date on cannabis use in bariatric surgery. While these have reported conflicting effects on weight loss and no effect on morbidity to date, validation in randomized trials is required to facilitate evidence-based recommendations.

Keywords Obesity · Bariatric surgery · Metabolic surgery · Cannabis · Marijuana

Introduction

The international prevalence of obesity has nearly doubled in 30 years and becomes a widespread priority for global health [1, 2]. Bariatric surgery is the most effective and enduring treatment for severe obesity and has been performed at increasing frequencies in the high-income world [3–9]. However, the overall uptake of this treatment remains as low

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as 1% for eligible patients in the USA [5, 6]. One factor may be the lack of literature on predictors of postoperative weight loss, which has marked documented heterogeneity [10, 11]. To mitigate the obesity epidemic, this has stimulated interest in the identification of variables which affect bariatric outcomes [10, 11]. While factors ranging from preoperative weight loss to a patient's psychological characteristics have been assessed, the effect of perioperative cannabis use is poorly understood [12, 13].

Both medicinal and recreational use of this drug is increasing, including among patients with severe obesity [14, 15]. Implications of cannabis on weight have been speculated; acute exposure stimulates appetite and weight gain, while chronic exposure decreases the risk of obesity and cardiometabolic pathology [16–20]. Subgroup analyses in patients with cancer, HIV/AIDS, or palliative care demonstrate weight gain with use, while population-based studies have generally reported outcomes suggestive of lower weight [21–23]. One retrospective study of 27,010 adolescents found significantly lower BMI in those who use cannabis compared with those who do not ($p < 0.01$), with a negative association between duration of cannabis use and BMI [24]. In a 3-year prospective study of 33,250 Americans, an attenuated BMI gain was observed in those who use cannabis compared with never-users [22]. For patients who are undergoing bariatric surgery, however, weight outcomes with perioperative cannabis use remain to be formally characterized [25].

The purpose of this study was to conduct a systematic review of the existing literature surrounding the perioperative use of cannabis within the context of bariatric surgery. In doing so, we aimed to synthesize evidence on postoperative outcomes and generate clinical recommendations to counsel patients with obesity who use cannabis.

Methods

Our review protocol was developed a priori in accordance with the PRISMA statement [26]. This protocol may be obtained through a request from the corresponding author (D.H.).

Search Strategy

We systematically searched MEDLINE and Embase from database inception up to March 2020. The search was designed and conducted by a medical research librarian, with input from study investigators (complete search strategy available in Supplementary Fig. 1). Studies were not restricted based on language or publication status. Reference lists of included studies were screened to identify any other texts of relevance.

Eligibility Criteria and Outcomes Assessed

We considered all research articles evaluating perioperative cannabis use in patients undergoing bariatric surgery. We excluded reviews, letters, and editorials, but did not exclude conference abstracts to maximize the number of eligible studies. There were no relevant exclusion criteria based on sample characteristics, including participant age, sex, race, or co-morbidity. Similarly, there were no relevant exclusion criteria based on the study context, including geographic location, cultural interests, or healthcare setting.

Primary outcomes included (1) characteristics of cannabis use, (2) weight loss outcomes, and (3) 30-day postoperative morbidity. Secondary outcomes were key study characteristics and descriptions of any other substance use.

Study Selection

Two reviewers (F.J., S.M.) independently evaluated all citations using a standardized, pilot-tested form. Titles and abstracts were screened to identify any clearly irrelevant references. Discrepancies during level 1 screening were resolved by automatic inclusion to ensure no relevant paper was missed. Level 2 screening of full texts was performed to identify articles for final inclusion, similarly in duplicate. Discrepancies were resolved by consensus between the two reviewers; a third reviewer (Y.L.) was consulted for any persisting disagreements. Reviewers were not masked to author or journal name.

Data Extraction

A data collection form was developed a priori and pilot tested. Data from each included study was abstracted in duplicate using a narrative approach, with discordance resolved through discussion. Abstracted data included study and patient characteristics, intervention and comparator details, substance use characteristics, and postoperative outcomes.

Based on pilot testing, it was determined that there were insufficient outcomes reported to the abstract type or route of administration (inhaled, oil, etc.), and purpose of use (medicinal, recreational, etc.). Missing data were treated as "not reported."

Risk of Bias Assessment

The risk of bias for each study was assessed by two independent reviewers (F.J., S.M.) using the MINORS (methodological index for non-randomized studies) tool. Funnel plots for assessment of publication bias were not constructed as no outcomes had ten RCTs contributing data.

Statistical Analysis

All statistical analyses for this paper were conducted using STATA (version 14, StataCorp, College, TX) and Review Manager (version 5.3, Cochrane, London, UK). Descriptive statistics were performed for pool patient characteristics. The threshold for statistical significance was set a priori at alpha = 0.05. Pooled effect estimates for continuous variable and heterogeneity assessments were not possible due to limited data.

A detailed narrative summary of study outcomes was performed following the Synthesis without Meta-Analysis (SWiM) guideline. No subgroup syntheses or prioritization of studies were performed across outcomes. Effects abstracted from narrative summaries were presented using tables.

Results

Systematic Search

The results from our systematic search are illustrated in Fig. 1. Our initial search returned 169 citations after 11 duplicates were removed. A total of 151 citations were excluded during title and abstract screening. Following a review of the remaining 12 articles, 6 full texts were ultimately included. Ultimately, 4 prospective cohort studies, 1 retrospective cohort study, and 1 cross-sectional study met this review's eligibility criteria for analysis [27–32].

Study and Patient Characteristics

Study and patient characteristics are detailed in Table 1. The 6 included cohort studies reported a total of 1167 patients, with publication dates ranging from 2015 to 2020. The weighted mean (SD) age of patients was 48.25 (5.64) years and 78.6% were female. Median follow-up was 12 months (range, 3.0 to 38.4 months). Patients across studies underwent different bariatric procedures. The Roux-en-Y gastric bypass (RYGB; 4/6 studies) and sleeve gastrectomy (SG; 4/6 studies) were the most commonly conducted.

There are 4 double-arm studies in current literature assessing outcomes between patients who use and do not use cannabis. Further subgroup analyses were pursued by one study through categorization of cannabis use within 30 days and the past year, in addition to increased use following bariatric surgery [27].

Perioperative Substance Use in Bariatric Surgery

All six studies reported cannabis use characteristics, however employed heterogenous definitions of "use" (Table 2). Self-reported data of variable time periods (range 1–12 months) was most commonly used. A total of 9.9% ($n = 116/1167$) patients used cannabis in the perioperative period. Cannabis use increased in 4.4% of patients ($n = 11/250$, 2 studies) and decreased in 7.5% ($n = 15/200$, 1 study) following bariatric surgery [27, 31].

The use of tobacco products, alcohol, benzodiazepines, cocaine, and opioids was reported in 878 patients; 35.9% ($n = 315$) of patients reported a positive perioperative history. The use of tobacco products was the most common, with 25.8% ($n = 54$) of cannabis users and 37.1% ($n = 174$) of non-users reporting a history.

Bariatric Surgery Outcomes in Patients Who Use Cannabis

Weight loss outcomes have been detailed in Table 3. The weighted mean BMI at baseline for was 49.8 (12.3) kg/m^2 for patients who use cannabis ($n = 151$, 4 studies) and 46.0 (10.5) kg/m^2 for non-users ($n = 721$, 4 studies) [27–29, 32].

Only single study data was available for each postoperative weight outcome. Significant difference reported only by one study comparing 8 patients who used cannabis with 231 patients who did not; a significantly higher 6- and 12-month excess weight loss in patients who use cannabis was found ($p = 0.002$) [28]. There was no difference in 90-day total weight loss ($p = 0.89$) nor 2-year excess BMI loss ($p = 0.63$) [29, 32].

Postoperative Morbidity in Patients Who Use Cannabis

Postoperative morbidity up to 90 days was reported by two trials in 577 patients (Table 4). There was no significant difference in minor (RR 0.91, 95%CI 0.49–1.71, $p = 0.77$) or major (RR 0.75, 95%CI 0.31–1.79; $p = 0.50$) complications.

Risk of Bias Assessment

The risk of bias assessment is summarized in Table 5. The mean MINORS score of the included studies was 17 ± 25.6, indicating a moderate quality of evidence [33]. All 6 studies had a clearly stated objective with an appropriate assessment of the study endpoint. Most had a prospective collection of data (5/6), unbiased assessment of study endpoints (4/6), and an appropriate period of follow-up (4/6). However, only half had a loss of follow-up less than 5%. Forner and Mitchell had the highest risk of bias, with a MINORS score of 8 and 13 out of 24 respectively.

Discussion

Our study systematically identified and reviewed 6 studies to date on cannabis use in patients undergoing bariatric surgery.

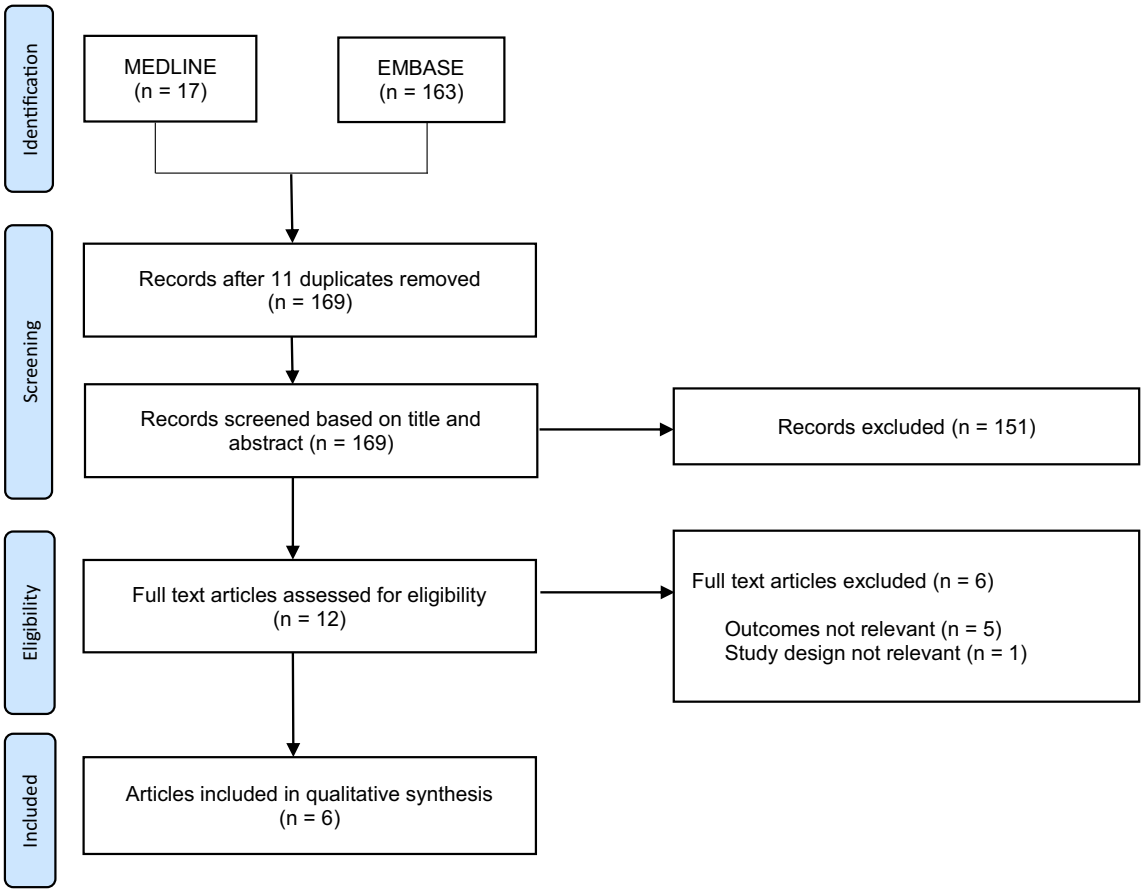

Fig. 1 PRISMA diagram—transparent reporting of systematic reviews and meta-analysis flow diagram outlining the search strategy results from initial search to included studies

There was a moderate overall risk of bias in this literature, with heterogenous study outcomes and definitions of cannabis use. Conflicting single-study data supported both a positive and a lack of effect of cannabis on postoperative weight loss. Two trials supported a lack of effect on postoperative morbidity. Overall, there was an underwhelming quality and quantity of evidence.

Despite the sparse clinical data, it may be possible to corroborate the conflicting findings of cannabis on postoperative weight loss. The NHANES III study (Third National Health and Nutrition Examination Survey) was a retrospective study conducted in the USA to evaluate the effects of cannabis on nutritional status; when 10,623 adults aged 20 to 59 years were stratified by exposure, heavy users (11 or more times monthly) had a significantly lower BMI compared with non-users ($p < 0.0001$), which persisted after adjusting for age, gender, education, cigarette smoking, and caloric intake ($p = 0.003$) [34]. However, no difference in BMI was observed between non-users and light (1 to 4 times monthly) or moderate users (5 to 10 times monthly). Our findings on postoperative weight loss in bariatric surgery patients may be similarly dependent on the level of exposure to cannabis. One of our studies reported that increased and/or regular cannabis use was predictive of higher scores on eating disorder subscales evaluating loss of controlled food intake, although BMI lost after WLS was not compared statistically in this cohort [27]. Overall, meaningful subgroup analyses are still not possible with current evidence due to heterogenous definitions of cannabis use and insufficient reporting of outcomes but would be of interest for future studies. There is also a heavy reliance to date on self-reported data to identify cannabis use, including by Shockcor, which reported the lack of effect on weight loss [29]. These conclusions may be affected by recall bias and underreporting. Future research which delineate frequency, route, and quantity of cannabis used, ideally with minimal reliance on self-reported data, have the most to contribute; this may facilitate validation of weight outcomes in patients undergoing bariatric surgery.

In previous reports of major elective surgeries, the increased perioperative risk with cannabis use was reported. A large retrospective study of a propensity score matched-pair cohort of 27,206 patients found a significant increase in perioperative myocardial infarction risk with active cannabis use disorder (OR:2.88; 95%CI:2.34–3.55, $p < 0.001$) [35]. Prolonged medical and recreational use was further observed to be associated with malignant arrhythmias, ischemic stroke,

Table 1 Study and patient characteristics. −, not reported; *P*, prospective cohort; *R*, retrospective cohort; *T*, transversal study; *BS*, bariatric surgery; *RYGB*, Roux-en-Y gastric bypass; *SG*, sleeve gastrectomy; *GB*, gastric banding; *AGB*, adjustable gastric band

Reference (year)	*N* (total)	Study design	Type of BS	Study arm	*N* in arm	% female	Age (years ± SD)	Mean follow-up (months)
Shockcor 29	146	P	RYGB SG	Preoperative cannabis use	73	82.2	40.0 ± 11.6	9.35 ± 6
				No preoperative cannabis use	73	80.8	40.1 ± 9.9	10.95 ± 6
Bauer 32	431	P	RYBG SG AGB	Preoperative cannabis use	36	75.0	41.7 ± 13.1	3.0
				No preoperative cannabis use	395	76.3	48.8 ± 12.0	3.0
Forner 30	100	T	-	Preoperative cannabis use	100	-	-	-
Vidot 27	50	P	SG RYGB AGB	Never used	22	90.9	27.1 ± 5.5	21.0 ± 13.4
				Current cannabis use (past 30 days)	9	77.8	28.5 ± 5.8	27.6 ± 11.6
				Recent cannabis use (past 1 year)	19	73.7	27.5 ± 5.6	31.2 ± 18.0
				Increased cannabis use post-BS	6	83.3	25.3 ± 6.4	38.4 ± 15.6
Almadani 28	239	R	SG	Preoperative cannabis use	8	-	-	12.0
				No preoperative cannabis use	231	-	-	12.0
Mitchell 31	201	P	RYGB	BS patients	200	81.1	48.25 ± 6.4	36.0

bronchiolitis, and immunosuppression with implications for the perioperative period [36–38]. There are also case reports of gastric and duodenal ulcers in patients with chronic synthetic cannabinoid use who are otherwise at low risk [39, 40]. Marginal ulceration is a known complication of bariatric procedures with an incidence of 1–16% [41–43]. It is thus interesting that in our review, cannabis use was not found to have any deleterious effects on morbidity up to 90 days following bariatric surgery based on the data of two studies [29, 32]. This may be explained by several reasons. One is that these conclusions were based on self-reported data without the context of dosing characteristics. Importantly, one study acknowledges their conclusions are limited by a low threshold for defining cannabis use ("use of any [cannabis] preparation within 30 days of surgery"), and refers to a particular potential cofounder which likely plays a significant role in morbidity outcomes: a younger ($p = 0.003$) and healthier ("across comorbidities," $p = 0.003$) cohort of patients who used cannabis

Table 2 Substance use characteristics. −, not reported; *BS*, bariatric surgery; *AUDIT*, alcohol use disorders identification test

Reference (year)	*N*	Study arm	*N* in arm	Definition of cannabis use	*N* with preoperative use of cannabis (%)	*N* with increased postoperative use of cannabis (%)	*N* with decreased postoperative use of cannabis (%)	Other substances used: *n* (%)
Shockcor 29	146	Preoperative cannabis use	73	Self-reported use within the last year or positive routine preoperative toxicology screen	73 (100)	-	-	Tobacco: 21 (28.8)
		No preoperative cannabis use	73	-	0 (0)	-	-	Tobacco: 22 (30.1)
Bauer 32	431	Preoperative cannabis use	36	Self-reports of regular use (> 1/month) during preop visit	36 (100)	-	-	Tobacco: 20 (55.6)
		No preoperative cannabis use	395	-	0 (0)	-	-	Tobacco: 152 (38.3)
Forner 30	100	Preoperative cannabis use	100	Psych interview, urinalysis to detect use in last 3 m	6 (6)	-	-	Tobacco: 13 (13) Alcohol: 15 (15) Benzodiazepine: 4 (4) Cocaine: 1 (1)
Vidot 27	50	BS patients	50	Self-reported use	28 (56)	11 (21.4)	-	-
Almadani 28	239	Preoperative cannabis use	8	Illicit or prescribed	8 (100)	-	-	Excluded co-users
		No preoperative cannabis use	231	-	0 (0)	-	-	Excluded co-users
Mitchell 31	201	BS patients	200	Diagnosis of cannabis use disorder	15 (7.5)	0 (0)	15 (7.5)	Smoking: 18 (9) Alcohol: 16 (8) Alcohol + AUDIT: 32 (16) Opioid: 1 (0.5)

Table 3 Weight loss outcomes. −, not reported; *BS*, bariatric surgery; *BMI*, body mass index; *EWL*, estimated weight loss; *TWL*, total weight loss; *EBMIL*, excess body mass index lost

Reference (year)	*N*	Study arm	*N* in arm	Follow-up time (months)	Weight (kg ± SD)	BMI (kg/m^2 ± SD)	% EWL	% TWL	% EBMIL
Shockcor 29	146	Preoperative cannabis use	73	0	53 ± 2.5	49.2 ± 7.2	-	-	0
				6	44 ± 3.2	-	-	-	60.6
				12	42 ± -	-	-	-	78.2
		No preoperative cannabis use	73	0	55 ± 1.4	47.6 ± 8.1	-	-	0
				6	30 ± 2.0	-	-	-	63.1
				12	22 ± 4.3	-	-	-	77.3
Bauer 32	431	Preoperative cannabis use	36	0	127 ± 22.6	44.7 ± 6.1	-	-	-
				3	-	-		0.18	-
		No preoperative cannabis use	395	0	126 ± 23.9	45.1 ± 6.5	-	-	-
				3	-			0.18	-
Vidot 27	50	Never used	22	0	-	46.6 ± 8.9	-	-	-
				24	-	35.3 ± 15.7	-	-	-
		Current cannabis use (past 30 days)	9	0	-	60.4 ± 21.7	-	-	-
				24	-	39.6 ± 15.7	-	-	-
		Recent cannabis use (past 1 year)	19	0	-	55.3 ± 18.1	-	-	-
				24	-	37.0 ± 12.5	-	-	-
		Increased cannabis use post-BS	6	0	-	46.0 ± 5.8	-	-	-
				24	-	30.4 ± 3.9	-	-	-
Almadani 28	239	Preoperative cannabis use	8	0	-	55.93	-	-	-
				12	-	-	33.0	-	-
		No preoperative cannabis use	231	0	-	46.93	0	-	-
				12	-	-	54.9	-	-
Mitchell 31	201	BS patients	200	-	-	50.35 ± 7.16	-	-	-

compared with non-users [32]. The conclusion that cannabis may not affect morbidity must thus be qualified with this likely clinically relevant limitation in study design. Future studies should prioritize recruiting a more homogenous population, as any conclusions regarding the role of cannabis in postoperative morbidity will otherwise remain unconvincing. With acknowledgment to the lack of evidence demonstrated in the current review, it is clear that further evaluation

Table 4 Patient complications. *BS*, bariatric surgery; *VTE*, venous thromboembolism; *SSI*, surgical site infection; *PEDV*, postoperative emergency department visit

Reference (year)	*N*	Study arm	*N* in arm	30 day minor complications		30 day major complications	
				N (%)	Description of complications: n (%)	*N* (%)	Description of complications: *n* (%)
Shockcor 29	146	Preoperative cannabis use	73	3 (4.1)	VTE: 0 (0) Bleeding: 2 (2.7) SSI: 1 (1.4)	5 (6.8)	Reoperation: 2 (2.7) Readmission: 3 (4.1)
		No preoperative cannabis use	73	5 (6.8)	VTE: 1 (1.4) Bleeding: 2 (2.7) SSI: 2 (2.7)	3 (4.1)	Reoperation: 2 (2.7) Readmission: 1 (1.4)
Bauer 32	431	Preoperative cannabis use	36	7 (19.4)	SSI: 1 (2.8) PEDV: 6 (16.7)	3 (8.3)	Readmission: 3 (8.3)
		No preoperative cannabis use	395	60 (15.2)	SSI: 6 (1.5) PEDV: 54 (13.7)	28 (7.1)	Readmission: 28 (7.1)

Table 5 MINORS assessment of studies. 1—clearly stated aim, 2—inclusion of consecutive patients, 3—prospective collection of data, 4—end points appropriate to the aims of the study, 5—unbiased assessment of the study end point, 6—follow-up period appropriate to the aim of the study, 7—Loss to follow-up less than 5%, 8—prospective calculation of the study size, 9—adequate control group, 10—contemporary groups, 11—baseline equivalence of groups, 12—adequate statistical analyses

Reference	MINORS criteria												
	1	2	3	4	5	6	7	8	9	10	11	12	Total
Shockcor 29	2	1	2	2	2	2	1	2	2	2	2	2	22
Bauer 32	2	1	2	2	2	1	2	2	2	2	1	2	21
Forner 30	2	2	2	2	0	0	0	0	NA	NA	NA	NA	8
Vidot 27	2	1	2	2	2	2	2	2	1	2	1	2	21
Almadani 28	2	1	1	2	2	2	0	2	2	2	0	2	18
Mitchell 31	2	1	2	2	0	2	2	2	NA	NA	NA	NA	13

of postoperative morbidity in patients undergoing bariatric surgery is pertinent. Most weight loss programs continue to consider cannabis use as a contraindication to bariatric surgery, and this conservative approach may be prudent until more evidence becomes available [44, 45].

The conclusions of our review have limitations. As previously recommended by Rummell et al., the generalizations drawn about cannabis' effect on bariatric surgery outcomes should be limited as other variables may contribute to the heterogeneity of results [45]. For example, we were unable to stratify the analysis based on the type of cannabis used (e.g., CBD oil, recreational edibles) due to a lack of reported data. Delineating the effect of cannabis based on product type will be important for minimizing the degree of uncontrolled variance [46]. Additionally, two studies included in our review endorsed polysubstance use within their cohort of cannabis users (e.g., tobacco, alcohol, opioids). The impact of this on weight loss outcomes after surgery remains indeterminate with current evidence and reveals itself to be an important confounder to consider in the future. The pooling of effects and calculation of hazard and odds ratios were not possible due to a lack of sufficient outcomes across studies. Differences in study design and methodology limited the capacity for non-qualitative analyses. As a result, our conclusions are broad and based on descriptive data only. All included trials reported observational data; as a result, exposure to cannabis was uncontrolled and there is likely marked heterogeneity between users included in our review.

Conclusion

Our comprehensive review found a paucity of studies on cannabis use in bariatric surgery, with heterogenic outcomes relying on self-reported data. Future research should collect data on route, type, and quantity of cannabis use, and we call for the first randomized study evaluating bariatric surgical considerations in these patients. In this new era of increased access to cannabis, investigation in the short future will have clinical importance, and clinicians should consider conservative preoperative counseling until further evidence becomes available.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflicts of interest.

Ethical Approval This article does not contain any studies with human participants or animals performed by any of the authors.

Informed Consent None.

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