

Medication management and pharmacokinetic changes after bariatric surgery

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Abstract

Objective To identify expected pharmacokinetic changes and provide practical recommendations for the medication management of chronic disease states after bariatric surgery.

Sources of information MEDLINE, EMBASE, PubMed, Scopus, and the Cochrane Library were searched. The search was limited to studies in human adults. Search terms included *obesity, obese, bariatric surgery, gastric bypass, gastrectomy, gastric band, RYGB, roux-en-y, gastrointestinal absorption, medication absorption, drug absorption, bioavailability, dose adjust, drug monitoring, medication adjust, drug change, medication change, medication management, and medication dosing*. Reference lists of original studies and reviews were also hand searched. Included studies were entered into PubMed and articles under the “Similar articles” heading were also reviewed. Only studies relevant to bariatric surgery types currently available in Canada (ie, Roux-en-Y gastric bypass, sleeve gastrectomy, or gastric banding) were included.

Main message Pharmacokinetic changes anticipated after bariatric surgery vary by surgery type. There are several guiding principles that might be applied to medication management regimens after bariatric surgery. Practice tips are also presented for medication management of specific chronic disease states.

Conclusion Changes to long-term medication regimens after bariatric surgery should be anticipated and managed in an appropriate and timely manner. The provided clinical practice recommendations might be used in conjunction with a patient’s clinical picture to adjust chronic medication regimens in an appropriate and evidence-based manner after bariatric surgery.

Obesity is a progressive chronic health condition affecting more than 1 in 4 adult Canadians.¹ Patients who are obese are at an increased risk of many other serious health conditions including type 2 diabetes, hypertension, cardiovascular disease, arthritis, and various types of cancer.² Bariatric surgery structurally modifies the gastrointestinal tract to reduce caloric consumption or absorption. The number of bariatric surgeries performed annually in Canada has more than tripled since 2009.³

In addition to restricting caloric absorption, bariatric surgeries also have the unintended potential to restrict absorption of other enteral products, including vitamins, minerals, and medications. After surgery, patients typically experience rapid weight loss and might require adjustments to long-term medication regimens owing to changing medication distribution patterns and the effects of weight loss on chronic disease states.

Bariatric surgeries are classified as having restrictive or malabsorptive properties. Restrictive surgeries reduce the volume of food that can be consumed at one time, leading to reduced total caloric intake. Malabsorptive procedures create a diversion around substantial portions of the digestive tract causing reduced absorption of consumed products. Bariatric surgeries currently offered in Canada include Roux-en-Y gastric bypass (RYGB),

Editor’s key points

- ▶ There is a paucity of high-quality literature to support medication management decisions after bariatric surgery. This review describes changes to the absorption of medications that can be anticipated after bariatric surgery and provides clinical guidance for the management of these changes. Clinical guidance must always be considered in conjunction with each patient’s clinical picture when adjusting medication regimens.
- ▶ General considerations include being aware of the high variability in absorption kinetics among patients; being aware that medication absorption issues might be temporary or permanent; knowing that issues with medication absorption and dosage modifications are more likely to occur and persist after malabsorptive procedures; and ensuring appropriate monitoring and follow-up is implemented.
- ▶ This review provides practical tips on managing specific disease states and anticipating pharmacokinetic changes. Anticipated pharmacokinetic changes after bariatric surgery include reduced ability of solid oral medications to dissolve and altered first-pass metabolism. Suggestions for management include switching solid-medication doses to liquids, dissolvable or crushable tablets, or capsules that can be opened; nonoral dose forms; and immediate-release formulations.

in which a small functional pouch at the top of the stomach is isolated from the rest of the stomach and directly connected to the jejunum, allowing food to bypass most of the stomach and the entire duodenum; sleeve gastrectomy, in which approximately 80% of the stomach is removed, leaving a smaller sleeve-like stomach; and gastric banding, in which an obstructive band is placed around the proximal stomach, physically restricting the rate at which food can pass into the stomach. Roux-en-Y gastric bypass has both restrictive and malabsorptive properties, while sleeve gastrectomy and gastric banding are primarily restrictive procedures.

Unfortunately, the current literature offers very few clear recommendations regarding specific medication management strategies in patients after bariatric surgery. The objective of this review is to identify expected pharmacokinetic changes and provide practical recommendations for the medication management of chronic disease states after bariatric surgery based on the current available evidence.

Case description

A 40-year-old woman is 2 weeks removed from an RYGB procedure and presents to a family medicine clinic with an elevated blood pressure of 158/96 mm Hg. All other vital signs are within normal limits. Her medical history is relevant for class III obesity and stage 1 hypertension, which had previously been well controlled with 10 mg of oral ramipril daily and 60 mg of oral extended-release nifedipine daily. The patient indicates she has adhered to and tolerated her prescribed regimen.

Sources of information

Search strategy. We searched MEDLINE, EMBASE, PubMed, Scopus, and the Cochrane Library for studies examining the effects of bariatric surgery on either drug absorption or chronic medication management. Search terms included *obesity, obese, bariatric surgery, gastric bypass, gastrectomy, gastric band, RYGB, roux-en-y, gastrointestinal absorption, medication absorption, drug absorption, bioavailability, dose adjust, drug monitoring, medication adjust, drug change, medication change, medication management, and medication dosing*. A librarian from the University of Alberta in Edmonton assisted with identification of appropriate search terms. Reference lists of original studies and reviews were also hand searched. Included studies were entered into PubMed and articles under the "Similar articles" heading were also reviewed. The search was limited to studies in human adults and is considered up to date as of February 2019.

Eligibility criteria. Human case reports, case series, cohort studies, and randomized controlled trials that evaluated or described drug absorption or chronic medication management in patients undergoing bariatric surgery types currently available in Canada (ie, RYGB,

sleeve gastrectomy, or gastric banding) were included. We excluded studies examining nutritional supplements such as vitamins and iron preparations.

Study selection. Based on the inclusion and exclusion criteria, we independently screened the titles and abstracts of each study to determine eligibility. Both authors independently assessed all full-text articles that were classified as included or unclear for final inclusion. Disagreements were discussed and resolved by consensus.

Data abstraction. Using standardized data extraction forms, we independently extracted data on study characteristics (eg, design, country, inclusion and exclusion criteria, funding sources), participants' clinical characteristics, interventions (eg, medication name, dosage type, dosage amount, surgery type), level of agreement among the evidence, and outcomes. Data not reported in the articles were extracted from supplementary texts where available. Authors were not contacted for missing data.

Main message

General practice tips. As physiologic and pharmacokinetic changes develop in the days to months after bariatric surgery, it is typically the responsibility of family physicians to modify chronic disease medication regimens in a timely and appropriate fashion. General strategies are available to manage medication regimens after bariatric surgery (Table 1).⁴⁻⁶ Strategies to improve medication absorption are not required for all patients; the decision to proactively implement these strategies will depend on many factors, including surgery type and each patient's long-term medication regimen. In many cases it will be reasonable to monitor patients after surgery and make adjustments if suboptimal medication absorption is suspected.

When reviewing general strategies for medication management after bariatric surgery, it is important to be mindful of these guiding principles:

- Changes to absorption kinetics of drugs after bariatric surgery have high variability among individuals. No single algorithm or practice tool can accurately predict these changes for all patients after bariatric surgery.
- Medication absorption issues might be temporary or permanent; therefore, medication modifications to counteract these issues might also be temporary or permanent.
- Issues with medication absorption and dosage modifications are more likely to occur and persist after malabsorptive procedures.
- When a medication adjustment is made, ensure appropriate monitoring and follow-up is implemented.
- Ensure medication regimens that are dosed by weight are regularly reviewed and adjusted as patients experience weight loss.

Specific disease state management. In addition to general management principles, we have identified a number

of strategies to guide medication management for specific chronic disease states after bariatric surgery (Table 2).⁴⁻⁴² Specific medications for which recommendations are made are intended to represent the most commonly prescribed medications in Canada at the time of the literature review.

Underlying pharmacokinetic changes. After bariatric surgery, there are multiple pharmacokinetic changes

that might occur and that might also explain why patients are not achieving an adequate response to their medications (Table 3).^{6,43-45} The resultant pharmacokinetic changes might develop within days to months after surgery, vary from patient to patient, and depend on the type of bariatric surgery performed. The changes might either partially or fully reverse as the body heals and adapts to the alterations made from bariatric surgery.

Table 1. General approaches to medication management after bariatric surgery based on anticipated changes: Based on the anticipated medication and absorption changes after 3 specific procedures: 2 types of restrictive procedures (gastric banding and sleeve gastrectomy) and 1 type with both restrictive and malabsorptive properties (Roux-en-Y gastric bypass).

PARAMETER	RECOMMENDATION
Suspicion that medications are not being absorbed appropriately	<ul style="list-style-type: none"> • Switch solid-dose forms to liquid-dose forms, dissolvable or crushable tablets, or capsules that can be opened and sprinkled on food^{4,5} • Consider using nonoral dose forms (eg, sublingual, intranasal, rectal, subcutaneous, transdermal)⁴ • Switch extended-release formulations to immediate-release formulations⁴ • Switch to medications that undergo less first-pass metabolism • Consider proactively adjusting medication regimens after malabsorptive procedures when treatment failure might result in a detrimental outcome
Medications that increase the risk of upper gastrointestinal irritation, ulceration, and impaired healing	<ul style="list-style-type: none"> • Minimize use of nonsteroidal anti-inflammatory drugs,^{5,6} oral bisphosphonates,⁵ and corticosteroids⁶
Dumping syndrome	<ul style="list-style-type: none"> • Avoid liquid formulations that have non-absorbable sugars (eg, mannitol, sorbitol)⁶

Table 2. Medication management strategies for specific chronic disease states after bariatric surgery: Based on the anticipated medication and absorption changes after 3 specific procedures: 2 types of restrictive procedures (gastric banding and sleeve gastrectomy) and 1 type with both restrictive and malabsorptive properties (RYGB).

DISEASE STATE OR MEDICATION CLASS	COMMENTS
Diabetes	<ul style="list-style-type: none"> • Frequent follow-up and monitoring by a health care provider is required in the postoperative period to ensure ongoing effectiveness and timely modifications of antihyperglycemic medications⁷ • While the medication burden might decrease initially after surgery, long-term monitoring is recommended given that diabetes is a progressive disease and can worsen with time in some patients⁷ <p>Drug-specific recommendations for type 2 diabetes</p> <p>Insulin*</p> <ul style="list-style-type: none"> • Insulin requirements might be volatile and are expected to decrease for at least 12 months after surgery or until weight loss stabilizes, with the most substantial reductions occurring during the first months^{7,8} • If the basal insulin dose is < 30 units/day before surgery, then discontinue after surgery⁷⁻⁹ • If the basal insulin dose is ≥ 30 units/day before surgery, then decrease by 50% to 80% after surgery⁷⁻¹⁰ • Short-acting insulin might be used to manage elevated glucose levels⁷⁻⁹ <p>Noninsulin options</p> <ul style="list-style-type: none"> • In patients taking 1 oral antidiabetic agent before surgery, the agent can be discontinued after surgery^{8,9} • If the patient is taking > 1 oral medication and ... <ul style="list-style-type: none"> -HbA_{1c} is < 9%, metformin is the preferred single-agent therapy^{7,10} -HbA_{1c} is ≥ 9%, a second agent can be coupled with metformin, preferably an agent that facilitates CV risk reduction^{7,11†} • Avoid oral medications that increase the risk of hypoglycemia^{7,8,11†}
Anticoagulation	<ul style="list-style-type: none"> • Warfarin is preferred over DOACs in patients who require continuous anticoagulation after bariatric surgery¹² -If considering DOAC therapy after bariatric surgery, then confirm that drug-specific laboratory monitoring is available to ensure levels are within the expected therapeutic range¹²

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DISEASE STATE OR MEDICATION CLASS	COMMENTS
Anticoagulation	<p>Drug-specific recommendations</p> <p>Warfarin</p> <ul style="list-style-type: none"> • Warfarin doses should typically decrease in the immediate postoperative period (about 3-4 wk) and then increase further out from surgery¹²⁻¹⁴ • To reduce bleeding risk, decrease the warfarin dose after surgery and adjust it based on the INR results, similar to a new warfarin start <p>Apixaban, rivaroxaban</p> <ul style="list-style-type: none"> • Limited evidence suggests that rivaroxaban and apixaban do not require dose adjustment after bariatric surgery^{15,16} • Drug-specific laboratory monitoring is recommended to ensure levels are within the expected therapeutic range¹² <p>Dabigatran, edoxaban</p> <ul style="list-style-type: none"> • Literature outlining the pharmacokinetic changes to dabigatran and edoxaban after bariatric surgery is lacking¹²
Antiplatelet therapy	<ul style="list-style-type: none"> • Antiplatelet therapy might increase the risk of gastrointestinal bleeding^{5,6} <ul style="list-style-type: none"> -Antiplatelet medication for primary prevention of CV events should be reassessed -Continuing antiplatelet therapy in patients who are at high risk of future CV events is appropriate at the lowest indicated dosage
Dyslipidemia	<ul style="list-style-type: none"> • Lipid levels might decrease with weight loss; consider monitoring every 3 mo until weight loss stabilizes and discontinue therapy if appropriate¹⁷⁻¹⁹ • In patients who are taking dyslipidemia therapy for secondary prevention of CV events, the dose might be determined by the previous event rather than postoperative laboratory values
Hypertension	<ul style="list-style-type: none"> • The need to use antihypertensive medications typically decreases after surgery. This decrease might begin immediately after surgery and continue for up to 2 y²⁰⁻²² <ul style="list-style-type: none"> -Patients should have frequent follow-up with a general practitioner -Patients should monitor their blood pressure daily until it stabilizes <ul style="list-style-type: none"> —Results should be recorded and assessed by a health care professional to support medication changes —Patients should be reminded of the correct self-monitoring technique • Consider discontinuing or changing diuretic therapy if patients develop dehydration⁸ • In patients with diabetes it might be preferable to continue an ACEI or ARB owing to their renoprotective effects⁸
Depression and anxiety	<ul style="list-style-type: none"> • Close monitoring for psychiatric symptom relapse after surgery is recommended²³ <ul style="list-style-type: none"> -Patients should be aware of the signs and symptoms of worsening psychiatric illness and be advised of whom to contact if this occurs • If relapse occurs, adjust psychiatric medications as quickly as possible owing to the anticipated lengthy response time associated with changing regimens • The literature suggests that the concentration of SSRIs might drop initially and then rebound within a few months; dose adjustments occurring in the immediate postoperative period might be temporary^{23,24} • Switching to a formulation that is absorbed more readily (eg, liquids, crushed pills, immediate-release preparations, tablets that dissolve orally) might be necessary <p>Drug-specific recommendations for medications that do not have an immediate-release version available in Canada</p> <p>Venlafaxine</p> <ul style="list-style-type: none"> • The literature suggests that RYGB does not substantially alter the absorption of extended-release venlafaxine or its active metabolite²⁵ <p>Duloxetine</p> <ul style="list-style-type: none"> • RYGB might decrease patients' exposure to duloxetine and this might persist for at least 12 mo after surgery²⁶ <ul style="list-style-type: none"> -If therapy appears to be ineffective after surgery, then an increased dose or alternative therapy might be required

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DISEASE STATE OR MEDICATION CLASS	COMMENTS
Depression and anxiety	<p>Desvenlafaxine</p> <ul style="list-style-type: none"> If therapy appears to be ineffective after surgery, then an increased dose or alternative therapy might be required <p>Bupropion</p> <ul style="list-style-type: none"> If therapy appears to be ineffective after surgery, consider the following: <ul style="list-style-type: none"> -Continuing or changing to SR bupropion <ul style="list-style-type: none"> —SR formulation is easier to crush than the extended-release formulation -Crush tablets and administer with water; this is expected to provide effects similar to the immediate-release tablets available outside of Canada -Divide total daily dosage in 3 to 4 daily doses. Maximum single dose should not exceed 150 mg, and maximum total daily dose should not exceed 450 mg²⁷
Migraine	<ul style="list-style-type: none"> Migraine or headache frequency might decrease after surgery^{28,29} Average time to medication reduction was about 5.6 mo after surgery (range 1 to 36 mo)²⁸ If initial migraines began after obesity onset, there is a greater probability that migraines will resolve postoperatively²⁸
Epilepsy or seizures	<ul style="list-style-type: none"> Seizures should be well controlled with medications before surgery Consider empirically switching to a liquid formulation, crushable tablets, or capsules that can be opened before malabsorptive procedures Where indicated, drug monitoring during the early postoperative period is recommended to ensure therapeutic drug levels
Asthma	<ul style="list-style-type: none"> Patients with asthma might require less medication after surgery^{30,31} <ul style="list-style-type: none"> -If patients report decreased rescue medication use, then consider reducing or discontinuing maintenance therapy
Psoriasis	<ul style="list-style-type: none"> Patients with psoriasis might require less medication after surgery^{32,33} <ul style="list-style-type: none"> -If patients report decreased psoriasis severity, consider reducing or discontinuing therapy
Pain	<ul style="list-style-type: none"> Avoid NSAIDs after bariatric surgery owing to increased risk of gastric injury (eg, marginal ulcers)^{4,6} For patients undergoing malabsorptive surgery and who are taking extended-release medications or high-dose opioid therapy, consider changing to immediate-release formulations or alternate routes of administration before surgery Liquid acetaminophen contains sorbitol, which increases the risk of dumping syndrome⁶
Transplant	<ul style="list-style-type: none"> If the patient is receiving transplant medications, consider stabilizing medication levels using a liquid formulation before surgery Increased levels of tacrolimus and mycophenolate have been observed after sleeve gastrectomy³⁴ Where indicated, monitor drug levels postoperatively and adjust the dose as appropriate
Ulcer prevention and GERD	<ul style="list-style-type: none"> Rapid-dissolve tablets or capsules that can be opened and sprinkled on food might have greater absorption and efficacy for patients after bariatric surgery <ul style="list-style-type: none"> -Patients who experienced postoperative ulceration healed significantly faster ($P < .001$) while taking opened and dispersed proton pump inhibitor capsules compared with those taking whole capsules or tablets³⁵ -Prescriber should specify “no substitution” when prescribing dispersible or open capsules
HIV	<ul style="list-style-type: none"> Sleeve gastrectomy does not appear to negatively affect CD4 counts and viral load, and appears to be safe in individuals living with HIV^{36,37} Substantially decreased absorption has been observed with raltegravir and atazanavir after sleeve gastrectomy³⁶⁻³⁸ <ul style="list-style-type: none"> -Suggest replacing raltegravir and atazanavir with alternative HIV therapy before bariatric surgery³⁶ -If replacing raltegravir and atazanavir is not possible, then ensure postoperative pharmacokinetic monitoring is performed and adjust medication doses accordingly³⁶
Contraception	<ul style="list-style-type: none"> Rocha et al³⁹ and Curtis et al⁴⁰ indicate that for women who have undergone a ... <ul style="list-style-type: none"> -malabsorptive procedure, oral contraceptives are not recommended owing to a theoretical risk of decreased drug absorption resulting in reduced contraceptive efficacy³⁹ -restrictive procedure, all contraceptive methods are acceptable^{39,40}

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DISEASE STATE OR MEDICATION CLASS	COMMENTS
Contraception	<ul style="list-style-type: none"> • Caution is recommended in all cases. Ensure the patient understands the potential risks of using oral contraception and that secondary methods (eg, male or female condoms, diaphragms) should be employed <p>Drug-specific considerations</p> <p>Effective after restrictive procedures only</p> <ul style="list-style-type: none"> • Combined oral contraceptive • Progestin-only pill <p>Effective after both procedures, but might be less effective in women weighing ≥ 90 kg (≥ 198 lb)⁴¹</p> <ul style="list-style-type: none"> • Ethinyl estradiol and norelgestromin patch <p>Effective after both procedures, but effectiveness in women who are obese is not well studied⁴²</p> <ul style="list-style-type: none"> • Ethinyl estradiol and etonogestrel vaginal ring <p>Effective after both malabsorptive and restrictive procedures</p> <ul style="list-style-type: none"> • Subcutaneous or intramuscular injection of medroxyprogesterone • Levonorgestrel intrauterine device • Copper intrauterine device

ACEI—angiotensin-converting enzyme inhibitor, ARB—angiotensin II receptor blocker, CV—cardiovascular, DOAC—direct oral anticoagulant, GERD—gastrointestinal reflux disease, HbA_{1c}—hemoglobin A_{1c}, INR—international normalized ratio, NSAID—nonsteroidal anti-inflammatory drug, RYGB—Roux-en-Y gastric bypass, SR—sustained release, SSRI—selective serotonin reuptake inhibitor.

*Insulin recommendations are based on current published evidence for the treatment of type 2 diabetes mellitus after bariatric surgery. Specific recommendations for type 1 diabetes mellitus were not identified in the current literature, although decreased insulin requirements after surgery have been observed.

[†]Examples of drugs that facilitate CV risk reduction include empagliflozin, canagliflozin, liraglutide, and semaglutide.¹¹

[‡]Examples of drugs that increase the risk of hypoglycemia include gliclazide, glimepiride, glyburide, and repaglinide.¹¹

Table 3. Anticipated pharmacokinetic changes after bariatric surgery: Based on the anticipated medication and absorption changes after 3 specific procedures: 2 types of restrictive procedures (gastric banding and sleeve gastrectomy) and 1 type with both restrictive and malabsorptive properties (RYGB).


PHARMACOKINETIC PARAMETER	POTENTIAL PHARMACOKINETIC PARAMETER CHANGES		POTENTIAL THERAPEUTIC IMPLICATIONS FOR ORAL MEDICATIONS
	RESTRICTIVE SURGERY	MALABSORPTIVE SURGERY	
Gastric motility	Might be impaired ^{6,43}		Disintegration and dissolution of oral medications might decrease ⁶
Gastric volume	Decreased, thereby decreasing the amount of fluids in the stomach available to act as solvents ⁶		
Gastric pH	Typically becomes more basic after bariatric surgery ^{6,43}		Solubility of basic drugs might decrease whereas solubility of acidic drugs might increase ^{6,43}
Surface area	Sleeve gastrectomy will decrease stomach surface area ⁶	RYGB will decrease contact with stomach and intestinal surface areas ⁶	Dissolution and absorption ⁶ of oral medications might decrease
Bile secretions	NA	Medications will have less contact with bile secretions ^{6,43}	Dissolution of highly lipophilic drugs might decrease ^{6,43}
Carrier proteins (eg, P-glycoprotein)	NA	Bypasses certain carrier proteins that are highly expressed in the proximal small intestine ^{6,43}	Might either increase or decrease absorption as both influx transporters and efflux pumps are known to be expressed in the upper small intestine ^{6,43}
First-pass metabolism	NA	The proximal small intestine has a high concentration of CYP3A4 enzymes ⁶	First-pass metabolism of CYP3A4 substrates might be decreased initially after malabsorptive procedures; decreased dosages might be required ^{6,44,45}
		Hepatic CYP enzyme activity might increase with weight loss ^{44,45}	First-pass metabolism of all CYP enzyme substrates (including CYP3A4 substrates) might increase with weight loss; increased dosages might be required

CYP—cytochrome, NA—not applicable, RYGB—Roux-en-Y gastric bypass.

Case resolution

This patient's hypertension has become poorly controlled after RYGB, most likely as a result of decreased absorption and efficacy of extended-release nifedipine. Extended-release oral nifedipine tablets use an osmotic gradient mechanism to control the release of medication; faster gastric transit time might result in incomplete emptying of tablets and thus incomplete absorption of medication. The family physician discontinues nifedipine and initiates 10 mg of oral amlodipine daily, while continuing ramipril as previously prescribed. Amlodipine and nifedipine have the same mechanism of action; however, amlodipine is available in a small immediate-release tablet and is less likely to be absorbed differently after bariatric surgery. The patient returns to the clinic 2 weeks later and presents with blood pressure at target, 136/84 mm Hg. In-clinic follow-up is planned for every 2 to 4 weeks until the patient's weight loss stabilizes, and she is encouraged to monitor her blood pressure at home between appointments.

Conclusion

Owing to alterations in the gastrointestinal tract after bariatric surgery, there is an intuitive presumption that the absorption, and therefore effectiveness, of medications will change. This review describes changes to the absorption of medications that can be anticipated after bariatric surgery and provides clinical guidance for management of these changes. There is a paucity of previous high-quality literature to support medication management decisions after bariatric surgery. This review closes this gap and provides clinical guidance to practitioners by consolidating the best available evidence. Clinical guidance provided here must always be considered in conjunction with each patient's clinical picture when adjusting medication regimens. To provide the best care to future bariatric surgery patients, further clinical studies are needed to reveal the effects of bariatric surgeries on drug absorption and to understand the underlying mechanisms. Awareness of this important issue must be stressed and it will be incumbent on prescribers to remain informed of new evidence in this area and adjust their practices accordingly. 

Dr Lorico is a pharmacist completing a pharmacy residency at the Red Deer Regional Hospital Centre within Alberta Health Services. **Mr Colton** is Medication Safety Pharmacist at Alberta Health Services and was previously a pharmacist at the Central Alberta Bariatric Clinic.

Contributors

Dr Lorico determined the initial search strategy, which was then modified after consultation with **Mr Colton** and a University of Alberta librarian. **Dr Lorico** identified all articles that met the search criteria. **Dr Lorico** and **Mr Colton** independently reviewed all titles and abstracts to determine which articles to include; discrepancies were resolved with discussion. **Dr Lorico** initially read the included articles and recorded pertinent results in a data collection spreadsheet; **Mr Colton** then read the articles to confirm the information and add to the data collection spreadsheet as required. **Dr Lorico** wrote most of the initial draft of the manuscript; **Mr Colton** proofread and edited it. All writing and editing was agreed upon by both authors. Consensus was achieved via discussion for all disputes.

Competing interests

None declared

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References

1. Statistics Canada. *Overweight and obesity based on measured body mass index, by age group and sex. Table 13-10-0373-01*. Ottawa, ON: Statistics Canada; 2017. Available from: <https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1310037301>. Accessed 2019 Apr 26.
2. Guh DP, Zhang W, Bansback N, Amarsi Z, Birmingham CL, Anis AH. The incidence of co-morbidities related to obesity and overweight: a systematic review and meta-analysis. *BMC Public Health* 2009;9:88.
3. Obesity Canada. *Report card on access to obesity treatment for adults in Canada 2019*. Edmonton, AB: Obesity Canada; 2019. Available from: <http://obesitycanada.ca/wp-content/uploads/2019/04/OC-Report-Card-2019-Eng-F-web.pdf>. Accessed 2019 Apr 26.
4. Miller AD, Smith KM. Medication and nutrient administration considerations after bariatric surgery. *Am J Health Syst Pharm* 2006;63(19):1852-7.
5. Brocks DR, Ben-Eltriki M, Gabr RQ, Padwal RS. The effects of gastric bypass surgery on drug absorption and pharmacokinetics. *Expert Opin Drug Metab Toxicol* 2012;8(12):1505-19. Epub 2012 Sep 24.
6. Azran C, Wolk O, Zur M, Fine-Shamir N, Shaked G, Czeiger D, et al. Oral drug therapy following bariatric surgery: an overview of fundamentals, literature and clinical recommendations. *Obes Rev* 2016;17(11):1050-66. Epub 2016 Jun 22.
7. Kheniser KG, Kashyap SR. Diabetes management before, during, and after bariatric and metabolic surgery. *J Diabetes Complications* 2018;32(9):870-5. Epub 2018 Jun 13.
8. Tritsch AM, Bland CM, Hatzigeorgiou C, Sweeney LB, Phillips M. A retrospective review of the medical management of hypertension and diabetes mellitus following sleeve gastrectomy. *Obes Surg* 2015;25(4):642-7.
9. Bland CM, Tritsch AM, Bookstaver DA, Sweeney LB, Wiley D, Choi YU. Hypertension and diabetes mellitus medication management in sleeve gastrectomy patients. *Am J Health Syst Pharm* 2013;70(12):1018-20.
10. Thorell A, Hagström-Toft E. Treatment of diabetes prior to and after bariatric surgery. *J Diabetes Sci Technol* 2012;6(5):1226-32.
11. Diabetes Canada Clinical Practice Guidelines Expert Committee. Diabetes Canada 2018 clinical practice guidelines for the prevention and management of diabetes in Canada. *Can J Diabetes* 2018;42(Suppl 1):S1-325.
12. Martin KA, Lee CR, Farrell TM, Moll S. Oral anticoagulant use after bariatric surgery: a literature review and clinical guidance. *Am J Med* 2017;130(5):517-24. Epub 2017 Feb 1.
13. Bechtel P, Bourse R, Rovito P, Harrison TD, Hong J. Warfarin users prone to coagulopathy in first 30 days after hospital discharge from gastric bypass. *Obes Surg* 2013;23(10):1515-9.
14. Strong AT, Sharma G, Nor Hanipah Z, Tu C, Brethauer SA, Schauer PR, et al. Adjustments to warfarin dosing after gastric bypass and sleeve gastrectomy. *Surg Obes Relat Dis* 2018;14(5):700-6. Epub 2018 Jan 2.
15. Moore KT, Kröll D. Influences of obesity and bariatric surgery on the clinical and pharmacologic profile of rivaroxaban. *Am J Med* 2017;130(9):1024-32. Epub 2017 Jun 8.
16. Kushnir M, Gali R, Alexander M, Billett HHH. Efficacy and safety of direct oral factor Xa inhibitors in patients after bariatric surgery. *Blood* 2019;134(Suppl 1):2439.
17. Bays H, Kothari SN, Azagury DE, Morton JM, Nguyen NT, Jones PH, et al. Lipids and bariatric procedures part 2 of 2: scientific statement from the American Society for Metabolic and Bariatric Surgery (ASMBS), the National Lipid Association (NLA), and Obesity Medicine Association (OMA). *Surg Obes Relat Dis* 2016;12(3):468-95. Epub 2016 Jan 12.
18. Ties JS, Zlabek JA, Kallies KJ, Al-Hamadini M, Kothari SN. The effect of laparoscopic gastric bypass on dyslipidemia in severely obese patients: a 5-year follow-up analysis. *Obes Surg* 2014;24(4):549-53.
19. Saul D, Stephens D, de Cássia Hofstätter R, Ahmed L, Langhoff E, Heimann TM. Preliminary outcomes of laparoscopic sleeve gastrectomy in a Veterans Affairs medical center. *Am J Surg* 2012;204(5):e1-6. Epub 2012 Aug 14.
20. Hinojosa MW, Varela JE, Smith BR, Che F, Nguyen NT. Resolution of systemic hypertension after laparoscopic gastric bypass. *J Gastrointest Surg* 2009;13(4):793-7. Epub 2008 Dec 3.
21. Moloney BM, Hynes DA, Kelly ME, Iqbal A, O'Connor E, Lowe D, et al. The role of laparoscopic sleeve gastrectomy as a treatment for morbid obesity; review of outcomes. *Ir J Med Sci* 2017;186(1):143-9. Epub 2016 Jul 28.
22. Eisenberg D, Bellatorre A, Bellatorre N. Sleeve gastrectomy as a stand-alone bariatric operation for severe, morbid, and super obesity. *JLS* 2013;17(1):63-7.
23. Roerig JL, Steffen K, Zimmerman C, Mitchell JE, Crosby RD, Cao L. Preliminary comparison of sertraline levels in postbariatric surgery patients versus matched nonsurgical cohort. *Surg Obes Relat Dis* 2012;8(1):62-6. Epub 2010 Dec 15.
24. Hamad GG, Helsel JC, Perel JM, Kozak GM, McShea MC, Hughes C, et al. The effect of gastric bypass on the pharmacokinetics of serotonin reuptake inhibitors. *Am J Psychiatry* 2012;169(3):256-63.
25. Krieger CA, Cunningham JL, Reid JM, Langman LJ, Grothe KB, Clark MM, et al. Comparison of bioavailability of single-dose extended-release venlafaxine capsules in obese patients before and after gastric bypass surgery. *Pharmacotherapy* 2017;37(11):1374-82. Epub 2017 Oct 10.
26. Roerig JL, Steffen KJ, Zimmerman C, Mitchell JE, Crosby RD, Cao L. A comparison of duloxetine plasma levels in postbariatric surgery patients versus matched nonsurgical control subjects. *J Clin Psychopharmacol* 2013;33(4):479-84.
27. Lexi-Drugs [database online]. *Bupropion*. Philadelphia, PA: Wolters Kluwer Health.
28. Gunay Y, Jamal M, Capper A, Eid A, Heitshusen D, Samuel I. Roux-en-Y gastric bypass achieves substantial resolution of migraine headache in the severely obese: 9-year experience in 81 patients. *Surg Obes Relat Dis* 2013;9(1):55-62. Epub 2012 Jan 21.
29. Bond DS, Vithianathan S, Nash JM, Thomas JG, Wing RR. Improvement of migraine headaches in severely obese patients after bariatric surgery. *Neurology* 2011;76(13):1135-8.

30. Sikka N, Wegienka G, Havstad S, Genaw J, Carlin AM, Zoratti E. Respiratory medication prescriptions before and after bariatric surgery. *Ann Allergy Asthma Immunol* 2010;104(4):326-30.
31. Van Huisstede A, Rudolphus A, Castro Cabezas M, Biter LU, van de Geijn GJ, Taube C, et al. Effect of bariatric surgery on asthma control, lung function and bronchial and systemic inflammation in morbidly obese subjects with asthma. *Thorax* 2015;70(7):659-67. Epub 2015 Apr 30.
32. Farias MM, Achurra P, Boza C, Vega A, de la Cruz C. Psoriasis following bariatric surgery: clinical evolution and impact on quality of life on 10 patients. *Obes Surg* 2012;22(6):877-80.
33. Sako EY, Famenini S, Wu JJ. Bariatric surgery and psoriasis. *J Am Acad Dermatol* 2014;70(4):774-9. Epub 2014 Jan 7.
34. Chan G, Hajjar R, Boutin L, Garneau PY, Pichette V, Lafrance JP, et al. Prospective study of the changes in pharmacokinetics of immunosuppressive medications after laparoscopic sleeve gastrectomy. *Am J Transplant* 2020;20(2):582-8.
35. Schulman AR, Chan WW, Devery A, Ryan MB, Thompson CC. Opened proton pump inhibitor capsules reduce time to healing compared with intact capsules for marginal ulceration following Roux-en-Y gastric bypass. *Clin Gastroenterol Hepatol* 2017;15(4):494-500. Epub 2016 Oct 20.
36. Amouyal C, Buysse M, Lucas-Martini L, Hirt D, Genser L, Torcivia A, et al. Sleeve gastrectomy in morbidly obese HIV patients: focus on anti-retroviral treatment absorption after surgery. *Obes Surg* 2018;28(9):2886-93.
37. Fysekidis M, Cohen R, Bekheit M, Chebib J, Boussairi A, Bihan H, et al. Sleeve gastrectomy is a safe and efficient procedure in HIV patients with morbid obesity: a case series with results in weight loss, comorbidity evolution, CD4 count, and viral load. *Obes Surg* 2015;25(2):229-33.
38. MacBrayne C, Blum JD, Kiser JJ. Tenofovir, emtricitabine, and darunavir/ritonavir pharmacokinetics in an HIV-infected patient after Roux-en-Y gastric bypass surgery. *Ann Pharmacother* 2014;48(6):816-9. Epub 2014 Mar 10.
39. Rocha ALL, Campos RR, Miranda MMS, Raspante LBP, Carneiro MM, Vieira CS, et al. Safety of hormonal contraception for obese women. *Expert Opin Drug Saf* 2017;16(12):1387-93. Epub 2017 Oct 11.
40. Curtis KM, Jamieson DJ, Petersen HB, Marchbanks PA. Adaptation of the World Health Organization's *Medical Eligibility Criteria for Contraceptive Use* for use in the United States. *Contraception* 2010;82(1):3-9. Epub 2010 Mar 29.
41. Evra [product monograph]. Toronto, ON: Janssen Inc; 2018.
42. Westhoff CL, Torgal AH, Mayeda ER, Petrie K, Thomas T, Dragoman M, et al. Pharmacokinetics and ovarian suppression during use of a contraceptive vaginal ring in normal-weight and obese women. *Am J Obstet Gynecol* 2012;207(1):39.e1-6. Epub 2012 Apr 28. Erratum in: *Am J Obstet Gynecol* 2013;208(4):326.
43. Padwal R, Brocks D, Sharma AM. A systematic review of drug absorption following bariatric surgery and its theoretical implications. *Obes Rev* 2010;11(1):41-50. Epub 2009 Jun 2.
44. Chan LN, Lin YS, Tay-Sontheimer JC, Trawick D, Oelschlager BK, Flum DR, et al. Proximal Roux-en-Y gastric bypass alters drug absorption pattern but not systemic exposure of CYP3A4 and P-glycoprotein substrates. *Pharmacotherapy* 2015;35(4):361-9. Epub 2015 Mar 10.
45. Brill MJ, van Rongen A, van Dongen EP, van Ramshorst B, Hazebroek EJ, Darwich AS, et al. The pharmacokinetics of the CYP3A substrate midazolam in morbidly obese patients before and one year after bariatric surgery. *Pharm Res* 2015;32(12):3927-36. Epub 2015 Jul 23.

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