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ORIGINAL CONTRIBUTIONS

Bowel Reconstruction to Treat Chronic Diarrhea and Hypoproteinemia Following Single Anastomosis Duodenal-Ileal Bypass with Sleeve Gastrectomy: a Single-Site Experience

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Abstract

Background Single anastomosis duodenal-ileal bypass with sleeve gastrectomy (SADI-S) is a modification of the biliopancreatic diversion with duodenal switch (BPD-DS) surgery. A concern with SADI-S is chronic diarrhea and hypoproteinemia. Common channel lengthening (CCL) is a surgical procedure to increase absorption in the small intestine to decrease diarrhea.

Objectives The aim of this study was to assess the occurrence and treatment of hypoproteinemia and chronic diarrhea with CCL following SADI-S surgery.

Setting Private practice in the USA.

Methods Patients were included if they underwent SADI-S from September 2013 to March 2018 and following surgery underwent CCL.

Results Average operating time for laparoscopic CCL is 56.5 ± 4.6 min. The average bowel movements for the eight patients before laparoscopic CCL were 9.1 ± 4.7 a day. After the surgery, the bowel movements were reduced to 2.6 ± 0.4 a day. This difference was found to be statistically significantly different ($p = .002$). The two patients experiencing hypoproteinemia improved protein levels following CCL.

Conclusion CCL is an effective way to treat symptomatic chronic diarrhea after SADI-S when conservative treatments have failed.

Keywords SADI-S · Chronic diarrhea · Hypoproteinemia · Common channel lengthening · Bowel reconstruction

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Introduction

Presently, surgical procedures are the only long-term solution for treating morbid obesity. However, with each type of surgery, there are unique risks. The single anastomosis duodenal-ileal bypass with sleeve gastrectomy (SADI-S) is a modification of traditional biliopancreatic diversion with duodenal switch (BPD-DS). The difference between SADI-S surgery and traditional BPD-DS surgery has been described in previous work [1]. Treatment for hypoproteinemia and chronic diarrhea following SADI-S involves lengthening the common channel by redoing the duodenal ileostomy [2–5].

Since mid-2013, our group has performed over 600 SADI-Ss. A common concern with intestinal modifications found in SADI-S and BPD-DS is the risk of malnourishment and chronic diarrhea. Previous studies have shown rates of malnutrition with these procedures to be 1.3–1.6% for SADI-S surgery and 1.4–8.2% for BPD-DS [6–8]. Previous studies have

also shown the rate of chronic diarrhea to be 1.6–5.6% for SADI-S surgery and 11.5–12% for BPD-DS [1, 6, 7, 9].

The aim of this study was to assess the effect of common channel lengthening (CCL) to treat chronic diarrhea and hypoproteinemia following SADI-S surgery.

Methods

This is a retrospective review of a prospectively gathered database from a single private practice. Patients were included if they underwent SADI-S either as a primary or revisional procedure from September 2013 to March 2018 followed by a CCL procedure. Three surgeons performed SADI-S and two surgeons performed CCL in two outpatient surgical centers and a local hospital. A standardized technique is used by all three surgeons and has been described previously [1, 2, 10–13].

The indications for CCL surgery include but are not limited to chronic diarrhea and chronic hypoproteinemia. We define chronic diarrhea as four or more loose stools per day for at least 4 weeks. We define chronic hypoproteinemia as protein levels below 6.3 g/dL despite conservative management with dietary counseling.

Nutritional, weight, and complication data were gathered for each patient; *t* tests were run using SigmaPlotTM (Systate Software Inc., headquartered in San Jose, CA) statistical software.

Results

There were nine patients who required CCL out of 780 primary and revisional SAD-S patients. Seven patients required CCL because of chronic diarrhea. Two patients required CCL because of hypoproteinemia with no diarrhea. None of these patients had serious vitamin malnutrition issues.

Patient 1

The first patient was a 63-year-old male with a body mass index (BMI) of 38.67 kg/m^2 who underwent SADI-S surgery and achieved a BMI of 22 kg/m^2. The patient was put on a low carb diet, probiotics, Devrom, and Lomotil to help control diarrhea. One year after surgery, the patient underwent CCL to relieve chronic diarrhea (six to eight loose stools/day for 8 weeks). His common channel was lengthened 200 cm. His protein and nutritional status (vitamins A, D, E, K, B1, and B12; albumin; prealbumin; copper; and zinc) were normal. Eighteen months after surgery, the patient is still experiencing normal bowel movement (NBM), which is < 4 BM a day. His BMI had increased from 22 to 27.8 kg/m^2. His percent excess weight loss (%EWL) had decreased by 1.8%.

Patient 2

The second patient was a 41-year-old female with a BMI of 42.93 kg/m^2 who underwent SADI-S surgery and achieved a BMI of 26.5 kg/m^2. The patient was put on a low carb diet, probiotics, Devrom, and Lomotil to help control diarrhea. Two years after SADI-S surgery, the patient underwent CCL to alleviate smelly flatulence, bloating, and chronic diarrhea (ten loose stools/day for 20 weeks). Her common channel was lengthened 200 cm. Fourteen months post-CCL, the patient has normal protein and nutritional status, with NBM. Her BMI had increased from 26.6 to 29.3 kg/m^2. Her %EWL has decreased by 0.28%.

Patient 3

The third patient was a 75-year-old female with a BMI of 42 kg/m^2 who underwent SADI-S and achieved a BMI of 20 kg/m^2. The patient was put on a low carb diet, probiotics, and Lomotil to help control diarrhea. Two years following SADI-S surgery, the patient underwent CCL to treat chronic diarrhea (six loose stools/day for 8 weeks). Her common channel was lengthened 290 cm. Three years post-CCL, the patient has normal protein and nutritional status, with NBM. Her BMI had increased from 20 to 29.6 kg/m^2. Her %EWL had decreased by 1.9%.

Patient 4

The fourth patient was a 28-year-old female with a BMI of 49.3 kg/m^2 who underwent SADI-S surgery and achieved a BMI of 32.9 kg/m^2. The patient was put on a low carb diet, probiotics, and Lomotil to help control diarrhea. One year postoperatively, the patient underwent CCL to treat chronic diarrhea (9–10 loose stools/day). Her common channel was lengthened 150 cm. One year post-CCL, the patient has normal protein and nutritional status, with NBM. Her BMI had decreased from 32.9 to 27.5 kg/m^2. Her %EWL had increased by 0.69%.

Patient 5

The fifth patient was a 70-year-old female with a BMI of 47.3 kg/m^2 who underwent SADI-S surgery and achieved a BMI of 21.6 kg/m^2. The patient was put on a low carb diet, probiotics, Devrom, and Lomotil to help control diarrhea. Two years following SADI-S surgery, the patient underwent CCL to treat chronic diarrhea (4–5 times/day). Her common channel was lengthened 250 cm. Two weeks post-CCL, the patient has normal protein, normal nutritional status except for vitamin D (27.5 ng/mL), and NBM. Her BMI had increased from 21.6 to 30.9 kg/m^2. Her %EWL had decreased by 2.7%.

Patient 6

The sixth patient was a 53-year-old female with a BMI of 49.8 kg/m^2 who underwent SADI-S surgery and achieved a BMI of 20 kg/m^2. The patient was put on a low carb diet, probiotics, and Lomotil to help control diarrhea. Two years following SADI-S surgery, the patient underwent CCL to treat chronic diarrhea (8 times/day for 48 weeks). Her common channel was lengthened 200 cm. The protein and nutritional status were normal. One month after surgery, the patient is still experiencing NBM. Her BMI had increased from 20 to 21.5 kg/m^2. Her %EWL had decreased by 0.3%.

Patient 7

The seventh patient was a 42-year-old female with a BMI of 61.7 kg/m^2 who underwent SADI-S surgery and achieved a BMI of 47.2 kg/m^2. The patient was put on a low carb diet, probiotics, and Lomotil to help control diarrhea. Two years following SADI-S surgery, the patient underwent CCL to treat chronic diarrhea (six to eight times/day). Her common channel was lengthened 150 cm. The protein and nutritional status were normal. Thirty months after surgery, the patient is still experiencing NBM. Her BMI had decreased from 47.2 to 40.4 kg/m^2. Her %EWL had increased by 0.31%.

Patient 8

The eighth patient was a 73-year-old male with a BMI of 41.1 kg/m^2 who underwent SADI-S surgery and achieved a BMI of 18.5 kg/m^2. The patient began experiencing a major depressive disorder 2 years after surgery and refused intake of solid foods. Multiple attempts at dietary intervention, nasojejunal feeding tube, and office counseling did not help resolve hypoproteinemia. Medications were not helping his chronic severe depression. Three years following SADI-S surgery, the patient underwent CCL to treat his hypoproteinemia (5.6 g/dL). His common channel was lengthened from 400 cm from the ileocecal valve to 70 cm from the ligament of Trietz. The nutritional status was normal except for vitamin D and albumin. One month after surgery, the patient's protein level increased (6.0 g/dL); however, it is still below normal. His BMI remained the same at 18.5 kg/m^2. He had no change in %EWL in this short time period.

Patient 9

The ninth patient was a 40-year-old male with a BMI of 58.47 kg/m^2 who underwent SADI-S surgery and achieved a BMI of 28.9 kg/m^2. Multiple attempts at dietary intervention, feeding tube, and office counseling did not help resolve hypoproteinemia. Two years following SADI-S surgery, he underwent CCL to treat hypoproteinemia (5.1 g/dL). His common channel was increased 200 cm. The patient's nutritional status was normal except for vitamins D, K, E; zinc; and copper. Two months after surgery, the patient's protein level did increase (5.3 g/dL); however, it is still below normal. His BMI increased from 28.9 to 34.2 kg/m^2. His %EWL had decreased 2.37%.

The average blood loss was less than five cc in all nine cases. The average operating time was 56.5 ± 4.6 min for laparoscopic CCL procedure.

The seven patients that received laparoscopic CCL for chronic diarrhea have resolution of the condition. The average bowel movements before laparoscopic CCL for these seven patients with chronic diarrhea were 7.1 ± 2.5 per day. After the surgery, the bowel movements were reduced to 2.625 ± 0.4 per day. This difference was found to be statistically significantly different ($p = .002$). In patient 8, the protein levels improved from 5.6 to 6.0 g/dL. In patient 9, the protein levels improved from 5.1 to 5.3 g/dL and his peripheral edema resolved. Complications followed the CCL surgeries are listed in Table 1. Weight loss was good for all patients (Table 2).

Discussion

One of the things that most surprised us during the course of gathering data was how long it took for these cases to present. In most instances, patients had been having diarrhea since surgery but were too enamored with their weight loss or assumed it was normal. Once they did present, we attempted conservative management first.

First, we always attempt dietary manipulation. Usually, post-SADI-S diarrhea is accompanied by intake of carbohydrates. Patients need to be advised against eating breads, pastas, and cereals. This almost always solves the problem of diarrhea. We also look for previously unidentified lactose intolerance, gluten intolerance, and celiac sprue.

If these dietary interventions prove negative, we try probiotics. We admit that probiotics treatment is in its infancy. The how, why, how much, and what types of bacteria are still hotly debated. In our practice, the probiotics work to alleviate diarrhea in many patients if the probiotics have more than three types of bacteria and are taken three times a day for 3 weeks before any further intervention is performed.

If the probiotics fail, we usually turn to Lomotil (3 weeks) which works in many cases. Additionally, Devrom, a medication manufactured to treat smelly stools, has helped some patients control diarrhea. Usually, these patients are placed on Devrom for 2 weeks. We had all patients who complain of diarrhea try this inexpensive over the counter medication before they contemplate surgery. Other surgeons have advocated for the use of pancreatic enzymes also in these situations however, we do not have any experience with these enzymes

Table 1 Outcomes with bowel reconstruction

Patient (no.)	Preoperative CCL/CCS			Postoperative CCL/CCS		
	Indication	Detail	Common channel length (cm)	Common channel length (cm)	Short-/long-term complication	Outcome
1	Diarrhea	6–8 loose stools a day	330	530	None	NBM
2	Diarrhea	10 loose stools a day	350	550	None	NBM
3	Diarrhea	6 loose stools a day	160	450	Small-bowel enterotomy	NBM
4	Diarrhea	9–10 loose stools a day	400	550	None	NBM
5	Diarrhea	4–5 loose stools a day	300	550	None	NBM
6	Diarrhea	8 loose stools a day	400	600	None	NBM
7	Diarrhea	6–8 loose stools a day	300	450	None	NBM
8	Hypoproteinemia	5.6 g/dL	400	870	None	Protein levels improved but below normal (6.0 g/dL)
9	Hypoproteinemia	5.1 g/dL	185	385	Kwashiorkor	Protein levels improved but below normal (5.5 g/dL)

EBWL excess body weight loss, *BMIR* body mass index reduction, *NBM* (normal bowel movement) = 2–3 bowel movement/day

for the treatment of diarrhea. If none of these interventions work, the patients are given the option of CCL.

Patient 9 with hypoproteinemia had played college football. He had a very large amount of muscle mass. He consumed > 100 g of protein a day. His common channel was miscounted at the time of the original surgery and his common channel length of 185 cm was simply not long enough to allow adequate uptake of protein for a man that muscular. Interestingly, he had no diarrhea and only mild abnormalities in his labs. We also miscounted another time causing the patient to have to return to the operating room. Since our second experience, we have increased the length of stretch we put on the small bowel while counting to ensure that this mistake does not happen again.

However, accurate counting does not rule out diarrhea or hypoproteinemia. Seven of our nine patients who presented with diarrhea or hypoproteinemia had common channels of greater than or equal to 300 cm. We have never pretended to know the "best" length for each patient. Our choice of 300 cm was not arbitrary but based on the work of Sánchez-Pernaute et al. His rates of malnutrition went from 8 to 0% when he went from 200 to 250 cm common channel; however, abnormal rates of albumin (13.7%) and protein (34%) were high [4, 14]. A 300-cm common channel in our series has lowered the rate of primary diarrhea to 1%, albumin abnormal levels to 7.7%, and protein abnormal levels to 10.3% (average protein levels at 4 years, 6.6) [6]. This to us seems an appropriate tradeoff for good weight loss. Ultimately, it is going to be a

Table 2 Weight loss

Patient (no.)	SADI-S	Preop CCL				Postop CCL				
	Preop BMI (kg/m^2)	Last available f/u since SADI-S (day)	BMI (kg/m^2)	% EWL	Change in BMI (+/−)	Time since surgery without complaint	Last available f/u since CCL (day)	BMI (kg/m^2)	% EWL	Change in BMI (+/−)
1	38.6	230	22	104.7	− 16.6	788	974	27.4	1.8	5.32
2	42.9	853	28.3	63.1	− 14.6	795	981	29.3	− 0.28	0.94
3	42	524	20	100.5	− 22	1306	1492	29.6	1.9	9.62
4	49.3	216	32.9	56.6	− 16.4	221	407	27.5	0.69	− 5.46
5	47.3	763	21.6	94.2	− 25.8	178	358	30.9	2.7	9.29
6	49.8	679	20	106.1	− 29.8	409	51	21.5	0.30	1.52
7	61.7	120	47.2	34.8	− 14.5	1061	865	40.4	0.31	− 6.80
8	41.1	601	18.5	123.3	− 22.5	690	16	18.5	0	0
9	58.5	560	28.9	86.9	− 30.7	1291	58	34.2	− 2.37	6.46

All the patients had regained weight following CCL

SADI-S stomach intestinal pylorus sparing, *CCL* common channel lengthening, *BMI* body mass index, *EWL* excess weight loss

decision that has to be discussed with the patient on how much risk versus the reward of greater weight loss.

We had a low complication rate in performing these revisions but we would not say they are easy to perform. It is still revisional surgery with all its potential complications.

Due to a low follow-up rate, there was only five out of the nine patients that followed up at 18 months. The average BMI gain following CCL was 1.3 kg/m^2. The final BMI of these five patients was 31.6 kg/m^2.

The primary limitations of this study were having a small sample size and a low follow-up rate at 18 months. The small sample size limits the generalization that can be made from this study and makes it difficult for us to say how CCL affects long-term weight recidivism. Despite this, the reason for intervention in seven patients was resolved immediately and in the other two, the protein levels were trending in the right direction within 2 months of surgery.

We also do not follow the bowel movements of our patients in a rigorous fashion. Hence, we cannot tell the reader if having six or more bowel movements a day occurs in a lot of our patients or very few. Interventions were solely based on complaints.

Conclusion

CCL is an effective procedure for treating chronic diarrhea following SADI-S. It also can be used to help patients with protein deficiencies.

Compliance with Ethical Standards

Conflict of Interest Author 1 has no conflicts of interest to declare.

Author 2, the corresponding author, reports personal fees from Medtronic, outside the submitted work.

Author 3 has no conflicts of interest to declare.

Author 4 has no conflicts of interest to declare.

Author 5 has no conflicts of interest to declare.

Author 6 has no conflicts of interest to declare.

Author 7 has no conflicts of interest to declare.

Statement of Human and Animal Rights All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study.

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