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ORIGINAL CONTRIBUTIONS

Biliopancreatic Diversion-Duodenal Switch: Independent Contributions of Sleeve Resection and Duodenal Exclusion

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Abstract
Background The choice of first-stage operation in biliopancreatic diversion with duodenal switch (BPD-DS) is controversial. There are no published long-term comparisons of one- and two-stage BPD-DS outcomes.
Methods During 2001–2009, among 1,762 patients scheduled for BPD-DS 48 had duodenal switch (DS) and 53 sleeve gastrectomy (SG) as first-stage procedures. We compared prospectively updated outcomes of 42 DS (100 % open) and 49 SG (88 % laparoscopic), 13 of whom completed their second stage, to a control group of 91 patients with open one-stage BPD-DS.
Results One-year mean percent excess weight loss (%EWL) was greater after SG than DS (47±19 vs. 39±13 SD; $p=0.01$) with earlier nadir (16±10 vs. 45±30 months; $p<0.0001$) but more rapid significant weight regain. After 5 years, %EWL was 12±35 for 9 SG, 45±19 for 30 DS ($p<0.0006$), and 70±18 for the first-stage BPD-DS ($p<0.0001$). Weight loss was less after two- than one-stage procedures ($p<0.02$). Comorbidities improved progressively between SG, DS and BPD-DS ($p<0.001$ for trend). HbA1C decreased by 10, 19, and 31 %, respectively ($p<0.0001$). Dyslipidemia was cured in 41, 82, and 100 %, respectively. Systolic and diastolic blood pressure decreased only after DS (12 %; $p<0.0002$). Patient satisfaction was similar for SG and DS but greater after BPD-DS overall ($p=0.04$).
Conclusions SG and DS independently contribute to beneficial metabolic outcomes after BPD-DS. Long-term weight loss and correction of metabolic abnormalities were better after DS favoring its use as first stage in BPD-DS; one-stage BPD-DS outcomes were superior to two-staged.

Keywords Severe obesity · Cirrhosis · Staged surgery · Metabolic surgery · Intestinal diversion · Sleeve gastrectomy · Duodenal switch

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Introduction

Biliopancreatic diversion was designed as a one-stage open operation to durably decrease fat absorption, preventing the weight regain after purely restrictive operations [1]. To prevent peptic ulcers from biliary diversion, the procedure was accompanied by distal gastric resection adding transient restriction [2]. Scopinaro et al. continue to report prolonged patency of the biliary diversion [3–6]. Hess [7] and our group [8, 9] replaced the distal with a vertical, sleeve, pylorus-preserving gastrectomy to decrease side effects by avoiding rapid emptying and by decreasing parietal cell mass, terming the operation "biliopancreatic diversion with duodenal switch" (BPD-DS).

In the early days of surgical laparoscopy, this complex operation was considered too difficult and time-consuming to perform routinely in a single stage in the heaviest patients [10, 11], prompting the suggestion for two stages, starting by a sleeve resection which did not require anastomoses [12]. This new approach became rapidly popularized [13–16]. Early weight loss led patients and surgeons to abstain from the second-stage diversion although its long-term efficacy had not yet been established.

The respective contributions of gastrectomy and diversion to long-term weight loss and comorbidity improvement have

not been determined. Over the years, we have performed 101 partial BPD operations, 48 as duodenal bypass or DS alone and 53 as sleeve gastrectomy (SG). Here, we study these patients to better understand the role of each component of BPD-DS.

Methods

Subjects

Between January 2001 and September 2009, among 1,762 patients scheduled for BPD-DS, 48 had duodeno-jejunal diversion or DS alone and 53 SG alone. The majority of these patients did not undergo a second, completion stage. After excluding seven deaths and three unavailable patients, the study group was composed of 42 DS and 49 SG (Table 1). This last group will serve for evaluating long-term effects. There was one postoperative death and higher late mortality in DS group owing to differences in age, sex, length of follow-up, baseline comorbidities, and disease severity. A control group of 91 patients with non-reoperated, i.e., primary open one-stage BPD-DS was matched for age, sex, and BMI.

Evaluation consisted in an office visit (exceptionally by phone call <5 %), blood analysis, and completion of a written or oral questionnaire on side effects, present medication use, and degree of satisfaction (completed by 83 %). Our electronic databank with prospectively collected data includes weight, comorbidities, complications, rehospitalizations, reoperations, side-effects, medication use, and lab work. Weight loss follow-up is based on the latest recorded weight measurement except as noted. The length of follow-up for side effects, laboratory data, and satisfaction ratings refers to 2011–2012. Satisfaction was measured on a scale of 1 to 5 (5=most satisfied) regarding overall satisfaction, weight loss, and side effects.

This study was approved by the Laval University and Laval Hospital Ethics Committee. All individuals initially provided written informed consent for conservation of data and tissue to facilitate clinical follow-up and research.

Table 1 Clinical characteristics of duodenal switch and sleeve gastrectomy

	DS (n=42)	SG (n=42)	p
Study group[a]			
Age	58.8±8.0	47.3±10.2	0.0001
Sex % men	67	41	0.06
Initial wt (kg)	143.9±25.2	139.3±36.2	0.50
Initial BMI kg/m^2	52.5±9.0	50.4±10.8	0.32
%Excess wt loss	41.5±18.2	39.3±25.8	0.64
FU duration	72.9±25.1	42.5±17.3	0.006
Open approach %	100	10	
Comorbidities[b]			
	n (%)	n (%)	
Diabetic %	30 (71)	23 (47)	0.02
Insulin %	13 (31)	4 (8)	0.007
Cirrhosis %	16 (33)	0	0.0001
HTA$^{\Psi}$ with medication %	37 (88)	32 (65)	0.014
Anti cholesterol medication %	17 (40)	12 (24)	0.12
Cardiac index >4 %	10 (4)	23 (47)	0.03

$^{\Psi}$ *HTA* arterial hypertension

[a] After exclusions of seven deaths (DS, cardiac, 10 days; cancer, 4 years; cardiac, 3 years; renal failure, 4 years; liver failure, 2 years; SG, sudden death 2 years; Parkinson, 4 years

[b] Before exclusion

Operations and Follow-Up

We have performed BPD-DS using the same technique via laparoscopy or laparotomy for the past 33 years. SG and DS were done in the same manner whether the procedure was partial or complete. The weight of the resected stomach, which influences protein digestion [17] was 122.6±31.9 g for 48 SG and 121.6±34.3 for 34 randomly chosen BPD-DS. A bougie was used to preserve a sufficient gastric lumen and not to narrow it, and its size was not recorded. The alimentary limb was always 250 cm and the common channel was 100 cm [9]. Multivitamins were routinely prescribed and adjusted according to routinely obtained blood analysis. All patients with duodenal switch received additional vitamins A, D, calcium, iron, and proton pomp inhibitors.

Weights were recorded once yearly. Percent excess weight loss (%EWL) was calculated using the formula: [(preoperative weight−current weight)/(preoperative weight−ideal weight)×100], where "ideal weight" was calculated=(the square of patient's height in centimeter/10,000)×23 [18].

Choice of Operation

The decision to proceed with the second stage as originally planned depended on patient satisfaction with weight loss, persistence of comorbidities, general health, and age. The reason for choosing DS as the first stage was presence of the metabolic syndrome or occasionally to avoid dissecting a predissected gastric region. The reason for choosing SG was to avoid dissecting an already affected small bowel region or, in the laparoscopic era, the greater ease of performing SG and early beneficial reports of SG as stand-alone procedure. Before 2006, DS was chosen in 33 versus 3 cases and after 2006 SG in 48 versus 15. Specific reasons for performing only one stage are listed in Table 2.

Table 2 Reasons for staging the procedure; study group

		n
Sleeve alone (*n*=49)		
Before surgery	Patient choice	11
	Expected noncompliant patient (surgeon's choice)	18
	BMI<37	2
	Severity of comorbidity	10
During laparoscopy	Technical difficulties (hernia/adhesions, 2; bleeding, 2; tissue friability, 4)	8
Switch alone (*n*=42)		
Before surgery	Severity of comorbidity	9
	Diagnosed cirrhosis	3
	Cancer in remission	1
During laparotomy	Technical difficulty (Duod anastomosis 5, exposure 6, anesthesia 1)	12
	Unexpected pathology	5
	Emergency surgery	2
	Pre-existing Nissen	4
	Unexpected cirrhosis	6

Statistics

We calculated means±standard deviation (SD) or percentages for continuous or categorical variables, respectively, the latter analyzed using Fischer's exact test or chi-square. Unpaired observations of continuous variables were analyzed with Student's *t* test. Patient survey scores were collected on a five-point Likert scale; a parametric mean per survey category was calculated to estimate centricity of the population response, while nonparametric contingency chi-square probabilities were calculated to decide on statistical significance of the observed response differences between groups. Results were considered significant with p values ≤0.05. The data were analyzed using the statistical package program SAS version 9.1.3 (SAS Institute Inc., Cary, NC, USA).

Results

Diversion alone (DS) was elected for older and sicker men with more advanced comorbidities (Table 1). There were no between-group differences in complications, rehospitalizations, reoperations, bone fractures, peptic ulcers, urolithiasis, or cancer prevalence. There were no differences whether staging of the procedure was elective or ad hoc.

Weight Loss

Early weight loss was more rapid after SG than DS. At 1 year, %EWL was 47±19 vs. 39±13 (p<0.0001), and weight loss nadir was earlier: 16±10 vs. 45±30 months (p<0.0001). At 3 years, %EWL was the same for DS and SG (44±14, 44±21) and it was 72±16 in 91 one-stage BPD-DS (p<0.0001). Between years 1 and 4, regain of %EWL after SG was 14±18 vs. 2±12 for DS (p=0.002). In the long term (>5 years) using the last recorded weight, %EWL for nine SG patients was 12±34 after 77±22 months; for 30 DS patients, it was 45±19 after 88±19 months (p<0.0006) and for 86 BPD-DS it was 70±18 (Fig. 1). Combining the groups with SG and DS, using present weight if not reoperated (n=81) and weight before reoperation if reoperated (n=10) %EWL was 40±22.5 with only 32 % losing more than 50 %EWL compared to %EWL of 71.3±16.6 in the 91 control patients with 90 % losing more than 50 %EWL (p<0.0001).

At *second stage*, completion operation was performed in 13 patients—an SG was added to a DS in 8 patients after a mean of 22±11 months at a mean of 33 %EWL and a DS was added to a sleeve in 5 patients after a mean of 28±10 months at 25 %EWL (ns). Adding SG to a DS resulted in an additional 28 %EWL after 65 months versus adding a DS to a SG resulted in an additional 31 %EWL after 42 months (ns). In aggregate, these 13 patients have lost 59±22 %EW, 60 months after a two-stage BPD-DS compared to a loss of 77.4±15.5 (p=0.02) by a control group of 13 patients matched for age sex and BMI 65 months after a one-stage BPD-DS. This implies that one-stage BPD-DS is more effective than two-stage regardless of choice of first stage.

Comorbidities

Diabetes There were 30 diabetics in the DS and 23 in the SG group. Despite the greater severity (insulin-dependent 30 vs. 8; p=0.007) and longer duration of the disease (patients' age 59 vs. 47 years; p<0.0001) in the DS group, remission (medication ceased) was 19/30 after 83.8±23.4 months after DS vs. 17/23 among SG (60.1±17.4 months; p=0.55). Discontinuation of insulin, 8/13 vs. 3/4, and of oral hypoglycaemic medication, 15/20 vs. 7/16 (p=0.087), were similar. The magnitude of improvements after both or either of DS or SG was about half of that seen after one-stage BPD-DS (37/37). HBA1c levels of non-reoperated patients were decreased by 10 % (0.063 to 0.057) in 40 SG patients 31 months after surgery; 19 % (0.066 to 0.054) in 32 DS, 64 months after surgery; and 31 % in BPD-DS patients (17 preop (0.068) and 27 postop (0.047); p<0.0001) 118 months after surgery.

Lipid Profile The magnitude of improvements in lipid profile is presented in Table 3. The decrease in total and low density cholesterol was more pronounced after DS than SG. Dyslipidemia was in remission in 41 % (5/12) after SG, 82 % (14/17) after DS, and 100 % (20/20) after BPD-DS.

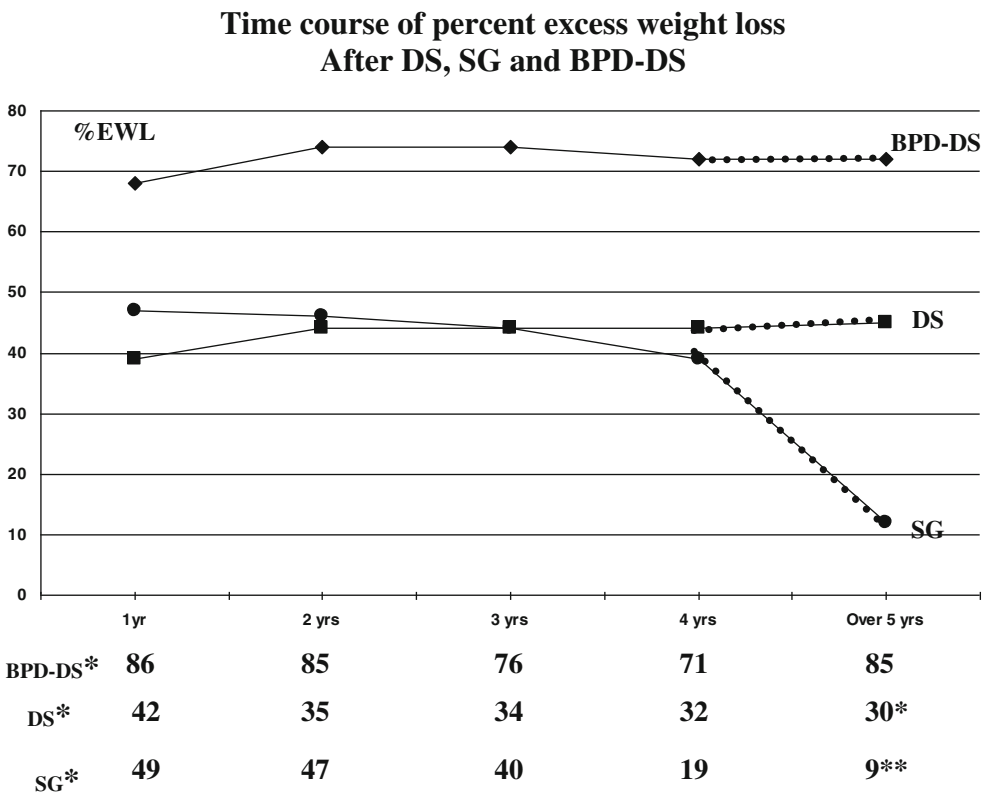

Fig. 1 Time course of percent excess weight loss; after DS, SG, and BPD-DS

Table 3 Improvement in different elements of the metabolic syndrome after DS, SG, and BPD-DS at 3 years

	DS *n* (%)	SG *n* (%)	*p*[a]	BPD-DS *n* (%)	*p*[b]
Medication ceased					
Diabetes	20/30 (67)	15/23 (65)	0.55	37/37 (100)	0.001
Dyslipidemia	14/17 (82)	5/12 (41)	0.05	20/20 (100)	0.07
HTA	12/37 (32)	8/32 (25)	0.60	37/66 (56)	0.02
Metab syndrome[c]	4/14 (29)	2/5 (40)	ns	9/12 (75)	0.05
Improvement in means (*n*=DS/SL 37/25)					
TC[d] dernier	4.7/3.5 (23)	4.8/4.3 (7)	0.03	4.9/3.5 (26)	ns
LDL[d] decrease	2.6/1.8 (20)	2.8/2.1 (4)	0.005	2.9/1.8 (35)	0.02
HDL[d] change	1.3/1.1 (6)	1.2/1.3 (8)	0.03	1.3/1.2 (2)	ns
TRI[d] decrease	1.9/1.8 (8)	1.8/1.6 (6)	0.85	1.8/1.2 (27)	0.08
CTO/HDL[e] decrease	4.2/3.3 (16)	4.1/3.5 (12)	0.57	4.0/3.0 (20)	ns
HBA1c[e] decrease	0.063/0.054 (19)	0.063/0.057 (10)	0.06	0.068/0.047 (31)	0.08

TC total cholesterol, *LDL* low-density cholesterol, *TG* triglyceride, *HDL* high-density cholesterol

[a] Difference between DS and SG

[b] Difference between DS and BPD-DS

[c] Metabolic syndrome treatment of all 3 (diabetic, dyslipidemic, HTA)

[d] Millimole per liter

[e] Ratio

Hypertension After DS or SG, 92 % of patients treated for hypertension had reduced medication requirements. However, with or without medication, the reduction between preoperative and most recent blood pressure was 11 % (146±16 to 130±16 mmHg; $p<0.0003$) in systolic and 12 % in diastolic pressure (81±10 to 71±11 mmHg; $p<0.0002$) after DS with no change after SG for systolic (130.9±16 to 130±10 mmHg and diastolic (82±18.3 to 78.4±9.3 mmHg). Improvement rates of hypertension were 9/19 for the study group and 12/12 for the control group ($p<0.004$).

Metabolic Syndrome Metabolic syndrome is defined by NCEP criteria [19] upon which several organizations have based their definition, viz. as the association of diabetes, dyslipidemia, and hypertension with obesity. For practical purposes, we chose patients on drug treatment for all three related comorbidities (diabetes, dyslipidemia, and hypertension) in the presence of obesity, since very few had comorbidities controlled by diet and exercise alone when accepted for surgery. We defined cure as cessation of treatment with normalization of all parameters. Improvement in the metabolic syndrome was greater after DS than SG for both glycemic and 161 lipid profile (Table 3).

Among the 91 patients in the study group (42 DS/49 SG), 6 of 19 or 32 % with metabolic syndrome were cured, whereas in the one-stage control group ($n=91$) the syndrome was cured in 9 of 12 or 75 % ($p<0.029$). Cure rates in DS, 4/14, and SG, 2/5, were similar, in line with the whole study group (ns).

Cirrhosis Four cirrhotic DS patients among 13 died (cardiac postoperative day 10, liver failure after 2 years, cardiac after 3, and cancer after 4 years). In nine patients, DS was beneficial; seven underwent DS alone as the first stage of BPD-DS and are doing well. Two others were submitted to a second stage and had a second intraoperative liver biopsy. The grade of fibrosis had decreased from 4 to 2 in one and the other patient remained stable at 4. Plasma gamma-glutamyl-transferase (GGT) decreased by 45 % (118 to 53.7 μ/L ($p<0.002$) after 77 months in 7/9 but increased by 68 % in 2/9 after 62 months.

Side-Effects, Nutritional State, Satisfaction These were evaluated after 31 months in 38 SG, after 64 months in 32 DS, and after 108 months in 61 BPD-DS patients. Daily stools were more frequent after DS (3.1 vs. 1.4) but the incidence of diarrhea (liquid stools >3 times daily) was similar (26 %) after each procedure. Malodorous flatulence was present in 40 % of DS patients but none after SG. Vomiting more than once/week was present in 16 % after SG but absent after DS (Table 4). Calcemia below normal (<2.15 mmol/l) with a PTH >100 ng/l was present in 2/32 (6 %); 64.2±22.2 months after DS and in 6/85 (7 %) 118±50 months after BPD-DS. Side effects were the same after BPD-DS and DS except for an increase in dyspepsia (Table 4).

Side effects did not affect the degree of satisfaction which was similar in both groups overall and in regard to weight loss. However, both scores were significantly better after BPD-DS—for weight loss, 2.7 vs. 3.5 ($p<0.001$) and overall, 3 vs. 3.5 ($p=0.04$).

Table 4 Prevalence of side effects; after DS ($n=35$ at 64 months), SG ($n=38$ at 31 months), and BPD-DS ($n=61$ at 108 months)

	DS *n* (%)	SG *n* (%)	*p**	BPD-DS *n* (%)	*p***
Vomiting>once/week	0/27	5/31 (16)	0.0001	4/61 (7)	0.30
Dyspepsia	2/25 (8)	11/29 (38)	0.01	20/57 (35)	0.01
Anti-ulcer medication	13/25 (52)	9/30 (30)	0.10	29/59 (49)	1.0
Number of stools per day	3.1	1.4	0.0001	3.4	–
Liquid stool more than 3 days/week	6/25 (24)	6/26 (23)	–	12/58 (21)	0.8
Use of antidiarrheic medication	4/24 (17)	2/26 (8)	0.40	6/56 (11)	0.5
Bloating: more than once a week	12/27 (44)	9/28 (32)	0.40	25/56 (44)	0.4
Malodorous gas: major problem	11/26 (42)	0/30	0.0001	13/58 (22)	0.07
Frequency of stools: major problem	3/26 (12)	0/29	0.10	6/58 (10)	ns
Hernia repair	1	1			
Bone fracture	4	3			
Kidney stone	–	1			
Peptic ulcer	1	0			

*p between DS and SG

**p between DS and BPD-DS

Discussion

This is the first clinical report comparing two separate components of the currently performed BPD-DS and comparing outcomes between one- and two-stage BPD-DS. It confirms the effectiveness of intestinal diversion by DS for maintaining weight loss and improving the metabolic syndrome and the early major yet transient weight loss after restriction by gastrectomy originally proposed by Scopinaro [3–6]. Our series differs from a previous report by Cossu et al. with shorter follow-up of less obese diabetic patients [20] where our patients had medically significant greater weight loss without the high prevalence of peptic ulcers reported by Cossu et al.

The 19 SG patients regained weight much faster than those with DS. At 5 years and later, weight loss with SG was only 20 % of that after complete BPD-DS, in accordance with case series of sleeve resection showing substantial weight regain over time [21–24], except for two outliers [25, 26]; one showing an unusual progressive weight loss up to 5 years, contrary to all other reports and the other showing a 30 % weight regain, but only after 5 years. Different factors may influence the rate of weight regain such as patient selection, adherence, and frequency of office visits and extent of gastric resection [27]. Our study and others raise the question of optimal choice of first-stage operation.

Compared to SG, DS gives more permanent weight loss, greater and more durable improvement in the metabolic syndrome including insulin resistance [28], β-cell function [29], and glycemic control [30]. Since metabolic syndrome and cirrhosis are related [31] and reversal of cirrhosis has been shown to occur with correction of the metabolic syndrome [32], it was not surprising that DS as a stand-alone operation, with its greater effect on the metabolic syndrome, was sufficient. Thus, DS appears to be a better first operation in a staged approach. It requires two small bowel anastomoses and is more difficult to perform laparoscopically; the mortality and complication rates were higher than in SG in our series, although the side-effects of intestinal diversion per se were easy to manage and did not affect patient satisfaction. All DS were performed open, and thus were more complication-prone, whereas 90 % of SG were laparoscopic. The observation periods were longer after DS and baseline disease severity, age, and % males were greater among DS.

Our results show that either component of the partial BPD-DS on its own is only half as effective as first-stage BPD-DS. Defining "failure" as less than 50 % excess weight loss and/or need for a second operation, Himpens et al. [21] reported a 64 % failure rate of sleeve gastrectomy at 6 years prompting them to conclude that the SG results are similar to those reported after purely restrictive operations. Our experience is similar.

Maintaining weight loss has always been the main stay of bariatric surgery. Taken together, our limited results question routine use of sleeve gastrectomy as a stand-alone operation or as the first choice in a staged approach, given the considerable risk of weight regain requiring a second operation with the problems of reoperative surgery and the superior outcomes and low mortality of one-stage BPD-DS done by trained surgeons [33–36].

The present retrospective study has limitations. All DS operations were performed open, whereas 88 % of SG were laparoscopic. This affected complications and mortality rates, which however were related to the greater severity of disease in the older predominantly male patients recommended DS. The groups with long-term observation are small, particularly SG with only nine patients beyond 5 years, although 3-year data (in our series 40 patients) appears to be sufficient according to current publishing practices [28]. For BPD-DS observation, time does not appear to be a limitation—our unpublished data on BPD-DS show that there is little change in satisfaction, weight loss, or side effects between 3 and 15 years, in line with our present observations of 30 DS patients during a mean 88±9 months.

We conclude that DS and SG individually contribute to at most half of the early beneficial effects of BPD-DS, whereas DS prevents long-term weight regain and is more effective than SG in durably correcting cardiometabolic comorbidity. Furthermore, one-stage BPD-DS is superior to the staged operation over the long term.

In search for the best risk-benefit ratio and least inconvenience, these results can be interpreted differently depending on many factors including type of patients, severity of disease, surgeons' expertise, etc. We have presented our own view based on our patients' opinions and reflected in our high follow-up rates.

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