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REVIEW

# Single-Anastomosis Duodenal Switch: Conceptual Difference between East and West

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## Abstract

Single-anastomosis duodenal switch (SADS) has become increasingly popular. This review compared the conceptual difference between Eastern (SADS-E) and Western (SADS-W) countries. After searching for SADS through PubMed and high-impact journals, 19 articles with 2280 patients were included for analysis. We found SADS-W was reserved for patients with a high body mass index (BMI) without type 2 diabetes mellitus (T2DM). Surgeons performing SADS-W used larger bougies and preferred shorter common channels. However, SADS-E was mainly preferred in T2DM patients with a low BMI. SADS-E bypassed less bowel and used smaller bougies. The spectra of major postoperative complications, nutritional deficiencies, and gastrointestinal disorders were different between SADS-E and SADS-W. SADS-W yielded better weight loss and better T2DM remission than SADS-E. SADS are effective bariatric and metabolic procedures with promising therapeutic outcomes and acceptable safety.

**Keywords** Single-anastomosis duodenal switch · Conceptual difference · Weight loss · T2DM remission · Complications

## Introduction

Obesity and its related comorbidities have become a severe health burden worldwide [1]. Bariatric surgery has been proven to be superior to medical therapy in terms of weight loss, metabolic disorder resolution, and quality-of-life improvement [2]. According to the IFSO worldwide survey, sleeve gastrectomy (SG) and Roux-en-Y gastric bypass (RYGB) remain the two major bariatric procedures globally [3]. However, these two procedures have their own limitations, such as weight regain and insufficient T2DM remission after SG and ulcers and dumping syndrome after RYGB [4–6]. Thus, exploration of novel bariatric procedures continues to enhance the therapeutic outcomes and overcome the aforementioned limitations.

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Single-anastomosis duodenal switch (SADS) was first introduced by Andrés Sánchez-Pernaute in 2007 and is a modification of biliopancreatic diversion with duodenal switch (BPD-DS) [7]. Later, several other modifications were published including stomach intestinal pylorus-sparing (SIPS) surgery and loop duodenojejunal bypass with sleeve gastrectomy (LDJB-SG). These were all modifications of Pernaute's original concept, being a sleeve gastrectomy with a single anastomotic small bowel bypass that preserved the pylorus (SADS). SADS has the following advantages compared with traditional bariatric procedures: (1) simpler surgery with fewer anastomoses than BPD-DS; (2) inclusion of a malabsorptive procedure to increase weight loss and T2DM control compared with SG alone; (3) preservation of pyloric function to avoid dumping syndrome.

With the emergence of high-quality data, IFSO officially endorsed SADS as an appropriate metabolic and bariatric procedure in 2018 and updated its statement in 2020 [8, 9]. ASMBS followed IFSO's lead, and in May of 2020 it endorsed SADS as an approved procedure [10]. Recently, both ASMBS and IFSO have been reporting the number of primary SADS procedures done worldwide.

Yet, despite the shared characteristics of both SADS-E and SADS-W, there are many conceptual differences in terms of patient selection and surgical technique that help explain the differing outcomes seen in the literature.

## Methods

We searched for SADS-related publications through PubMed and three high-impact journals, including *Obesity Surgery*, *Surgery for Obesity and Related Diseases*, and *Surgical Endoscopy*, from 2007 to date. The following terms were used: single-anastomosis duodenal switch, modified duodenal switch (MDS), single-anastomosis duodeno-ileal bypass with sleeve gastrectomy (SADI-S), stomach intestinal pylorus-sparing surgery (SIPS), loop duodenojejunal bypass with sleeve gastrectomy (LDJB-SG), and single-anastomosis duodenojejunal bypass with sleeve gastrectomy (SADJB-SG). Original papers reporting the outcomes of SADS in humans were included, and reviews, case reports, animal studies, and studies involving second-stage or revision surgery were excluded.

Extracted data were pooled to analyze overall results regarding patient characteristics, surgical techniques, surgical complications, weight loss, and comorbidities. The values are presented as the mean ± SD or number (percentage, %).

## Results

A total of 2465 records were identified through searching PubMed and three high-impact journals. After duplicate removal and title/abstract screening, 234 articles were reviewed. Then, 215 articles were excluded according to the inclusion and exclusion criteria introduced in the methods. Of these, a total of 19 articles [11–29] containing 2280 patients were included in this review (Fig. 1). Of these 2280 patients, 339 patients underwent SADS-E and 1941 patients underwent SADS-W surgery. The characteristics of the included reports are summarized in Table 1.

### Patient Selection

As listed in Table 1, SADS-E was mainly performed by surgeons in mainland China, Chinese Taiwan, and India, while SADS-W surgery were mainly performed by surgeons in the USA, Europe, and South America. Approximately 77.0% of the patients who underwent SADS-E had T2DM and a low

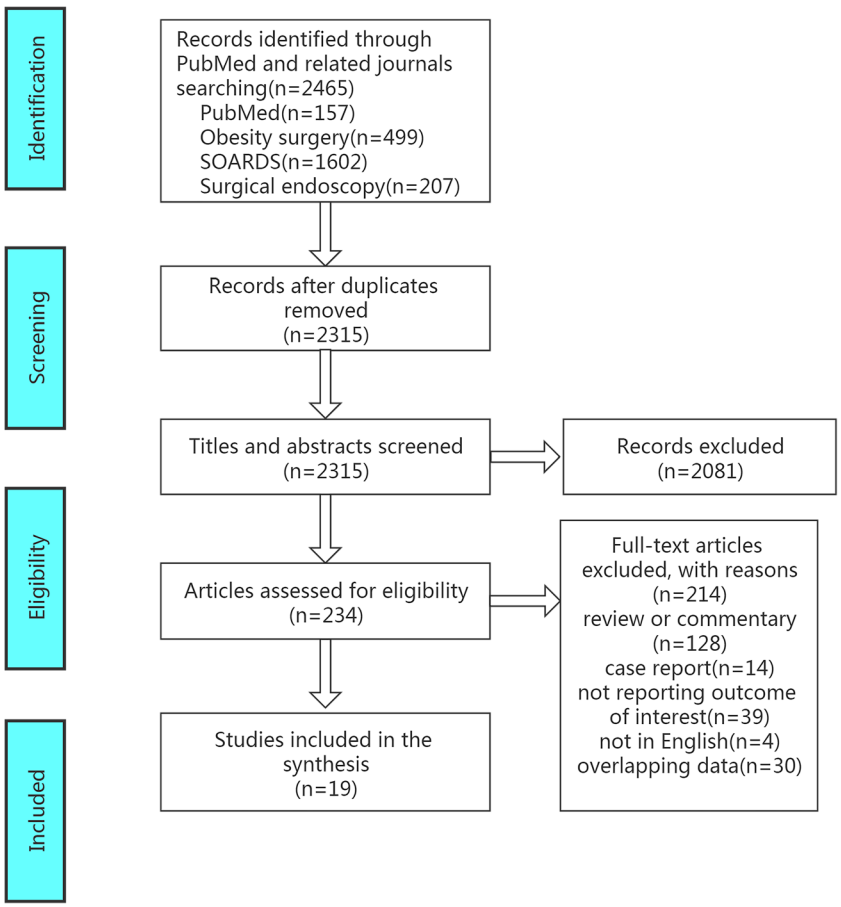


**Fig. 1** PRISMA flowchart for this review search protocol

**Table 1** Baseline characteristics of patients

| Type of surgery | First author, year | Country | No. of patients | FU (months) | F/M | BMI (kg/m$^2$) | T2DM (*n*) | HT (*n*) | HLP (*n*) |
|---|---|---|---|---|---|---|---|---|---|
| DJB-SG | Lin, 2019 [11] | China | 28 | 36 | 16/12 | 26.5±2.8 | 28 | 5 | NA |
| DJB-SG | Ser, 2018 [12] | Taiwan, China | 148 | 60 | 96/52 | 34.2±5.9 | 118 | NA | NA |
| DJB-SG | Huang, 2016 [13] | Taiwan, China | 30 | 12 | 18/12 | 28.2±3.6 | 30 | 12 | 18 |
| DJB-SG | Ruan, 2017 [14] | China | 7 | 48 | 3/4 | 27.7±2.5 | 7 | 5 | NA |
| DJB-SG | Vennapusa, 2020 [15] | India | 126 | 36 | 35/91 | 40.92±5.74 | 78 | NA | NA |
| SADIS | Gebelli, 2016 [16] | Spain | 67 | NA | 46/21 | 53.5 | 18 | 33 | 24 |
| SADIS | Sánchez, 2015 [17] | Spain | 97 | 60 | 52/45 | 44.3 | 97 | 66 | 74 |
| SADIS | Nelson, 2016 [18] | USA | 69 | 12 | 48/21 | 58.4±8.3 | 18 | 33 | NA |
| SADIS | Sánchez, 2016 [19] | Spain | 100 | 60 | NA | 44.6 | NA | NA | NA |
| SADIS | Andalib, 2020 [20] | Canada | 31 | 12 | NA | 48.7 | 20 | 20 | 15 |
| SADIS | Yashkov, 2020 [21]* | Russian | 226 | 60 | 158/68 | 48.9±9.0 | 80 | 149 | NA |
| SADIS | Zaveri, 2018 [22] | USA | 437 | 48 | 276/161 | 49.8±8.8 | 191 | 245 | 168 |
| SADIS | Surve, 2020 [23] | Australia | 91 | 24 | 61/30 | 43.2±5.7 | 35 | 27 | 27 |
| SADIS | Cottam, 2020 [24] | USA | 118 | 12 | 80/38 | 46.8±5.8 | 65 | 73 | NA |
| SADIS | Enochs, 2020 [25] | USA | 160 | 24 | 125/35 | 48.2±8.1 | NA | NA | NA |
| SIPS | Neichoy, 2018 [26] | USA | 134 | 12 | NA | 52.9±9.5 | NA | NA | NA |
| SIPS | Mitzman, 2016 [27] | USA | 123 | 12 | 78/45 | 49.4±9.2 | 55 | 60 | NA |
| SIPS | Sabrudin, 2016 [28] | USA | 168 | 26 | NA | NA | NA | NA | NA |
| SIPS | Surve, 2017 [29] | USA | 120 | 24 | 78/42 | 49.5±9.4 | NA | NA | NA |

*DJB-SG* duodenojejunal bypass with sleeve gastrectomy, *SADI-S* single anastomosis duodeno-ileal bypass with sleeve gastrectomy, *SIPS* stomach intestinal pylorus sparing, *FU* follow-up, *F/M* female/male, *T2DM* type 2 diabetes mellitus, *HT* hypertension, *HLP* hyperlipidemia

*All operations were performed through laparotomy

body mass index (BMI), while in the West, SADS-W surgery were mainly performed in patients with morbid obesity. The preoperative BMI of patients treated with SADS-W was significantly higher than that of patients treated with SADS-E (49 vs. 35.4 kg/m$^2$), but the percentage of T2DM patients was much lower (29.8% vs. 77.0%) (Table 2).

## Surgical Techniques

In SADS-E, most Eastern surgeons bypassed the proximal 200 cm of jejunum starting at the ligament of Trietz to increase the malabsorptive effect after surgery. While in the west, SADS-W surgeons usually preserved 250–300 cm of ileum as the common channel to avoid malnutrition after surgery [9]. Through time, there was a tendency for Western surgeons to extend the length of the common channel from a low of 200 cm to the present SADS-W standard of 250 to 300 cm.

**Table 2** Comparison between SADS-E and SADS-W

| | SADS-E | SADS-W |
|---|---|---|
| No. of patients | 339 | 1941 |
| Pre-BMI (kg/m$^2$) | 35.4 | 49.0 |
| Post-BMI (kg/m$^2$) | 24.9 | 27.7 |
| ▵BMI (kg/m$^2$) | 10.5 | 21.3 |
| %TWL | 25.5 | 37.6 |
| T2DM (*n*) | 261 | 579 |
| T2DM (%) | 77.0 | 29.8 |
| T2DM complete remission rate (%) | 53.6 | 75.7 |

Regarding the bougie size, Eastern surgeons preferred 36–40 F, while most Western surgeons preferred 40 F or larger [9]. Thus, the gastric sleeve after SADS-W surgery was larger than that after SADS-E. The Eastern surgeons chose smaller gastric sleeves to prevent weight regain after surgery, while the Western surgeons selected larger gastric sleeves to prevent malnutrition after surgery.

Despite the lower preoperative BMI in Eastern patients, SADS-E required longer operative times (176 min vs. 84 min), possibly due to the learning curve of the Eastern surgeons as they have performed fewer procedures than Western surgeons.

## Surgical Complications

Regarding major postoperative complications, leakage, bleeding, and stricture formation were the most severe surgical complications (Table 3). Interestingly, stricture formation usually occurred at the sleeve not at the duodeno-ileostomy. This was attributed by Cottam et al. to the learning curve (82.8%, 24/29) [22, 24, 26–29]. Cottam et al. also reported that the rate of anastomotic stricture formation was higher with the linear

**Table 3** Three major complications and reoperation rate for SADS-E and SADS-W

| | Stricture | Leak | Bleeding | Reoperation |
|---|---|---|---|---|
| SADS-E | 0.3% (1/339) | 1.5% (5/339) | 0.9% (3/339) | 5.0% (17/339) |
| SADS-W | 1.5% (29/1941)* | 0.8% (15/1941) | 0.7% (13/1941) | 3.0% (59/1941) |

*As for 29 patients with stricture, 24 were gastric sleeve strictures, 5 were duodeno-ileal anastomosis strictures

stapling technique than with the hand-sewing technique although all strictures in the papers occurred during their learning curves [30]. There were no statistical differences between SADS-E or SADS-W in terms of major complications.

Regarding the long-term safety of SADS, differences in the spectrum of severe complications between the East and West can also be seen. Reflux symptoms (approximately 30%) were the most common complications after SADS-E [11]; however, only 1.3% of patients experienced reflux after SADS-W surgery. Seventeen patients were reported to undergo reoperation in the SADS-E group, and 65% of these reoperations were due to de novo GERD. The small bougie size may be responsible for the high incidence of reflux symptoms in the SADS-E group. Despite the lower incidence of diarrhea in the SADS-W group than in the SADS-E group (1.1% vs. 4.7%), when it did happen it was more severe in the SADS-W group. Fifty-nine patients were reported to undergo revision surgery, and most of these patients underwent lengthening of the common channel due to severe diarrhea or hypoproteinemia.

Interestingly, in the cohort of Eastern patients, iron-deficiency anemia seemed to be more severe. Our data indicate that 25% of the patients experienced new-onset iron-deficiency anemia after SADS-E [11]. Dietary differences and microelement supplementation may be reasons for the high incidence of anemia, as our patients consumed less red meat and showed poor compliance with multivitamin and microelement supplementation.

Generally, the longer the intestine the surgeon bypasses, the poorer the nutritional status the patient experiences. In the West, several studies reported that vitamin D, vitamin $B_1$, and vitamin $B_{12}$ levels were improved but levels of vitamin A, vitamin E, and zinc were worsened after SADS-W although all patients were instructed to take oral micronutrient supplements after surgery [25, 31]. However, in the East, few studies investigated the postoperative status of vitamins and microelements.

## Weight Loss

Due to the significant difference in the preoperative BMI, it is unfair to compare the outcome of weight loss between the Eastern and Western patient groups. Based on the collected data, we found that the Eastern and Western patients treated with SADS-W and SADS-E reached similar postoperative BMIs (Table 4). These data indicate that SADS-W yielded greater weight loss than SADS-E. Regarding postoperative underweight, our previous data indicated that SADS-E only resulted in underweight in patients with a preoperative BMI less than 25 kg/m$^2$ [11]. Regarding weight regain after SADS, limited data have been published. Ser showed that SADS-E yielded maximal weight loss at the 1-year follow-up, followed by slight weight regain [12]. For SADS-W, Sánchez-Pernaute and cottam et al. both reported long-term stability of weight loss with a <15% long-term failure rate after 5 years of follow-up [19, 32].

## Comorbidities

We systemically collected data on the resolution of T2DM, hypertension, and hyperlipidemia after SADS.

Regarding T2DM remission, the following definitions were used [33]: complete remission (CR) of T2DM was defined as fasting blood glucose (FBG) <5.6 mmol/L and HbA1c <6.0% without antidiabetic medication for over 1 year. Partial remission (PR) was defined as FBG <7 mmol/L and HbA1c <6.5% for at least 1 year without antidiabetic medication. Thirteen articles reported the remission rate of T2DM. Twelve series reported the 1-year CR rate of diabetes. Four series reported the sum of the CR and PR rates of diabetes at 1 year. As shown in Table 4, we collected the CR rates in Eastern and Western cohorts and found that SADS-W resulted in higher rates of T2DM remission than SADS-E, which may be explained by the following: (1) the higher preoperative BMI in the Western population; (2) the better weight loss after SADS-W; (3) the longer length of bypassed intestine after SADS-W. It is worth noting that the severity of T2DM may also contribute to this phenomenon, as Eastern surgeons preferred SADS-E in patients with a longer duration of diabetes, poorer FBG and HbA1c levels, preoperative usage of insulin, and more advanced age.

Eight articles reported the hypertension remission rate (62.0%), and four articles reported the hyperlipidemia remission rate (73%). Specific details are listed in Table 4.

# Discussion

Although SADS-W and SADS-E both consist of SG combined with duodenal switch, the origins of SADS-E and

**Table 4** Therapeutic effect of SADS on weight loss and metabolic syndrome at 1 year

| First author, year | No. of patients | BMI (kg/m$^2$) | %TWL | %EWL | T2DM remission (%) | HT remission (%) | HLP remission (%) |
|---|---|---|---|---|---|---|---|
| Lin, 2019 [11] | 28 | 20.3±1.7 | 23.6 | NA | 75* | 80 | NA |
| Ser, 2018 [12] | 148 | 25.0±5.1 | 25.5 | 83.9 | 52.5 | 96 | NA |
| Huang, 2016 [13] | 30 | 22.4±2.5 | NA | NA | 36.6 | NA | 44.4 |
| Ruan, 2017 [14] | 7 | 21.8±1.7 | NA | NA | 57.1 | 60 | NA |
| Vennapusa, 2020 [15] | 104 | 26.78±3.7 | 34.64 | 95.77 | 90.91* | NA | NA |
| Sánchez, 2015 [17] | 90 | NA | 39 | 91 | 71.6 | 52 | 96 |
| Nelson, 2016 [18] | 24 | NA | NA | 61.6±12 | 50 | 42.4 | NA |
| Sánchez, 2016 [19] | 73 | 27 | 37 | 87 | 70 | NA | NA |
| Andalib, 2020 [20] | 24 | 29.4 | NA | 86.8 | 95 | 50 | 73.3 |
| Yashkov, 2020 [21] | 212 | NA | 39.4 | 77 | 93.4 | NA | NA |
| Zaveri, 2018 [22] | 266 | NA | NA | 77.69±20.92 | 78.6 | 66.4 | 72.4 |
| Surve, 2020 [23] | 41 | 27.9 | 34.6 | 69.2 | 94.2 | 68 | 75 |
| Cottam, 2020 [24] | 91 | 29.8 | 36.6 | 70.5 | 88.9 | 66 | NA |
| Enochs, 2020 [25] | 148 | 29.9 | NA | 83.3 | NA | NA | NA |
| Neichoy, 2016 [26] | 54 | 22.5 | 41.1 | 68.9 | NA | NA | NA |
| Mitzman, 2016 [27] | 64 | 19 | 38.6±0.7 | 72.3±1.7 | NA | NA | NA |
| Sabrudin, 2016 [28] | 96 | 27 | 37 | 87 | NA | NA | NA |
| Surve, 2017 [29] | 73 | 33.3 | 31.9 | 79.3 | NA | NA | NA |

*Complete remission rate plus partial remission rate

SADS-W are different. SADS-W originated from the modification of BPD-DS, while SADS-E originated from the concept of adding duodenal switch to SG.

Many of the differences between the outcomes seen in this paper result from different objectives of surgeons in the East and those of the West. In Eastern countries, SADS-E was mainly performed as a metabolic surgery to treat T2DM in patients with a low BMI. Most Eastern surgeons believe that SG is not metabolically active enough for T2DM patients with a low BMI and that RYGB is not an ideal metabolic surgical procedure due to the concern of gastric cancer within the bypassed stomach and the high incidence of postoperative ulcers and anemia.

Based on the foregut theory, adding duodeno-jejunal bypass to a SG would increase insulin sensitivity without the downsides of a RYGB [34]. Animal studies have demonstrated that gut hormones, such as GLP-1, and genes related to glucose metabolism, such as GLUT1 and SGLT1, are highly expressed in rats after SADS [35, 36]. Lee and Huang confirmed that SADS-E exerted a hypoglycemic effect similar to that of RYGB and a better hypoglycemic effect than SG alone.

In western countries, SADS-W surgery was mainly performed as a bariatric surgery to treat morbid obesity, as reflected by the higher preoperative BMI of these patients. The original concept behind adding the duodeno-ileum bypass was to increase the malabsorptive effect of SG and decrease the surgical difficulty compared to that of BPD-DS.

Based on the present data, we found major differences between SADS-E and SADS-W in terms of therapeutic outcomes and spectrum of postoperative complications. It seemed that SADS-W offered better weight loss and rates of T2DM remission than SADS-E (Table 2).

Due to postoperative diarrhea and hypoproteinemia after SADS-W, the length of the common channel was extended from 200 cm as originally described by Pernaute [7], which reflects that the optimization of this procedure is ongoing in the West. However, with limited surgical experience with SADS-E, we did not observe a tendency for lengthening of the bypassed intestine to improve the therapeutic outcome or expanding the caliber of the gastric sleeve to decrease postoperative GERD.

The efficacy and safety of both procedures are satisfactory; however, it is too early to conclude whether SADS is the most ideal bariatric and metabolic surgery, as an increasing number of novel sleeve plus procedures are performed around the world.

There are several limitations to our study. First, this is the first review to discuss the conceptual differences in SADS between the East and West. The scope of the discussion is limited by the lack of eastern literature and the ongoing changes in the way the western procedure is performed. Finally, high-quality clinical studies and further communication between East and West about SADS are urgently needed to optimize common channel lengths and bougie sizes based on unique patient characteristics.

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## Declarations

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

**Informed Consent** Informed consent does not apply.

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

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