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One-year cardiovascular risk assessment after laparoscopic sleeve gastrectomy: A retrospective cohort study

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MAIN POINTS

- Sleeve gastrectomy reduced Framingham cardiovascular risk score by 52.7% at one year, independent of BMI change magnitude.
- HDL cholesterol demonstrated a paradoxical biphasic pattern with initial decrease followed by increase above baseline levels.
- Age was a strong negative predictor of risk reduction, emphasizing the importance of optimal surgical timing.
- Patients with higher baseline cardiovascular risk achieved greater absolute risk reduction.
- The lack of correlation between BMI change and cardiovascular risk reduction suggests benefits beyond simple weight loss.

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ABSTRACT

Aim: Bariatric surgery effectively reduces cardiovascular risk, though the mechanisms remain incompletely understood. This study aimed to evaluate changes in Framingham cardiovascular risk scores and identify predictors of risk reduction following sleeve gastrectomy.

Materials and Methods: This retrospective cohort study included 111 patients (73% female; median age, 33 years [range 18--63]; median BMI, 43 kg/m² [range 35--77]) who underwent laparoscopic sleeve gastrectomy between January 2021 and June 2024. Framingham 10-year cardiovascular disease risk scores were calculated at baseline and 12 months postoperatively. Multivariable linear regression identified independent predictors of absolute risk reduction.

Results: The Framingham risk score decreased from 6 (-10--25) to 3 (-9--26) at 12 months ($p<0.001$), representing a 50% relative risk reduction. BMI decreased from 43 (35--77) to 29 (21--55) kg/m² ($p<0.001$). Notably, change in BMI was not correlated with cardiovascular risk reduction ($r = 0.032$, $p = 0.735$). HDL cholesterol demonstrated a biphasic trend---initially decreasing at 3 months, then exceeding baseline values at 12 months ($p<0.001$). In multivariable analysis, age ($\beta = -0.223$, $p<0.001$); baseline Framingham score ($\beta = 0.532$, $p<0.001$); and HDL change ($\beta = 0.279$, $p = 0.047$) were independent predictors of the absolute risk reduction. Interestingly, an increase in HDL showed a negative association in univariable analysis but a positive association in multivariable analysis.

Conclusion: Sleeve gastrectomy achieved a significant reduction in cardiovascular risk independent of the magnitude of weight loss. The HDL paradox and age-dependent response suggest that complex mechanisms beyond simple weight reduction are involved. These findings support incorporating cardiovascular risk assessment, not just BMI, when determining surgical indications.

Keywords: Sleeve gastrectomy, Framingham risk score, Cardiovascular risk, HDL paradox, Bariatric surgery, Weight loss

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INTRODUCTION

Obesity has become a major global health problem and is recognized as an independent risk factor for cardiovascular disease (CVD) [1, 2]. The prevalence of obesity continues to rise worldwide; in the United States, it increased from 30.5% to 42.4% between 2000 and 2018, while severe obesity nearly doubled from 4.7% to 9.2% [2]. Obesity is strongly associated with metabolic disorders such as hypertension, diabetes, and dyslipidemia, thereby contributing to increased CVD morbidity and mortality [2, 3].

The effects of obesity on the cardiovascular system are multifactorial. Increased adipose tissue elevates metabolic demand, blood volume, and cardiac workload, potentially leading to left ventricular hypertrophy and diastolic dysfunction [2]. Moreover, obesity promotes endothelial dysfunction via oxidative stress and the release of pro-inflammatory cytokines [3].

Laparoscopic sleeve gastrectomy is one of the most widely used and effective bariatric procedures for morbid obesity. In addition to significant weight loss, this surgery has been shown to improve cardiovascular risk factors [4]. According to Framingham data, each 1-unit increase in BMI is associated with a 5% higher risk of heart failure in men and a 7% higher risk in women [5]. A recent study found that sleeve gastrectomy reduces visceral adiposity, improves retinal microvascular parameters, and significantly decreases the Framingham Risk Score [6].

The aim of this study was to investigate changes in the Framingham cardiovascular risk score and its determinants following sleeve gastrectomy. Understanding these changes may contribute to the development of personalized treatment strategies in bariatric surgery.

MATERIALS AND METHODS

Study design and population

This single-center, retrospective cohort study evaluated changes in cardiovascular risk among patients who underwent laparoscopic sleeve gastrectomy between January 2021 and June 2024. Only patients with at least 12 months' follow-up were included. Data were extracted from electronic medical records at baseline, 3, 6, and 12 months postoperatively.

This study was approved by the Ethics Committee of Sancaktepe Şehit Prof. Dr. İlhan Varank Training and Research Hospital (Decision No: 2025/263, Date: 18.07.2025).

Inclusion and exclusion criteria

Inclusion criteria

- Age 18–65 years, BMI $\geq$ 40 kg/m^2 or $\geq$ 35 kg/m^2 with obesity-related comorbidities
- Underwent primary laparoscopic sleeve gastrectomy
- Complete 12–month follow-up data available.

Exclusion criteria

- History of cardiovascular disease (CAD, MI, revascularization, stroke, TIA, PAD)
- Previous or revision bariatric surgery
- Incomplete baseline or 12–month laboratory/blood pressure data
- Additional procedures beyond sleeve gastrectomy
- Inability to calculate Framingham risk score.

Data collection

- Demographics: Age, sex
- Anthropometrics: BMI at baseline and 12 months
- Biochemistry: Total cholesterol, HDL cholesterol at all time points
- Cardiovascular: Systolic blood pressure at baseline, 3, and 12 months; antihypertensive use
- Lifestyle: Smoking status at all visits.

Cardiovascular risk assessment

The primary endpoint was the change in the Framingham 10–year CVD risk score [7]. Absolute and relative risk reductions were calculated.

Surgical technique

A standardized laparoscopic sleeve gastrectomy was performed using a 36–38-French bougie, starting 4 cm from the pylorus, with complete fundus mobilization. Staple line reinforcement and leak testing were routinely performed.

Statistical analysis

All statistical analyses were performed using IBM SPSS Statistics version 25.0 (Armonk, NY: IBM Corp.). Continuous variables were expressed as median (min–max) and categorical variables as n (%). Between-group comparisons of continuous and categorical variables were performed using the Mann–Whitney U test and the chi-square test, respectively. Within-group comparisons between two time points were analyzed using the Wilcoxon signed-rank test, while comparisons across three or more time points were evaluated with the Friedman test followed by Bonferroni-adjusted post hoc pairwise comparisons. Changes in binary outcomes, such as smoking status, were assessed using Cochran's Q test with Bonferroni-adjusted McNemar tests where applicable.

Correlations between continuous variables were assessed using Spearman's rank correlation coefficient (ρ). Independent predictors of absolute cardiovascular risk reduction were determined through multivariable linear regression analysis. Model assumptions—including linearity, independence, and homoskedasticity—were verified through residual plots, Q–Q plots, and the Shapiro–Wilk test. Heteroskedasticity-robust (HC3) standard errors were applied, and multicollinearity was assessed using the variance inflation factor (VIF < 2.5). Model performance was reported with R^2 and adjusted R^2 values.

As this was a retrospective study that included all eligible patients during the study period, no a priori sample size calculation was performed. However, an exploratory post hoc power analysis for the multivariable regression model was conducted using G*Power version 3.1.9.2 (Universität Düsseldorf, Germany). Based on the observed model fit (R^2 = 0.413, Cohen's $f^2 \approx 0.70$), with n = 111, k = 5, and $\alpha = 0.05$, the achieved power (1–β) was estimated to be to exceed 0.90, indicating adequate statistical power to detect large effects.

A two-tailed p-value < 0.05 was considered statistically significant.

RESULTS

Baseline characteristics

A total of 111 patients [81 females (73%) and 30 males (27%)] were included in the final analysis. The median age of the study population was 33 years (range, 18–63), and the median

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Table 1. Baseline patient characteristics and differences between groups.

Characteristic	All Patients	Female	Male	p-value
Age (years) median (min--max)	33 (18--63)	34 (18--57)	30 (19--63)	0.705
BMI (kg/m²) median (min--max)	43 (35--77)	43 (35--77)	43 (36--53)	0.651
Total cholesterol (mg/dL) median (min--max)	191 (127--316)	191.5 (127--305)	191 (160--316)	0.700
HDL cholesterol (mg/dL) median (min--max)	46 (26--70)	46 (26--66)	44.5 (27--70)	0.735
Systolic blood pressure (mmHg) median (min--max)	120 (80--170)	120 (80--170)	110 (90--160)	0.799
Antihypertensive use n(%)	22 (19.8)	18 (22.2)	4 (13.3)	0.297
Current smoking n(%)	53 (47.7)	39 (48.1)	14 (46.7)	0.890
Framingham score (%) median (min--max)	6 (-10--25)	6 (-8--23)	6 (-10--25)	0.239

Values are presented as median (min–max) or n (%); BMI:body mass index; HDL: high-density lipoprotein; $p < 0.05$ was considered statistically significant; †Mann–Whitney U test was used for continuous variables and Chi-square test for categorical variables.

Table 2. Temporal changes in cardiovascular risk parameters.

Parameter	Preop	3 months	6 months	12 months	p-value
BMI (kg/m²) median (min--max)	43 (35--77)			29 (21--55)	<0.001**†
Total cholesterol (mg/dL) median (min--max)	191 (127--316)[a,b]	187 (110--320)[e]	183(114--300)	178 (124--337)	<0.001**‡
HDL cholesterol (mg/dL) median (min--max)	46 (26--70)	44 (26--65)	48 (28--72)	50 (33--70)	<0.001**‡
Blood pressure (mmHg) median (min--max)	120 (80--170)			110 (80--140)	<0.001**†
Framingham score (%)median (min--max)	6 (-10--25)			3 (-9--26)	<0.001**†
Current smoking n(%)median (min--max)	53 (47.7)	42 (37.8)	35 (31.5)	34 (30.6)	<0.001**§

[a]: Preop–3 months; [b]: Preop–6 months; [c]: Preop–12 months; [d]: 3–6 months; [e]: 3–12 months; [f]: 6–12 months; †Wilcoxon signed-rank test; §Cochran's Q test; ‡Friedman test with Bonferroni-adjusted post hoc analysis; Values are presented as median (min–max) or n (%); $p < 0.05$ was considered statistically significant.

Table 3. Gender-based comparison of bmı and framingham risk score changes.

Parameter	Female (n=81)	Male (n=30)	p-value
BMI measurements			
Preoperative BMI (kg/m²) (kg/m²), median (min--max)	43 (35--77)	43 (36--53)	0.651
Postoperative 12-month BMI (kg/m²), median (min--max)	29 (21--55)	28.5 (26--37)	0.338
BMI change (kg/m²), median (min--max)	15 (4--23.6)	14.55 (10--19)	0.963
BMI change (%), median (min--max)	31.8 (10--52.91)	32.9 (27.03--40.43)	0.106
Framingham risk score			
Preoperative score (%), median (min--max)	6 (-8--23)	3.5 (-10--25)	0.239
Postoperative 12-month score(%) median (min--max)	3 (-8--19)	2 (-9--26)	0.724
Absolute risk reduction(%)‡ median (min--max)	3 (-9--15)	2 (-7--8)	0.159
Relative risk reduction(%)δ median (min--max)	37.4 (-128.57--500)	14.4 (-500--500)	0.105

‡Absolute risk reduction = Preoperative – 12-month value, δRelative risk reduction = (Absolute reduction / Preoperative value) × 100. †Mann–Whitney U test, Values are presented as median (min–max), $p < 0.05$ was considered statistically significant.

preoperative BMI was 43 kg/m^2 (range, 35–77). The median baseline Framingham 10-year cardiovascular risk score (FRS) was 6% (range: -10 to 25). There were no significant differences in baseline characteristics between genders (p>0.05; Table 1).

Changes in cardiovascular risk parameters

At 12 months, significant improvements were observed across all cardiovascular risk parameters (Table 2). BMI decreased from 43 (35–77) to 29 (21–55) kg/m^2 (p<0.001), systolic blood pressure from 120 (80–170) to 110 (80–140) mmHg (p<0.001), and total cholesterol.

The values progressively declined from 191 (127–316) mg/dL at baseline to 178 (124–337) mg/dL at 12 months (p<0.001). HDL cholesterol demonstrated a biphasic response, decreasing to 44 (26–65) mg/dL at 3 months and subsequently rising above baseline to 50 (33–70) mg/dL at 12 months (p<0.001).

Framingham risk score changes

The FRS decreased significantly from 6 (-10–25) preoperatively to 3 (-9–26) at 12 months (p < 0.001; Table 2). When analyzed by gender, no significant differences were observed in absolute risk reduction between females and males: females, 3% (−9–15); males, 2% (−7–8); p = 0.159 (Table 3). The temporal trajectory of risk reduction is shown in Figure 1.

Predictors of risk reduction

In the correlation analysis, absolute risk reduction was negatively associated with change in HDL (r = -0.235, p = 0.013) and positively associated with reduction in systolic blood pressure (r = 0.399, p<0.001), but not associated with change in BMI (r = 0.032, p = 0.735) (Table 4). As shown in Figure

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Table 4. Univariable and multivariable analyses of predictors of absolute cardiovascular risk reduction

(a) Univariable analysis of factors associated with absolute risk reduction.

Variable	Correlation with Absolute Risk Reduction	
	r	p
Change in BMI (kg/m²)	0.032	0.735
Change in HDL cholesterol (mg/dL)	-0.235*	0.013
Change in systolic blood pressure (mmHg)	0.399**	<0.001
Antihypertensive discontinuation	Median (min - max)	
Discontinued (n=104)	6 (-9--15)	0.738
Continued (n=7)	11 (-4--10)	

(b) Multivariable linear regression analysis for predictors of absolute risk reduction.

Variable	Unstandardized Coefficients		Standardized Coefficients	t	p
	B	Se	β		
(Constant)	4.598	2.692		1.708	0.091
Age	-0.223	0.045	-0.519	-4.926	<0.001**
Gender	-0.856	0.865	-0.075	-0.990	0.325
Preoperative Framingham score	0.532	0.068	0.848	7.835	<0.001**
Change in HDL cholesterol (mg/dL)	0.279	0.139	0.154	2.006	0.047*
Change in systolic blood pressure (mmHg)	-0.073	0.046	-0.119	-1.575	0.118

Table 4a: BMI, body mass index; HDL, high-density lipoprotein; r, Spearman's correlation coefficient. **p<0.05; **p<0.01. Mann-Whitney U test was used for antihypertensive discontinuation comparison.
Table 4b: HDL, high-density lipoprotein; SE, standard error. **p<0.05; **p<0.01. Model summary: R^2=0.413, Adjusted R^2=0.385, F(5.105)=14.769, p<0.001.

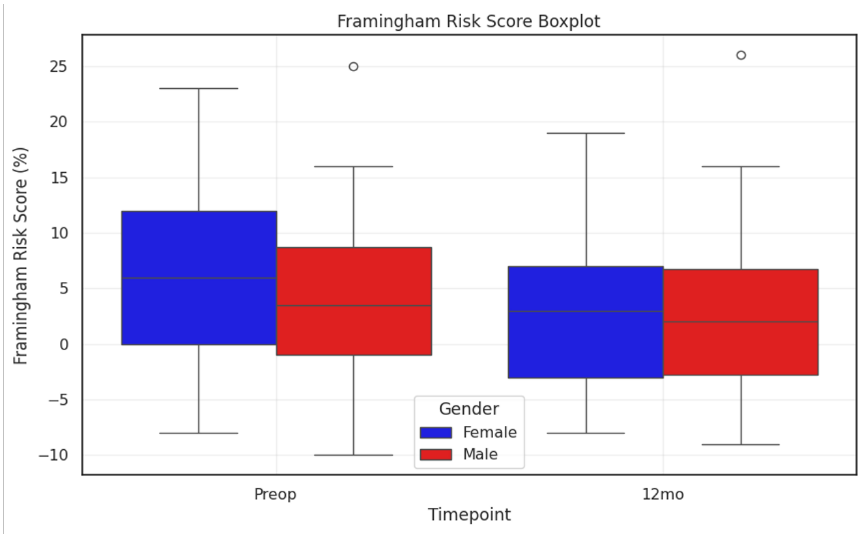

Figure 1. Clustered boxplot illustrating Framingham 10-year cardiovascular risk scores at the preoperative and 12-month postoperative timepoints, stratified by gender (female = blue; male= red). Boxes represent medians and interquartile ranges; whiskers indicate the full range; circles denote outliers.

2, BMI reduction was not significantly correlated with cardiovascular risk reduction. Multivariable linear regression analysis (R^2 = 0.413, Adjusted R^2 = 0.385, F = 14.769, p<0.001) identified independent predictors of absolute risk reduction:

- Age (β= - 0.223, p<0.001) - older age associated with less risk reduction.
- Baseline FRS (β = 0.532, p<0.001) - higher baseline risk associated with greater absolute reduction.
- Change in HDL cholesterol (β = 0.279, p = 0.047).

Gender (β = -0.856, p = 0.325) and change in systolic blood pressure (β = -0.073, p = 0.118) were not significant predictors in the multivariable model.

Smoking cessation

Smoking prevalence decreased from 47.7% (n=53) at baseline to 30.6% (n=34) at 12 months (p<0.001).

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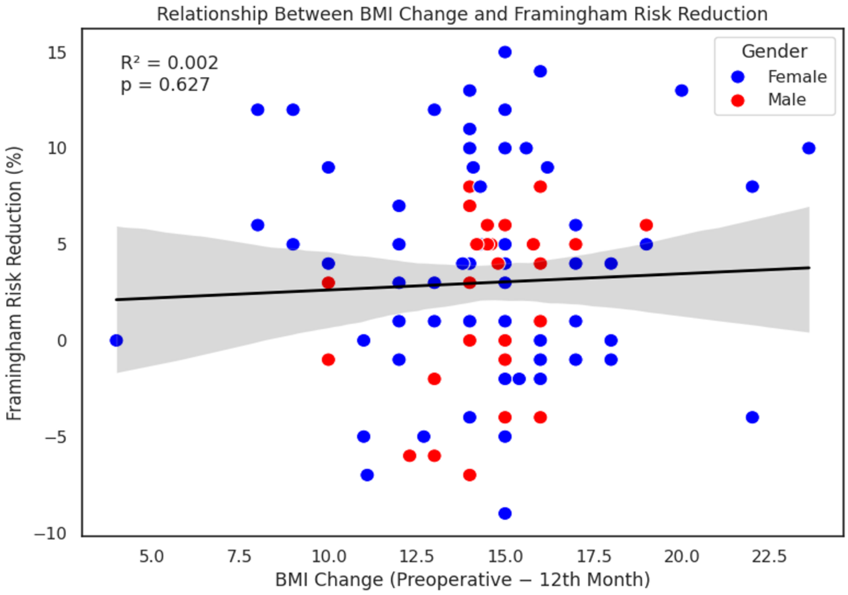

Figure 2. Scatter plot showing the relationship between BMI change and absolute cardiovascular risk reduction. Each point represents an individual patient (female = blue; male = red). The solid line represents the linear regression model with its 95% confidence band.

DISCUSSION

In this retrospective cohort study, the findings from a one-year follow-up of 111 patients who underwent laparoscopic sleeve gastrectomy highlight the need to re-evaluate the cardiovascular effects of bariatric surgery. Although the 50% reduction in the Framingham cardiovascular risk score is clinically significant, one of the most striking observations is that this improvement did not correlate with the 31.8% reduction in BMI ($r = 0.032$, $p = 0.735$). This suggests that the reduction in cardiovascular risk may occur independently of the magnitude of weight loss. Moreover, multivariable analysis identified age, baseline Framingham score, and changes in HDL cholesterol as independent predictors, indicating that the cardiovascular benefits of sleeve gastrectomy are mediated through multifactorial mechanisms rather than weight loss alone.

The lack of correlation between BMI change and cardiovascular risk reduction is consistent with recent literature emphasizing the complexity of the obesity–cardiovascular disease relationship. The joint position statement of the World Obesity Federation and the World Heart Federation underscores that this link is mediated by metabolic, endocrinological, immunological, structural, humoral, and hemodynamic mechanisms [8]. In their large cohort, Katsoulis et al. also demonstrated that the effect of weight loss on cardiovascular outcomes is nonlinear and varies by BMI category [9]. Our findings, showing risk reduction despite the absence of correlation with BMI change, support the notion that sleeve gastrectomy confers benefits beyond adipose tissue loss.

The biphasic HDL cholesterol pattern observed in our study has been previously described in the bariatric literature [10-12]. HDL typically shows an early postoperative decline, followed by recovery to levels above preoperative levels. In our series, HDL levels decreased to 44 mg/dL at 3 months, then increased to 50 mg/dL at 12 months. Interestingly, univariable analysis showed a negative correlation between HDL increase and risk reduction ($r = -0.235$, $p = 0.013$), this association became positive in the multivariable model ($\beta = 0.279$, $p = 0.047$).

This paradoxical finding, which may be termed the “HDL paradox”, supports the hypothesis that bariatric surgery alters HDL functionality rather than simply its quantity [11,12].

Age was identified as a strong negative predictor in our study ($\beta = -0.223$, $p<0.001$), consistent with reports that metabolic plasticity decreases with age. Athanasiadis et al. reported that younger patients achieved greater weight loss and resolution of comorbidities [13], and Tabasi et al. similarly observed greater reductions in BMI in younger cohorts [14]. Our findings in a population with a median age of 33 years (range, 18–63) underscore the importance of early surgical intervention. Although older patients also experienced significant risk reduction, the greater adaptive capacity of younger patients underscores the importance of optimal timing for surgery.

Additionally, patients with higher baseline Framingham scores experienced greater absolute risk reduction ($\beta = 0.532$, $p<0.001$). This aligns with van Veldhuisen et al.’s meta-analysis, which reported a 41% reduction in cardiovascular mortality after bariatric surgery [15], and with El Ansari et al., who observed Framingham score reductions of up to 32% in high-risk patients [16]. These findings suggest that surgical indications should incorporate cardiovascular risk assessment alongside BMI.

In our cohort, no statistically significant sex differences were found in cardiovascular risk reduction after sleeve gastrectomy, although women showed a numerically greater improvement. This supports prior evidence that bariatric

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surgery provides cardiometabolic benefits largely independent of sex [17-19]. Despite the underrepresentation of men in bariatric cohorts, accumulating evidence—including our results—indicates that short- and mid-term outcomes are comparable across sexes. Consistent with this, we observed significant improvements in systolic blood pressure, from 120 (80–170) to 110 (80–140) mmHg, in total cholesterol, from 191 (127–316) to 178 (124–337) mg/dL, as well as a reduction in smoking prevalence from 47.7% to 30.6%. Although smoking cessation was not an independent predictor in multivariable analysis, its potential long-term contribution to cardiovascular outcomes remains important.

Limitations

This study has several limitations. The retrospective design precludes causal inference, and the 12-month follow-up may not capture long-term cardiovascular events. Medication use and HbA1c levels, which could influence the Framingham score, were not systematically assessed. The relatively small proportion of men (27%) limited statistical power for sex comparisons, and lifestyle factors such as dietary compliance and physical activity were not measured. Despite these limitations, our findings provide valuable insights into the complex interplay among bariatric surgery, HDL dynamics, and cardiovascular risk.

CONCLUSION

Sleeve gastrectomy produced a significant reduction in cardiovascular risk, independent of the magnitude of weight loss. Change in BMI was not correlated with improvements in the Framingham Risk Score, indicating that weight loss alone does not confer cardiovascular benefit. The HDL paradox—negative in univariable analysis but positive in multivariable modeling—suggests that functional changes in HDL may be more important than absolute concentrations in mediating cardiovascular protection after bariatric surgery.

Ethics Committee Approval: The study protocol was approved by the Ethics Committee of Sancaktepe Şehit Prof. Dr. İlhan Varank Training and Research Hospital (Decision No: 2025/263, Date: 18.07.2025).

Informed Consent: Due to the retrospective nature of this study and the use of de-identified data extracted from medical records, the requirement for informed consent was waived by the ethics committee. Patient anonymity was carefully protected throughout the study; all personal identifiers were removed from the dataset, and data were analyzed using coded identification numbers.

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