



# Factors influencing postoperative abdominal pain in DIEP flap breast reconstruction

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**Background:** Identification of a subgroup of patients with severe postoperative pain is important for adequate pain management for enhanced, fast recovery after deep inferior epigastric artery perforator (DIEP) flap breast reconstruction. The purpose of this study was to identify factors influencing postoperative abdominal pain in patients undergoing DIEP flap breast reconstruction.

**Methods:** Consecutive patients who underwent unilateral breast reconstruction using DIEP free flaps from October 2018 to July 2020 were included in this study. Visual analog scale (VAS)-guided postoperative pain scores were documented every 3 hours until 48 hours postoperatively. Factors affecting patient-reported pain scores were analyzed using a linear mixed-effects model. Independent variables included patient characteristics, history of previous open abdominal surgery, and operative factors including the flap size, flap weight, use of a unipedicled or bipedicled flap, number of perforators, timing of reconstruction, and use of a catheter-based subcutaneous plane block in the abdomen. A catheter was placed above the rectus fascia during closure, and analgesics were continuously infused during the 48 hours using an ON-Q Pain Relief System (I-Flow Co., Lake Forest, CA, USA).

**Results:** Fifty-five patients were included in the analysis. In the linear mixed effect model using multiple clinical variables, the harvested flap weight was significantly associated with the degree of pain ( $\beta$  coefficient =0.157,  $P=0.008$ ). The pain degrees significantly decreased according to postoperative days ( $\beta$  coefficient =-0.649,  $P<0.001$ ). The flap type (unipedicle or bipedicle), number of perforators, timing of reconstruction, and history of previous abdominal surgery did not influence pain degrees. The use of subcutaneous plane block did not affect the degree of pain or dose of analgesics used.

**Conclusions:** A larger flap weight is associated with an increased degree of pain in patients undergoing DIEP flap breast reconstructions. Vigorous pain management might be necessary when a large flap is elevated.

**Keywords:** Breast reconstruction; deep inferior epigastric artery perforator flap (DIEP); pain

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## Introduction

A microsurgical breast reconstruction using an abdominal flap (deep inferior epigastric artery perforator flap, DIEP) is the most common form of autologous breast reconstruction (1). A DIEP flap is associated with increased patient satisfaction with low donor site morbidity (2). However, patients often complain of severe postoperative pain at abdominal donor sites, especially during the early postoperative period. Enhanced Recovery After Surgery (ERAS) protocols have been proposed in microsurgical breast reconstruction, and postoperative pain management is an importance component in these protocols (3).

Uncontrolled postoperative pain at the abdominal donor site after DIEP flap breast reconstruction is a common complaint of the patients, and it can be associated with increased opioid consumption, prolonged hospitalizations, and chronic pain syndromes in some patients (4). For this reason, various methods have been used to reduce postoperative donor-site pain, including the systemic use of opioids, patient-controlled anesthesia (PCA), continuous anesthetic infusion via a catheter placed into the donor site, and a direct nerve block via transversus abdominis plane (TAP) blockade (5,6). Despite the use of the same protocol for postoperative pain management, the degree of postoperative pain is different between individuals, and some patients complain of uncontrolled, severe pain (7). In this context, identification of a subgroup of patients with severe postoperative pain is important for adequate pain control, which improves patient satisfaction and surgical outcomes. However, little is known regarding factors influencing postoperative donor site pain in patients undergoing DIEP flap breast reconstruction. The purpose of this study was to identify factors influencing postoperative abdominal pain in patients undergoing DIEP flap breast reconstruction.

We present the following article in accordance with the STROBE reporting checklist (available at <https://dx.doi.org/10.21037/gs-21-175>).

## Methods

### *Population and variables*

A total of 55 patients who underwent unilateral breast reconstruction using DIEP flap at a single institution between October 2018 and July 2020 were included in this study. This study was approved by the institutional review board of our institution (IRB No. 2020-03-015),

which waived the need for informed consent because the research involved no more than minimal risk to the study participants, and was conducted in accordance with the Declaration of Helsinki (as revised in 2013).

Data were prospectively collected for consecutive patients who underwent DIEP flap breast reconstruction performed by a single surgeon (KJW). In bipediced DIEP flap reconstructions, intra-flap anastomosis with turbocharging technique was used. We captured the following data: demographic information, history of previous open abdominal surgery, harvested flap weight, unipediced or bipediced flap, number of perforators, harvested flap weight, presence or absence of a catheter-based subcutaneous plane block using an ON-Q Pump (I-Flow Co., Lake Forest, CA, USA), timing of reconstruction (immediate/delayed), and dosage of pain medications.

### *Measurement of pain scores after surgery*

The postoperative degree of pain at the donor site was measured using a visual analog scale (VAS), which has been commonly used to assess severity of pain in abdomen-based breast reconstruction, with scores ranging from 0 to 10. The mean pain scores were calculated over time to evaluate pain score patterns. Patients were educated that a VAS score of 5 was defined as the degree of pain at which the patient found it difficult to sleep or rest without additional pain control, and a VAS score of 10 was defined as pain as severe as death. The pain scores were evaluated by an attending physician or surgeon and recorded at every scheduled postoperative flap examination. The postoperative VAS scores were documented every 3 hours until 48 postoperative hours. Thereafter, VAS scores were captured every 6 hours until the completion of 5 postoperative days.

### *Subcutaneous plane block*

An ON-Q Pain Relief System was applied when it was available and the patient had consented to its use for a continuous percutaneous anesthetic infusion. The infusion catheter was placed above the rectus fascia for subcutaneous layer block at the time of donor-site closure. A total of 400 mL of an anesthetic solution consisting of 260 mL of 0.75% ropivacaine (AstraZeneca Korea, Ltd., Seoul, Republic of Korea) and 140 mL of normal saline was continuously infused for 48 hours. For patients who did not receive a percutaneous ON-Q infusion, the

abdominal wound was closed without catheter placement.

### *Donor-site closure procedure*

Abdominal donor-site closure was performed using a documented standard protocol. Two-layer closure of the anterior rectus sheath was performed with 1-0 Vicryl in interrupted pattern and 1-0 Prolene running sutures without mesh support. Abdominal plication of the rectus fascia was performed. Two closed suction drains were inserted into the abdomen.

### *Postoperative analgesic use*

An intravenous (IV) PCA device administering fentanyl (Hana Pharm Co., Ltd., Seoul, Republic of Korea) and ramosetron (Daiichi Sankyo Korea Co., Ltd.) is routinely applied in the postanesthesia care unit after surgery. The patients were instructed to press the button whenever they felt that their pain control was inadequate. The IV PCA device was removed after 48 hours, at which time the remaining dose was recorded. The IV PCA device started with a total volume of 60 mL consisting of 10 to 12 µg fentanyl per kg of the patient's body weight and was continuously infused at a rate of 0.5 mL/h. The device was set to purge 0.5 mL boluses whenever the patient pressed the designated button. When the patient required additional analgesia, pain control was augmented using IV acetaminophen, IV ketorolac, or oral acetaminophen. For comparison, pain medications were converted to morphine equivalents to calculate the total usage of pain medication.

### *Statistical analysis*

R language version 3.3.3 (R Foundation for Statistical Computing, Vienna, Austria) and T&F program ver. 3.0 (YooJin BioSoft, Korea) were used for all statistical analyses. Continuous variables are presented as mean ± standard deviation or median (interquartile range) based on the distribution of the data, and frequencies and proportions are used to describe categorical variables. Linear mixed-effects models were used to analyze the effect of clinical variables on the VAS scores that were repeatedly measured until 48 hours postoperatively. The mixed-effects models included each clinical variable and a time variable as fixed effects and a random intercept and slope. The differences in morphine equivalents and morphine equivalents per body weight between the subcutaneous plane block and control groups

were analyzed using the Mann-Whitney U test. Analysis of covariance was also performed to adjust confounding covariates.

## **Results**

Fifty-five patients were included in the analysis. The mean age of the patients was 48.76±7.9 years, and the median body mass index (BMI) was 23.49 (21.66–25.92) kg/m<sup>2</sup>. Fifteen patients had a history of previous abdominal surgery. Fifty-three patients underwent unipedicled flap reconstruction, and the remaining 2 patients underwent bipedicled flap reconstruction using a turbocharging technique. The number of perforators was 1 for 8 patients, 2 for 30 patients, 3 for 14 patients, and 4 for 3 patients. All 55 patients received IV PCA. Two patients complained of nausea due to IV PCA, and the IV PCA device was removed in these patients before the 48 hours had elapsed. Subcutaneous plane block was applied in 22 patients. Forty-one patients underwent immediate reconstructions, and 14 patients underwent delayed reconstructions. The median harvest flap weight was 661 (502–902) g. The median morphine equivalent was 40 (25–65) mg (*Table 1*).

The mean VAS score of the overall patients gradually decreased with time. The mean VAS scores at 3 hours and 48 hours postoperatively were 3.76±1.77 and 2.74±1.60, respectively. The trend in VAS scores over time is shown in *Figure 1*.

In the analysis of effects of time and each clinical variable on the postoperative VAS scores using linear mixed effect models, body weight (β coefficient =0.045, P=0.009), BMI (β coefficient =0.130, P=0.005), and harvested flap weight (β coefficient =0.171, P=0.005) were significantly associated with VAS scores. Age, height, history of previous abdominal surgery, bilateral pedicle harvest, number of perforators, and subcutaneous plane block use were not significantly associated with VAS scores. Time was significantly associated with VAS scores in all analytical models for each variable (*Table 2*). In the analysis of effects of time and multiple clinical variables on the postoperative VAS scores using linear mixed effect models, VAS scores significantly decreased with time (P value <0.001). An increased harvested flap weight was also significantly associated with higher VAS scores (P=0.008). The VAS scores of patients undergoing DIEP flap breast reconstruction decreased 0.898 points for each postoperative day during the 48-hour postoperative period and increased 0.157 points for each 100-g increase in harvested flap weight. However, subcutaneous plane block use did not

**Table 1** Clinical and surgical variables of overall patients

Variable	Value
Age, mean $\pm$ SD, y	48.76 $\pm$ 7.9
BMI, median (IQR), kg/m <sup>2</sup>	23.49 (21.66–25.92)
Prior abdominal surgery	
Yes	15 (27.3)
No	40 (72.7)
Flap height, median (IQR), cm <sup>2</sup>	12.5 (12–13)
Flap width, median (IQR), cm <sup>2</sup>	30 (28–33)
Flap area, mean $\pm$ SD, g	389.68 $\pm$ 70.21
Bilateral pedicle harvest	
Yes	2 (3.6)
No	53 (96.4)
Perforator number	
1	8 (14.5)
2	30 (54.5)
3	14 (25.5)
4	3 (5.5)
Harvested flap weight, median (IQR), g	661 (502–902)
Subcutaneous plane block use	
Yes	22 (40)
No	33 (60)
Timing of reconstruction	
Immediate	41 (74.5)
Delayed	14 (25.5)
Morphine equivalents, median (IQR), mg	40 (25–65)

SD, standard deviation; BMI, body mass index; IQR, interquartile range.

have a significant effect on VAS scores ( $\beta$  coefficient =0.540,  $P=0.110$ ) (Table 3).

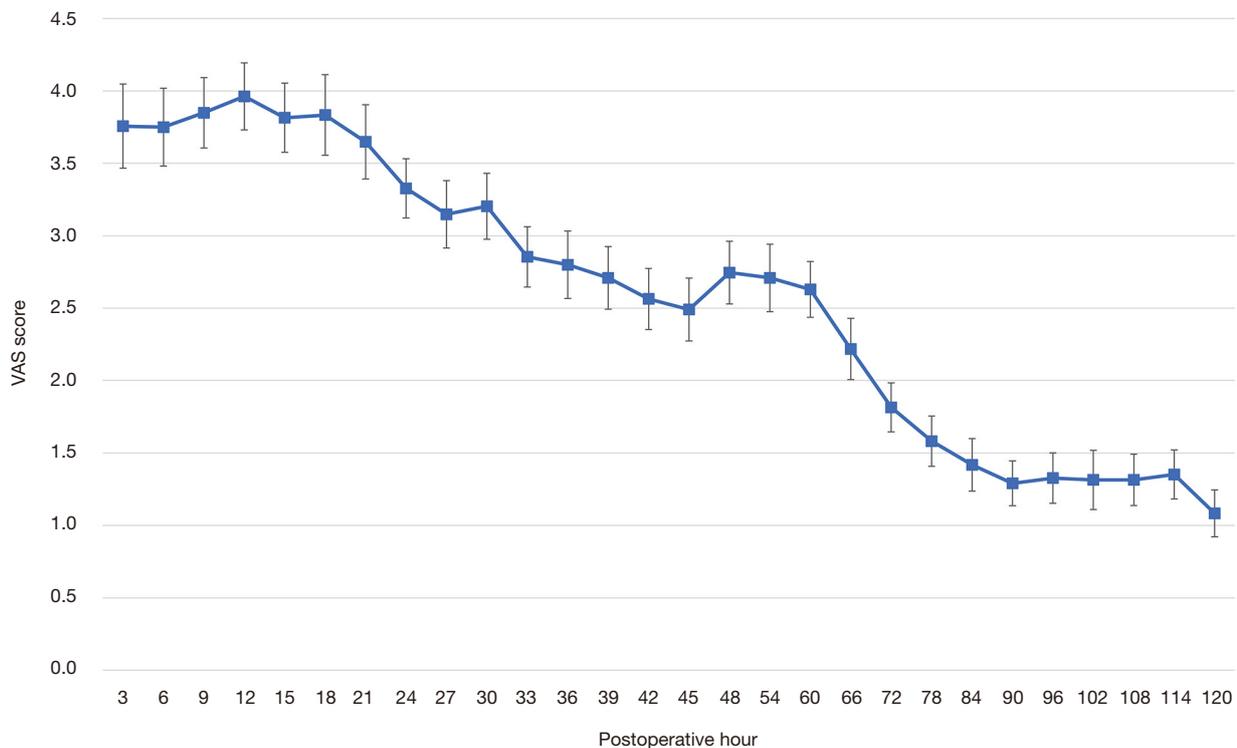
In the analysis of the difference of in morphine equivalents between the subcutaneous plane block and control groups, no significant differences in morphine equivalents or morphine equivalents per body weight were observed between the two groups ( $P=0.557$  and  $0.751$ , respectively, Table 4). After controlling for covariates including age, history of previous abdominal surgery, harvested flap weight, perforator position, and timing of reconstruction, there were also no significant differences

in morphine equivalents or morphine equivalents per body weight between the two groups ( $P=0.871$  and  $0.671$ , respectively, Table 5).

## Discussion

In this retrospective study, we evaluated factors associated with donor-site pain after DIEP flap breast reconstruction and demonstrated that the postoperative time and harvested flap weight were significantly associated with pain scores. The VAS scores of donor-site pain gradually decreased over time during the 48-hour postoperative period and were significantly higher when the harvested flap weight was increased. However, the use of subcutaneous plane block did not significantly affect VAS scores.

Several studies have been conducted to evaluate the effect of regional blocks on donor-site pain after abdomen-based breast reconstruction. TAP blockade is the most widely used peripheral block that affects the nerves of the anterior abdominal wall, and its effects on reducing the length of hospital stay and opioid consumption have been well established (8–10). In a study of patients undergoing DIEP flap breast reconstruction, a bupivacaine TAP blockade was associated with significantly reduced narcotic consumption compared with infusion pump anesthetic administration and local anesthetic injection (11). Recently, liposomal bupivacaine, which has a long duration of effect, has been widely used in TAP blocks (12). The TAP block technique using liposomal bupivacaine has also been reported to reduce the length of hospital stay after surgery and costs associated with postoperative management after breast reconstruction surgery (8). Some surgeons also used a subcutaneous plane block combined with TAP blockade (3,13). However, to our knowledge, the effect of a subcutaneous plane block has not been evaluated separately from the effect of TAP blockade in abdomen-based breast reconstruction. Therefore, we evaluated the effect of a subcutaneous layer block without TAP blockade using an On-Q pump after DIEP flap breast reconstruction and demonstrated that the use of an On-Q pump for the subcutaneous plane block did not significantly affect VAS scores or morphine equivalents during the 48-hour postoperative period. A subcutaneous plane block may not be recommended when performing TAP blockade in patients undergoing breast reconstruction according to the results of this study. Further comparative studies between a TAP blockade alone group and a TAP blockade combined with subcutaneous plane block group would be necessary to



**Figure 1** The VAS scores of donor-site pain after DIEP flap breast reconstruction during 5 days postoperatively are depicted using the means and standard errors of the VAS scores. VAS, visual analog scale; DIEP, deep inferior epigastric artery perforator.

confirm the results of this study.

Previous studies have demonstrated that bilateral abdomen-based breast reconstruction might lead to greater postoperative pain than unilateral reconstruction (14–16). However, the effect of bilateral harvesting of vascular pedicles on postoperative pain remains unclear because performing surgery on both breasts can also be associated with increased postoperative pain. According to a recent study by Azizi *et al.*, morphine usage was significantly lower in a bipediced DIEP flap group than in a unipediced DIEP flap group in patients undergoing unilateral breast reconstruction (17). In their multivariate analysis, bipediced reconstruction was still an independent predictor of lower immediate postoperative morphine requirements. The authors suggested that this was an unexpected finding and was in contrast to the results of previous studies and their hypothesis. According to the results of the current study, an increased flap weight was significantly associated with increased postoperative pain scores. In unilateral breast reconstruction using a DIEP flap, a bipediced DIEP flap is used when the abdominal flap volume is relatively small.

Furthermore, a smaller harvested flap size can be achieved when using a bipediced flap than when using a unipediced flap because nearly the full size of the harvested flap can be used for flap inset in bipediced reconstruction. Thus, the reduced flap weight in bipediced reconstruction could lead to reduced postoperative pain although the pedicles were harvested bilaterally. The length of intramuscular dissection during the flap harvest, on the other hand, might not influence postoperative abdominal pain. In this study, bipediced flap harvest or increased number of perforators of the DIEP flap did not increase postoperative abdominal pain (Table 2).

The current study is the first to demonstrate that the abdominal flap weight is a significant predictor of increased postoperative pain scores. Because the abdominal flap weight has been known to be significantly correlated with BMI, patients with a higher BMI may have more severe postoperative pain (18). Notably, there have been reports showing that TAP blockade is more effective in patients with a higher BMI. Hunter *et al.* reported that patients with a BMI greater than 30 kg/m<sup>2</sup> benefitted more from TAP

**Table 2** Fixed effects of time and each clinical variable on the postoperative VAS scores in the linear mixed effect models

Variable	Effect	$\beta$ coefficient	Standard error	P value	Semi-partial R <sup>2</sup> (95% CIs)
Age	Time	-0.894	0.126	<0.001	0.096 (0.059–0.140)
	Variable	-0.018	0.023	0.428	0.008 (0.000–0.026)
Height	Time	-0.895	0.126	<0.001	0.096 (0.059–0.139)
	Variable	-0.005	0.031	0.874	0.000 (0.000–0.009)
Body weight	Time	-0.896	0.126	<0.001	0.102 (0.064–0.147)
	Variable	0.045	0.017	0.009	0.082 (0.048–0.124)
BMI	Time	-0.896	0.126	<0.001	0.103 (0.065–0.148)
	Variable	0.130	0.044	0.005	0.094 (0.058–0.138)
History of previous abdominal surgery	Time	-0.896	0.126	<0.001	0.097 (0.060–0.140)
	1 vs. 0	-0.380	0.393	0.339	0.012 (0.001–0.033)
Bilateral pedicle harvest	Time	-0.896	0.126	<0.001	0.097 (0.060–0.141)
	1 vs. 0	-0.986	0.933	0.295	0.015 (0.002–0.037)
Perforator number	Time	-0.895	0.126	<0.001	0.104 (0.066–0.148)
	2 vs. 1	-0.416	0.485	0.394	0.010 (0.001–0.029)
	3 vs. 1	0.711	0.539	0.193	0.009 (0.000–0.027)
	4 vs. 1	-0.740	0.822	0.372	0.020 (0.005–0.046)
Harvested flap weight*	Time	-0.895	0.126	<0.001	0.103 (0.065–0.148)
	1 vs. 0	0.171	0.058	0.005	0.096 (0.059–0.140)
Subcutaneous plane block use	Time	-0.898	0.126	<0.001	0.100 (0.062–0.144)
	1 vs. 0	0.671	0.350	0.060	0.044 (0.019–0.077)
Timing of reconstruction	Time	-0.895	0.125	<0.001	0.098 (0.061–0.142)
	Delayed vs. immediate	0.592	0.398	0.142	0.028 (0.009–0.056)

\*, values divided by 100 were used for this analysis. VAS, visual analogue scale; CI, confidence interval; BMI, body mass index.

**Table 3** Fixed effects of time and multiple clinical variables on the postoperative VAS scores in the linear mixed effect models

Variable	$\beta$ coefficient	Standard error	P value	Semi-partial R <sup>2</sup> (95% CIs)
Time	-0.898	0.126	<0.001	0.106 (0.068–0.151)
Harvested flap weight*	0.157	0.057	0.008	0.083 (0.048–0.124)
Subcutaneous plane block use	0.540	0.332	0.110	0.030 (0.010–0.059)

\*, values divided by 100 were used for this analysis. VAS, visual analogue scale; CI, confidence interval.

blockade (19). Similarly, Salibian *et al.* reported that patients with a BMI greater than 25 kg/m<sup>2</sup> had significant decreases in the degree of pain and opioid consumption with TAP blockade, but the same was not found in patients with a BMI less than 25 kg/m<sup>2</sup> (9). From the results of our study, it might

be inferred that patients with a higher BMI could have more severe pain; thus, TAP blockade was more effective.

According to the results of this study, more vigorous pain management can be planned for patients undergoing reconstruction of large breasts or in patients in whom

**Table 4** Comparison of morphine equivalents between subcutaneous plane block and control groups

Variable	Subcutaneous plane block group (N=33, 60%)	Control group (N=22, 40%)	P value
Morphine equivalents, median (IQR), mg	35.0 (26.25–62.5)	47.5 (20.0–65.0)	0.557
Morphine equivalents/body weight, median (IQR), mg/kg	0.60 (0.47–1.07)	0.89 (0.44–1.11)	0.751

IQR, interquartile range.

**Table 5** Comparison of morphine equivalents between subcutaneous plane block and control groups after adjusting covariates

Variable	Subcutaneous plane block group (N=33, 60%)	Control group (N=22, 40%)	P value
Morphine equivalents, mean $\pm$ SD, mg	50.7 $\pm$ 8.4	51.8 $\pm$ 9.9	0.871
Morphine equivalents/body weight, mean $\pm$ SD, mg/kg	0.85 $\pm$ 0.15	0.89 $\pm$ 0.17	0.671

SD, standard deviation.

a large flap is necessary. The information regarding factors related to postoperative pain also can be useful for preoperative patient counselling because postoperative pain is one of the most frequently identified reasons for which patients decline to undergo breast reconstruction after breast cancer surgery (20). In some cases, bipediced flap harvesting can be actively considered when indicated, because the bipediced flap not only can minimize tension on the abdominal donor site but also reduce donor site pain by decreasing the flap size.

This study has some limitations. First, the VAS score is a subjective pain score that is perceived by the patient. To minimize subjectivity, all of the pain scores included in this study were collected by an attending physician or surgeon in a uniform manner. Second, the sample size in this study was relatively small and patients who receiving catheter-based anesthetic infusions were not randomly selected. However, only patients who underwent breast reconstruction performed by a single surgeon were included in this study to minimize bias. Because pain severity can be affected by the timing of the examination, VAS scores were frequently evaluated by the doctors within 3-hour intervals. Finally, only subcutaneous layer placement of a catheter-based analgesic infusion pump was performed in this study. Comparative studies evaluating TAP blockade, subcutaneous layer blocks, and combined blocks are warranted to establish the most effective procedure.

## Conclusions

A larger flap weight is associated with an increased

degree of pain in patients undergoing DIEP flap breast reconstruction. Vigorous pain management might be necessary when a large flap is elevated, or bipediced flap harvesting can be considered to reduce the harvested flap weight.

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## Footnote

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*Ethical Statement:* The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was

approved by the Institutional Review Board of Ewha Womans University Mokdong Hospital (IRB No. 2020-03-015) and performed in accordance with the principles of the Declaration of Helsinki (as revised in 2013). Individual consent for this retrospective analysis was waived.

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