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Effect of enhanced recovery after surgery (ERAS) protocol on maternal and fetal outcomes following elective cesarean section: an observational trial

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Abstract

Background We aimed to investigate the maternal, fetal, and neonatal outcomes in parturients scheduled to undergo cesarean section (CS) receiving either standard care or enhanced recovery after surgery (ERAS) protocol.

Methods After approval of ethics committee (Gazi University Protocol Record Decision no: 502/31.05.2021) and registry to clinical trials (*NCT06753058*, Date 12/30/2024) 450 ASA II-III parturients at ≥ 18 years of age scheduled for elective CS under spinal anesthesia using bupivacaine plus opioids were included ($n=150$, ERAS group and $n=300$, control group). The ERAS protocol included restricting the fasting period before and after the surgery, administering oral nonparticulate carbohydrate solution (25 g of maltodextrin) 2 h (h) before surgery, intraoperative multimodal analgesia under spinal anesthesia and postoperative nausea and vomiting prophylaxis with intravenous (IV) 10 mg metoclopramide + 1.5 mg granisetron; postoperative analgesia was provided with IV nonsteroidal anti-inflammatory drug + paracetamol. While mother-baby contact was provided for both groups, all babies in the ERAS group were encouraged to breastfeed as soon as they were born. Maternal fasting duration, flatus, mobilization, urinary catheter removal times, postoperative visual analogue scale (VAS), rescue analgesic requirement, incidence of postoperative nausea-vomiting (PONV), length of stay (LOS), complications, Turkish version of the Obstetric Quality of Recovery Score 11 (ObsQoR-11T), were recorded in both groups. Newborn demographics, APGAR scores, umbilical cord blood gas analysis, nutritional and breastfeeding status and complications were also recorded.

Results In the ERAS group the ObsQoR-11T scores were better than the control group ($p<0.001$). Maternal preoperative and postoperative fasting duration, postoperative first flatus and mobilization times and LOS, postoperative VAS, rescue analgesic requirement in the ERAS group were shorter than the control ($p<0.001$, $p=0.034$,

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$p < 0.001$ and $p = 0.018$, $p < 0.001$, $p < 0.001$) and the incidence of PONV was less ($p = 0.001$). The pH and pO_2 were different between the groups.

Conclusions We suggest that ERAS use is favorably promising to achieve better maternal recovery in terms of ObsQoR and improved neonatal outcome in terms of nutrition and breastfeeding in the ERAS pathway.

Trial registration This study was retrospectively registered to clinical trials (*NCT06753058 and published on 12/30/2024, 09:19)* according to instructions at https://www.biomedcentral.com/getpublished/editorial-policies#trial+registration.

Keywords Enhanced recovery after surgery (ERAS), Cesarean section, Spinal anesthesia, Patient reported outcome measures (PROM), Obstetric quality of recovery (ObsQoR) score, Infant welfare

Introduction

The Enhanced Recovery After Surgery (ERAS) protocol in obstetrics was introduced by obstetric anesthetists in 2013 [1]. Then guidelines including preoperative, intraoperative and postoperative care for standardization of the surgical process, ensuring optimal treatment and care, and facilitating the earliest possible discharge of the patient have been launched by obstetricians and gynecologists in 2018 and 2019 [2–4]. Thereafter, successful implementation of the ERAS program has demonstrated reduced postoperative length of stay (LOS) in the hospital and/or inpatient opioid use after cesarean section (CS) in comparison to traditional/standard care in several studies and meta-analysis [5–10].

Since maternal and infant health is an important indicator of a country's healthcare prosperity, a consensus statement on ERAS recommendations has been launched by The Society for Obstetric Anesthesia and Perinatology (SOAP) in 2021 [11]. Based on the increased rate of CS worldwide between developed and developing countries, optimized postpartum recovery managed by ERAS has become a priority. Studies investigated and reported unidimensional outcome measures of ERAS such as LOS, opioid consumption, and pain scores as a quality improvement initiative until very recently obstetric quality -of-recovery score (ObsQoR) which is a patient -reported outcome measure (PROM), has been regarded as a gold standard for measuring postpartum recovery [12–15]. The meta-analysis investigating the general 15-item quality of recovery (QoR) scale and the most recent study that retrospectively reviewed specific ObsQoR-11 before and after implementation of ERAS showed that these scales have been considered a valid, reliable, and comprehensive helpful tool [14, 15]. Yet to our knowledge, the benefit of ERAS protocol versus standard care on both maternal and neonatal outcomes using ObsQoR-11 prospectively has not been conducted for CS in a controlled trial. Therefore, we aimed to investigate the benefits of preoperative, intraoperative, and postoperative ERAS elements on maternal and neonatal outcomes in ASA II or III term pregnant women scheduled to undergo elective CS under spinal anesthesia receiving either standard care or ERAS protocol using the Turkish version of the ObsQoR-11T prospectively. Primary purpose was to learn if implementing ERAS protocol can improve maternal outcomes in pregnant women using a responsive PROM. Secondly, to learn if implementation of maternal ERAS protocol can improve neonatal outcome in terms of nutrition and breastfeeding in Gazi University School of Medicine.

Methods

This study was approved by Gazi University Clinical Research Ethics Committee (Gazi University Protocol Record Decision number: 502/Date: 31.05.2021) and registered to clinical trials *(NCT06753058)*. The study was performed in accordance with the ethical standards as laid down in the *1964 Declaration of Helsinki* and its later amendments or comparable ethical standards. After obtaining written informed consent to participate in the study and consent for publication from each the parturient, data were collected prospectively in 450 ASA II or III term pregnant women aged ≥ 18 years scheduled to undergo elective CS under spinal anesthesia between June 2021 and June 2023. Gazi University Hospital, which is a re-accredited tertiary care referral center by ESAIC (European Society of Anaesthesiology and Intensive Care), has an annual rate of approximately 1400 deliveries. Parturients younger than < 18 years old with fetal compromise, ASA IV or V physical status and emergency cases were not included in this study. The ERAS protocol introduced for our unit was adapted from the SOAP [11]. Our study was conducted as an unblinded, non-randomized, observational cohort study. In this study, surgeons who accepted the ERAS protocol were selected first, then the ERAS group ($n = 150$) was formed with pregnant women who accepted the protocol as shown in the consort diagram (Fig. 1). Surgeons and/or pregnant women who did not accept the protocol formed the control group ($n = 300$). Therefore, our study was designed as a non-randomized and unblinded cohort study. The data of the participants having standard care were compared with those who were enrolled in the ERAS pathway. Primary outcome measure was improved maternal recovery in terms of ObsQoR-11 in the ERAS pathway. Secondary

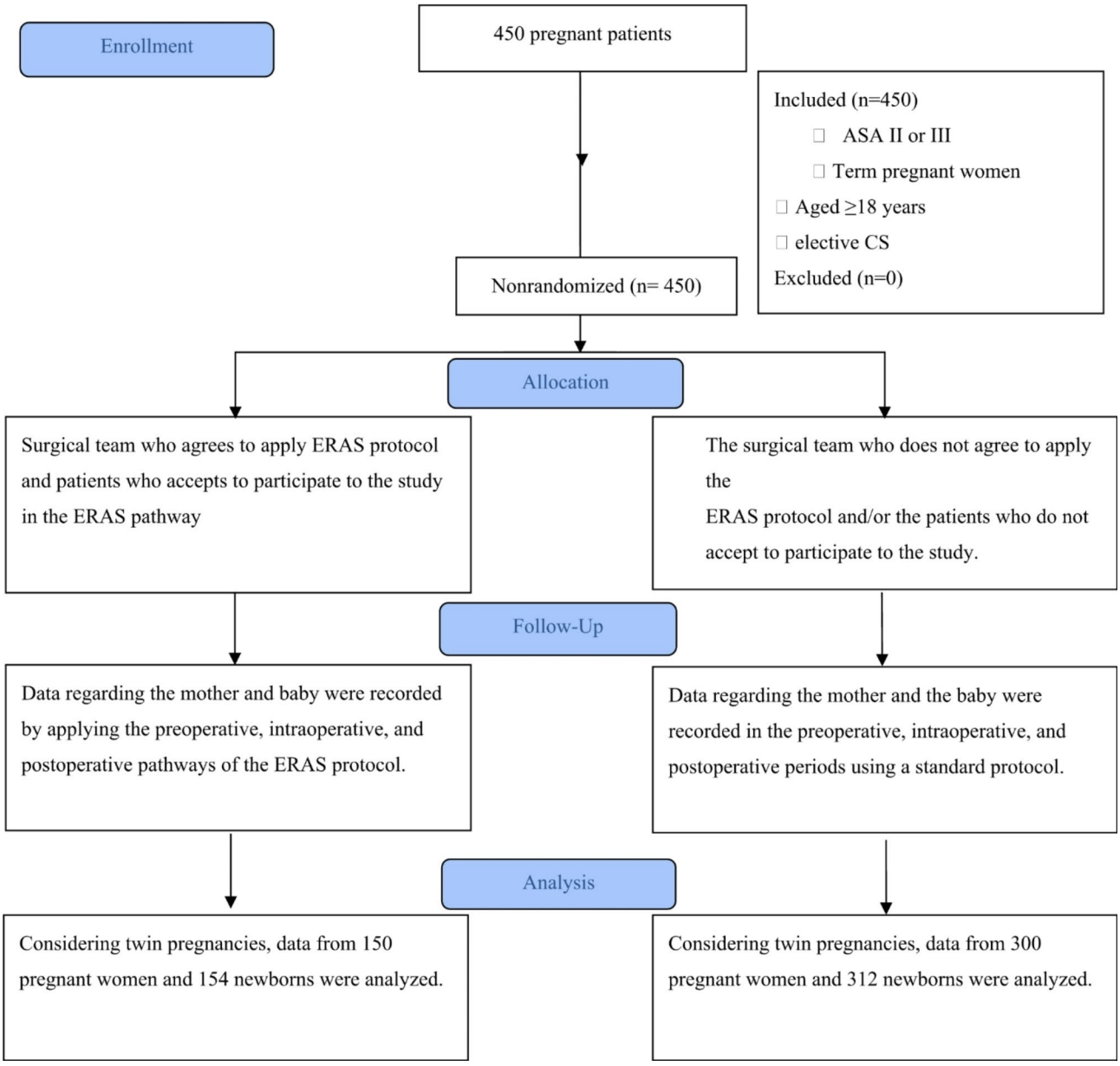


Fig. 1 CONSORT diagram

outcome measure was improved neonatal outcome in terms of the ERAS pathway.

After assigning patients to the ERAS group and control group; preoperative, intraoperative, and postoperative elements of the ERAS protocol were listed. Preoperatively, the control group fasted after 12 pm according to the standard protocol, regardless of the time of surgery, while the ERAS group was allowed to fast limitedly according to the scheduled time of the surgery. Unlike the control group, the pregnant women in the ERAS group were given a particle-free carbohydrate solution approximately 2 h before surgery under the supervision of an anesthesiologist. In the intraoperative period, the ERAS group was given double antiemetic drugs unlike the control group. Breastfeeding and maternal-infant bonding via intraoperative skin to skin contact was promoted immediately after birth as recommended in the ERAS protocol by SOAP [11]. While babies in the control group were followed according to standard protocol within the first hour described as the golden hour of breastfeeding.

In the postoperative period, while oral intake was started earlier in the ERAS group, the urinary catheter was removed earlier. In addition, instead of routine paracetamol and NSAIDs if needed in the standard protocol for postoperative analgesia, routine paracetamol and NSAIDs were given to the ERAS group.

Features of ERAS implementation and standard care in the study

Step 1. preoperative components

1. Enrolled patients were seen in the antenatal clinic to give face to face education including information about fasting, CS and/or anesthesia, antimicrobial prophylaxis, skin washing, breastfeeding preparation and support by the principal researcher anesthesiologist for ERAS pathway to improve patient understanding and engagement in their own care.
2. Principally fasting 6 h for solids and 2 h for clear fluids was provided. To standardize fasting duration according to the scheduled time of surgery in the ERAS group, pregnant women scheduled for CS before 12:00 PM were allowed to have breakfast at 2:00 AM, while the rest scheduled for CS after 12:00 PM were allowed to have breakfast at 6:00 AM. On the morning of surgery, parturient (either diabetic or non-diabetic) in the ERAS implemented group were given a carbohydrate solution prepared by the principal researcher anesthesiologist containing 25 g of maltodextrin in 330 mL (Nutricia Fantomalt 400 Gram, Nutri Gıda Ürünleri San. ve Tic. A.Ş., Istanbul, Türkiye) approximately 2 h prior to surgery, again under the supervision of the anesthetist. The control group fasted after 12:00 AM regardless of the scheduled CS time and no carbohydrate solution was administered prior to surgery (Table 1).
3. Anemia screening and treatment for hemoglobin optimization was done in both groups.

Table 1 Demographic data, comorbidities with medications and history [n, (%)]

	Control Group (*n* = 300)	ERAS Group (*n* = 150)	*p*
Age (years)	31.37 ± 4.85	31.07 ± 5.47	0.769
BMI (kg/m^2)	30.66 ± 4.94	31.58 ± 4.90	0.102
Gestational age (weeks)	38.60 ± 0.82	38.88 ± 0.86	0.100
ASA II / ASA III	241 (80.3)/59 (19.7)	116 (77.3)/34 (22.7)	0.459
Systemic disease	145 (48.3)	73 (48.7)	0.947
Diabetes mellitus (DM): Type 1 / Type 2 / Gestational	0 (0)/2 (0.7)/43 (14.3)	1 (0.7)/2 (1.3)/26 (17.3)	0.346
Insulin use	22 (7.3)	16 (10.6)	0.413
Hipertension (HT): Chronic / Gestational	2 (0.7)/ 14 (4.7)	1 (0.7)/ 12 (8)	0.360
Antihypertensive medication	9 (3)	2 (1.4)	0.091
Thyroid disease			
Hypothyroidism /Hyperthyroidism during pregnancy	71 (23.7)/1 (0.3)	35 (23.3)/0 (0)	> 0.05
Medication for hypo/ hyperthyroidism	72 (24)/ 3 (1)	45 (30)/ 0 (0)	0.199
Drug allergy history	21 (7)	13 (8.7)	0.528
Surgical history	228 (76)	113 (75.3)	0.876
Obstetric history	170 (56.7)	82 (54.7)	0.687

Step 2. intraoperative components

1. Standard intravenous (IV) antibiotic prophylaxis as per hospital guidelines was done in both groups (IV Cefazolin 2 gram in case of no known allergy history).
2. Management of anesthesia/analgesia (neuraxial 100 µg of morphine and 10 µg of fentanyl) with maintenance of fluid and surgical techniques was similar in both groups. As per our obstetric anesthesia division practice [16, 17], weight-height adjusted dose of hyperbaric bupivacaine 0.5% with 100 µg of morphine plus 10 µg of fentanyl was used during co-loading of 500 mL of colloid (VOLUHES, HES 130/0.4, 6% I.V., Polifarma, Türkiye) for spinal anesthesia and spinal anesthesia induced hypotension was treated with 10 mg of ephedrine (only available vasopressor drug in the country) in IV bolus doses in both groups.
3. Despite both groups receiving 10 mg of IV metoclopramide prophylactically, ERAS implemented group received IV 1.5 mg of the 5-HT3 antagonist granisetron additionally. In both groups, in case of risk factors for intraoperative and postoperative nausea and vomiting (PONV), IV 4 mg of dexamethasone was added.
4. To maintain normothermia body temperature loss was prevented using under-patient-mattress-blankets and warmers along with the control of the operating theatre temperature.
5. After the delivery of the baby, uterotonics were administered as per hospital guidelines (50 µg of carbetocin IV bolus was given and followed by 20 IU of oxytocin in 1000 ml of normal saline infusion was started at a rate of 2.5–7.5 IU/ hour) in both groups.

Delayed cord clamping was not performed in any of the groups by the obstetricians.

Step 3. postoperative components

1. In both groups who are at risk for deep vein thrombosis, prophylaxis was provided using pneumatic compression stockings.
2. Blood glucose monitoring was conducted only in diabetic patients and those with symptoms of hypoglycemia during follow-up.
3. In the ERAS implemented group, the diet management plan was as follows:

- drinking clear water was started at 2 h postoperatively.
- eating liquid diet (regime I or II) was started at 4 h.
  - Regime I (R-I) is a clear liquid diet that contains pulp-free, grain-free liquid drinks such as sweetened tea, fruit juice, compote water, lemonade, meat and chicken broth.
  - Regime II (R-II) is a soft diet that consists of soft, easily chewable and digestible foods such as light soups, mashed and boiled potatoes, puddings and liquid drinks, etc.
- eating normal diet (regime III) was started at 6 h.

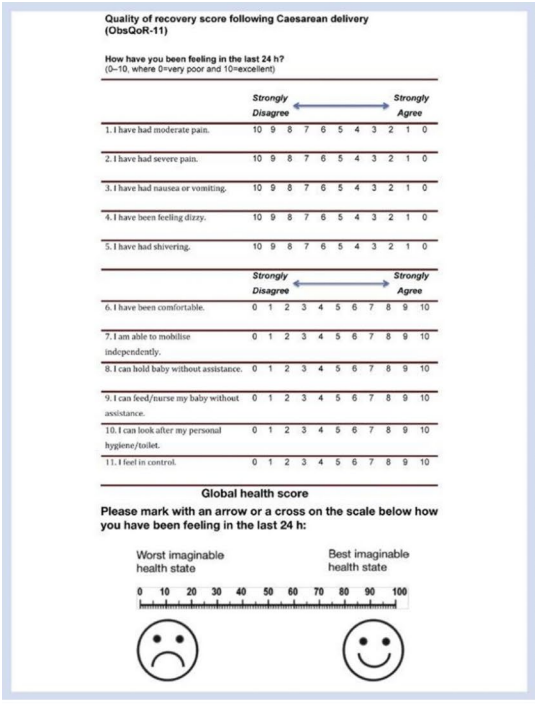
In the control group, the oral intake -diet management plan was as follows:

- drinking water at 6 h postoperatively.
- who do not have PONV and who can tolerate drinking water eating diet regime I-II.
- eating diet R III after 1st flatus.

4. ERAS implemented group were encouraged to chew gum with early feeding, while patients in the control group were not.
5. The urinary catheter was removed just before mobilization in the ERAS implemented group, whereas it was removed when urine output reached to 1000 mL as per clinical conventional procedure in the control group.
6. Mother-infant contact was provided in both groups through skin-to-skin contact. All babies in the ERAS group were encouraged for breastfeeding immediately after birth, while babies in the control group were monitored according to the standard protocol within the first hour [11].
7. Prior to discharge, both groups were asked to fill out the validated Turkish version of the ObsQoR-11 [17] with 11-point Likert scale [15]. These forms were collected (Fig. 2A and B).
8. The standard post-operative analgesia practice in our clinic was to administer paracetamol as a routine practice and NSAIDs when needed. However, in the ERAS group, both paracetamol and NSAIDs were routinely administered to provide multimodal analgesia in line with the ERAS protocol recommendations.

Recorded parameters

- maternal demographics, comorbidities with medications and history (drug allergy, surgical and obstetric).



(A)

Final Turkish version of the ObsQoR-11

Son 24 saattir nasıl hissediyorsunuz? (0-10, 0:çok kötü ve 10:mükemmel)

	10=Kesinlikle katılmıyorum → → → → → → Kesinlikle katılıyorum=0										
1.	Orta şiddetli ağrım oldu.	10	9	8	7	6	5	4	3	2	1	0
2.	Çok şiddetli ağrım oldu.	10	9	8	7	6	5	4	3	2	1	0
3.	Bulantı ve kusmam oldu.	10	9	8	7	6	5	4	3	2	1	0
4.	Göz kararması yaşadım.	10	9	8	7	6	5	4	3	2	1	0
5.	Titrememe oldu.	10	9	8	7	6	5	4	3	2	1	0
	0=Kesinlikle katılmıyorum → → → → → → Kesinlikle katılıyorum=10										
6.	Rahat hissettim.	0	1	2	3	4	5	6	7	8	9	10
7.	Tek başıma hareket edebilirim.	0	1	2	3	4	5	6	7	8	9	10
8.	Bebeğimi yardım almadan tutabiliyorum.	0	1	2	3	4	5	6	7	8	9	10
9.	Bebeğimi yardım olmadan emzirebiliyorum.	0	1	2	3	4	5	6	7	8	9	10
10	Kişisel bakım ve temizliğimi yapabiliyorum.	0	1	2	3	4	5	6	7	8	9	10
11.	Kontrol altında hissediyorum.	0	1	2	3	4	5	6	7	8	9	10

(B)

Fig. 2 (**A**) Quality of recovery scoring after cesarean delivery (ObsQoR-11). (**B**) The ObsQoR-11 Turkish version

- preoperative duration of fasting for fluid and solid food, time to intake of 1st postoperative water, regimen I-II and regimen III-IV.
- time to mobilization, urinary catheter removal and flatus and LOS for mother (in hours).
- postoperative pain within 24 h of the surgery was assessed for all patients using VAS scores at postoperative 24 h in rest and extra analgesic requirement.
- validated Turkish version of 11-item ObsQoR score with an 11-point numerical Likert scale (0 being strongly negative, 10 being strongly positive) resulting in a maximum score of 110 [15, 18].
- postoperative complications (hypoglycemia, hypotension, PONV).
- newborn demographics and Apgar scores, umbilical cord gas analysis, newborn LOS in days.
- need for follow-up in the ward or newborn intensive care unit (NICU) for transient tachypnea of the newborn (TTN) or phototherapy.
- status of mother-baby bonding and breastfeeding.

Statistical analysis

Due to the preliminary results, we assumed a medium effect size of 0.5 for the purposes of sample size estimation which is supported by previous literature recommending effect sizes of 0.5 or greater for clinical study [19]. Sample size was calculated using the G*Power 3.1.9.7 program. With a 95% confidence interval, an effect size of 0.5, and a case: control ratio of 1:2, it was aimed to reach at least 48:96 people to reach 80% power. Power analysis revealed that 99% for ObsQoR-11 score and 72.1% for the first flatus time with a 95% confidence interval.

Post-hoc power analysis for neonatal pH and PO_2 values revealed a statistical power of 78.37% for pH and 99.17% for PO_2. The effect size was calculated as a small effect with 0.30 for pH and 0.36 for PO_2.

This study was analyzed using Statistical Package for Social Sciences (SPSS), version 23.0 for Windows (SPSS Inc., Chicago, USA). Descriptive statistics were presented for categorical variables as n or percentage, while continuous variables were expressed as mean ± standard deviation (Mean ± SD) or median (IQR) where appropriate. The normality of numerical variables was assessed using visual methods (histograms and probability plots) and analytical methods (Kolmogorov-Smirnov/Shapiro-Wilk tests). Regarding the analysis of normally distributed numerical data, independent samples t-test was employed for comparisons between the two groups, while Mann-Whitney U test was used for non-normally distributed data. Categorical variables were compared using the Chi-square test or Fisher's exact test (in case of assumptions of the Chi-square test were not met due to observed cell values). A p value of <0.05 was considered as statistically significant.

Table 2 Preoperative fasting times for fluid and solid food and postoperative time elapsed to intake water and regimen I-II and III oral intake in hours (h) (Mean ± SD)

	Control Group	ERAS Group	*p*
Fasting Fluids (h)	10.94 ± 2.68	2.50 ± 0.73*	< 0.001
Fasting Solids (h)	12.25 ± 2.10	7.97 ± 1.54*	< 0.001
POST-OPERATIVE			
Time to Water Intake (h)	5.49 ± 1.02	2.0 ± 0*	< 0.001
Time to Regimen I-II Intake (h)	8.05 ± 2.21	4.0 ± 0*	< 0.001
Time to Regimen III Intake (h)	20.32 ± 5.45	6 ± 0*	< 0.001

* $p < 0.001$ between the groups

Table 3 Time to mobilization, first Flatus, length of stay (LOS) and postoperative visual analogue scale (VAS) at 24 h in rest and extra analgesic requirement (Mean ± SD, %)

	Control Group	ERAS Group	*p*
First Flatus Time (h)	18.35 ± 6.26	16.72 ± 6.47*	0.034
Mobilization Time (h)	6.69 ± 1.45	6.09 ± 1.06*	< 0.001
LOS (h)	30.48 ± 5.46	29.05 ± 2.54*	0.018
Postoperative VAS at 24 h in rest	4.53 ± 2.22	1.68 ± 1.59*	< 0.001
Extra analgesic requirement	51%	6.7%	< 0.001

LOS: Length of Stay

VAS: Visual Analogue Scale

* $p < 0.005$ between the groups

Results

Demographic characteristics were presented in Table 1. There are no statistically significant differences in age and BMI among all pregnant women in both groups. Distribution of history and comorbidities such as diabetes mellitus (type 1, 2 or gestational), hypertension (chronic or gestational) and hypothyroidism/hyperthyroidism along with medications and ASA classification (II or III) were comparable between the groups (Table 1).

Since fasting was strictly adjusted based on the ERAS protocol, the ERAS group had a shorter fasting period than the control group. Also, oral intake was allowed earlier in the ERAS group than in the control group according to the protocol in the postoperative period ($p < 0.001$, Table 2).

First flatus times were significantly shorter in the ERAS group than that of the control group ($p = 0.034$, $p < 0.001$, respectively) (Table 3). Six patients in the control group had a prolonged 1st flatus time managed by obstetricians using enema.

The maternal LOS and postoperative VAS at 24 h in rest were significantly shorter in the ERAS group when compared to the control group ($p = 0.018$ and $p < 0.001$, respectively) (Table 3).

When ObsQoR-11T scores with Likert scale were assessed, the ERAS group had significantly higher scores when compared to the control group ($p < 0.001$, Table 4).

Regarding the postoperative complications of the groups, blood glucose monitoring was performed only in diabetic patients (type 1 DM, type 2 DM, and gestational DM) and in patients who showed symptoms of hypoglycemia such as tremors, sweating, headache and dizziness, nausea and fatigue. In the control group, blood glucose monitoring in 46 patients, including 43 cases with gestational diabetes, 2 cases with type 2 diabetes, and 1 symptomatic patient. In the ERAS group, blood glucose monitoring in 30 patients, including 26 cases with gestational diabetes, 1 case with type 1 diabetes, 2 cases with type 2 diabetes and 1 symptomatic patient. Patients with blood sugar glucose below 70 mg/dl during blood glucose monitoring were considered to have hypoglycemia and were intervened. Hypoglycemia was observed in 8 cases in the control group and these patients were given IV dextrose ($p = 0.019$). Hypoglycemia observed in the control group was associated with prolonged fasting periods, especially in the postoperative period. The rate of PONV and medication requirement were significantly lower in the ERAS group than that of the control group (Table 5).

In this study there were 466 newborns (154 from the ERAS group and 312 from the control group) due to the number of twin pregnancies (24 and 8 in the control and ERAS groups, respectively). Demographic characteristics of the newborns did not reveal any significant differences in terms of birthweights (categorized as small, appropriate or large for gestational age), and 1 and 5-minute APGAR scores between the groups (Table 6).

Although analysis of umbilical cord blood gases exhibited lower pH and PO_2 levels in the ERAS group compared to the control group, the mean pH values were not less than 7.2 in both groups (Table 7).

The mean newborn LOS were comparable between the groups (1.16 days in the ERAS group and 1.20 days in the control group, $p = 0.630$). The mean weight loss at 24 h was significantly lower in the ERAS group than in the control group (5.32% vs. 5.66%, $p = 0.025$). During the postnatal follow up of the newborns; neither follow-up in the ward requiring oxygen in the incubator or via hood nor NICU need either for TTN or phototherapy did not significantly differ between the groups.

The mean newborn LOS was not statistically significant when compared between groups (1.16 days in the ERAS group and 1.20 days in the control group, $p = 0.630$). The mean newborn weight loss at 24 h was significantly lower in the ERAS group than in the control group and the rate of complete breastfeeding was markedly higher without need for formula feeding in the ERAS group (Table 8).

Table 4 The obstetric Quality-of-Recovery – 11T score with likert scale (Median, IQR)

	Control Group	ERAS Group	*p*
ObsQoR-11T Score	82 (74–95)	93 (87–99)	< 0.001
Likert Scale	4 (3–5)	5 (5–5)	< 0.001

ObsQoR-11T: Turkish version of the Obstetric Quality of Recovery Score 11

Table 5 Comparison of complications (Normoglycemia/hypoglycemia, hypotension, PONV and medication requirement) [n, (%)]

	Control Group	ERAS Group	*p*
Normoglycemia / Hypoglycemia	38 (82.6) / 8 (17.4)	30 (100) / 0*	0.019
Hypotension (No/Yes)	290 (96.6) /10 (3.4)	149 (99.3) / 1 (0.7)	0.109
PONV (No/Yes)	230 (76.7) / 70 (23.3)	133 (88.7) / 17 (11.3)*	0.001
Medication requirement (No/Yes)	34 (48.6) / 36 (51.4)	14 (82.4) / 3 (17.6)*	0.012

PONV: Postoperative nausea and vomiting

* $p < 0.001$ between the groups

Table 6 Comparison of newborn demographics and APGAR scores [n (%) or median (IQR)]

	Control Group (*n* = 312)	ERAS Group (*n* = 154)	*p*
Gender (Girl/Boy)	153 (49)/159 (51)	78 (50.6)/76 (49.4)	0.744
AGA	283 (90.7)	142 (92.2)	0.697
SGA	13 (4.2)	4 (2.6)	
LGA	16 (5.1)	8 (5.2)	
1-minute APGAR	9 (9–9)	9 (6–10)	0.222
5-minute APGAR	10 (9–10)	10 (9–10)	0.347

SGA: Small for Gestational Age

AGA: Appropriate for Gestational Age

LGA: Large for Gestational Age

Table 7 Analysis of umbilical cord blood gas (Mean ± SD)

	Control Group (*n* = 312)	ERAS Group (*n* = 154)	*p*
pH	7.31 ± 0.06	7.29 ± 0.08*	< 0.001
PCO_2 (mmHg)	46.21 ± 8.43	47.39 ± 9.06	0.167
PO_2 (mmHg)	20.21 ± 12.19	16.28 ± 7.22*	< 0.001
Base excess	-2.39 ± 2.94	-2.76 ± 3.94	0.629

* $p < 0.001$ between the groups

Table 8 Newborn breastfeeding status and weight loss within 24 h [n (%) or mean ± sd]

	Control Group (*n* = 312)	ERAS Group (*n* = 154)	*p*
Full breastfeeding	265 (84.9)	145 (94.2)*	0.013
Predominantly breastfeeding	44 (14.1)	9 (5.8)	
Formula feeding	3 (1.0)	0 (0)	
Newborn weight loss within 24 h (%)	5.66 ± 1.40	5.32 ± 1.42*	0.025

Discussion

Our study demonstrated that the ERAS group had significantly better ObsQoR-11T score with Likert scale compared to standard care; LOS and postoperative VAS were significantly reduced, PONV and antiemetic requirement was reduced, and 1st flatus and urinary catheter removal times were shortened with early mobilization. Despite lower fetal pH in the ERAS group, it did not affect newborn outcomes because mean pH was not less than 7.2 which has been accepted as the cut of value for fetal acidosis. Newborn Apgar scores, LOS for infants, need for postnatal follow-up in the ward or NICU were comparable in both groups. The mean newborn weight loss within 24 h was lower in the ERAS group than in the control group and the rate of complete breastfeeding was markedly higher with no need for formula feeding in the ERAS group.

The increasing volume of cesarean deliveries requires best practice available if possible. According to a recent overview of national databases using Robson 10 group classification system, total and primary CS rates between 2018 and 2023 were 57.55% and 28.83%, respectively and Robson Groups 1–4 constituted 58% of CSs in Turkey [20]. Therefore, to improve the quality and safety in obstetric anesthesia and reduce maternal morbidity and/or mortality, implementation of ERAS in routine practice could be of benefit.

The PROM assesses functional recovery after CS. Lately ObsQoR-11 has become a gold standard PROM to assess postpartum recovery, after development of initial 9-itemQoR score, QoR-40 and short form of QoR-15 scale which have been most widely used tool to assess quality of recovery (0 being very poor and 150 being excellent) [12–15]. A systematic review using the 'Consensus-based standards for selection of health measurement tools' (COSMIN) criteria to define and assess PROM quality found that of 13 PROMs used to assess the quality of recovery after Caesarean section in 20 studies involving 9214 patients, five were specific to postpartum recovery and only two were specifically designed for use after Caesarean section (the Obstetric Recovery Quality-11 and the Post-Caesarean Recovery Scale). Overall, the Obstetric Recovery Quality-11 met the highest COSMIN standards for any PROM in the study [21]. In another study, ObsQoR-11 correlated with global health status NRS ($r = 0.53$; 95% confidence interval: 0.43–0.62; $P < 0.0001$) and distinguished good from poor recovery (NRS score ≥ 70 vs. < 70 mm) at 24 h. Thus, ObsQoR-11 was considered a valid, reliable, and sensitive global assessment of recovery after elective cesarean delivery [22]. Recently, successfully improved functional recovery associated with decreased LOS was demonstrated by using ObsQoR-11 as a patient centered outcome measure when medical records were reviewed before and after the implementation of ERAS pathway during elective CS [15]. After implementation of ERAS pathway, median ObsQoR-11 score has significantly increased from 82 to 85 and median LOS significantly shortened from 78 to 55 hours [15]. To translate and validate the psychometric properties of the Turkish version of the Obstetric Recovery Quality Score 11 instruments used to measure recovery after cesarean delivery in Turkish-speaking patients, a total of 186 patients completed the ObsQoR-11T after CS. When the correlation between the ObsQoR-11T and the VAS for recovery was assessed, there was a strong correlation between the ObsQoR-11T and the VAS (correlation > 0.70) after CS. The study demonstrated that the Obstetric Recovery Quality Score 11 is a valid and reliable instrument to measure the quality of recovery after cesarean delivery in Turkish-speaking patients, and the psychometric properties of the Turkish version of the scale to measure the quality of recovery after cesarean delivery were like seminal English version (18).

In our study, when the ERAS group was compared with the control in terms of ObsQoR-11T score, we achieved ''better recovery" in the ERAS group with a higher ObsQoR-11 score (median 93) than that of the control group (median 82).

Regarding the key elements of preoperative ERAS pathway that include limiting fasting interval, loading non-particulate carbohydrate liquid and patient education, duration of fasting for fluid and solid food and times to intake of 1st postoperative water, R I-II and R III oral intake was started earlier in the ERAS pathway. Although 45 g of different carbohydrate solutions (e.g., Gatorade 32 oz: 54 g carbohydrate) clear apple juice (16 oz: 56 g carbohydrate) in non-diabetic women have been recommended by SOAP, we preferred 25 g of carbohydrate diluted in the 330 mL (fantomalt, nutricia) in both diabetic and non-diabetic pregnant women. Distribution of type 1, type 2 and gestational DM were similar between the groups. Hypoglycemia was observed in 8 cases of the control group, while there was no hypoglycemia in the ERAS pathway. These benefits could have been contributed to the deliberately pre-scheduled ERAS protocol and we suggest less amount of carbohydrate loading.

Since early mobilization and urinary catheter removal were deliberately done in the postoperative ERAS pathway, time to first flatus and LOS were significantly shorter in the ERAS group. Six patients in the control group had delayed flatus that required management using enema by the obstetricians.

Pan and coworkers [23] implemented ERAS protocol for elective CS under combined spinal epidural (CSE) using intrathecal 5% ropivacaine (12.5–13.5 mg) and managing postoperative analgesia via patient controlled epidural analgesia (PCEA) including 6 mg morphine plus IV dexmedetomidine 0.5 μg/kg in a prospective

randomized controlled trial. Since they did not use intrathecal opioids (100 mcg of morphine plus 10 mcg of fentanyl) like us, they had to use much more epidural opioids (morphine initial bolus 2 mg and 6 mg via PCEA in the control and ERAS group respectively) plus IV dexmedetomidine infusion postoperatively. As expected, they found significantly decreased VAS scores at 24 h and 48 h both in rest and motion but without difference in the extra requirement of analgesics between the groups. Although we did not consume that much neuraxial opioid in our study, we observed significantly decreased postoperative VAS at 24 h in rest as well which can be explained with the benefit of using intrathecal opioids plus local anesthetics for surgical anesthesia which could have successfully prevented postoperative unnecessary opioid need via PCEA and/or analgesic use like IV dexmedetomidine. Secondly, we demonstrated less extra analgesic requirement in the ERAS group though we used the same intrathecal anesthesia protocol.

Regarding neonatal outcomes, all newborns were comparable in terms of demographics and APGAR scores between the groups.

Mother-infant bonding process starts from the gestation period and continues in the postpartum period. Parents' attachment to the fetus and newborn may be influenced by many factors. Antenatal and postnatal mother-infant attachment plays a very important role in maintaining the baby's physical, mental, and emotional health. Therefore, ''attachment" is regarded as one of the basic psychological developments of the baby and the relationship of the baby that has been established with the outside world. In this regard mother-infant bonding and breastfeeding should be started as soon as possible and/or in the operating room, having mother and baby stay in the same room, or yoga and meditation and social support applications can be utilized if available [24].

Another element of the obstetric ERAS pathway is to encourage early initiation of breastfeeding, immediate skin-to-skin contact, and encourage breastfeeding in the operating room. In Rush University Medical Center, a study project was developed for women who had planned CS. The proportion of women who initiated breastfeeding within 1 h of the ERAS protocol increased from 39 to 75% [25]. In our study, skin-to-skin contact was provided between mother and newborn in both groups. In the ERAS group, proactive breastfeeding was promoted "as soon as the baby is born in the operating room". As a result of earlier proactive breastfeeding in the ERAS protocol, none of the newborns required formula feeding subsequently newborn weight loss within the 24 h was lower in the ERAS group.

Analysis of umbilical cord blood gas parameters in the ERAS group revealed lower pH and PO_2 levels. Although power analysis demonstrated a statistical power of 78.37% for pH and 99.17% for PO_2, the mean pH in both groups remained above 7.20.

The interpretation of umbilical cord blood gas values can vary depending on the criteria used to define normality and the population being studied. A large-scale cohort study employing universal UC-pH measurement reported that UC-pH levels below 7.20 were associated with an increased risk of neonatal morbidity and mortality. Even pH levels between 7.10 and 7.19 were linked to elevated risks of severe neonatal morbidity, with risks further increasing when pH levels fell below 7.10 [26]. In our study, however, the mean pH value in both groups was above 7.20.

In addition to these considerations, the lower pH levels observed may also be attributed to the use of ephedrine for the treatment of maternal hypotension secondary to spinal anesthesia, although the incidence of maternal hypotension was comparable between the groups. Without further detailed analyses, the clinical significance of these findings remains uncertain. Nonetheless, as acidosis was present in both groups, it is unlikely that the ERAS protocol alone accounts for the observed fetal acidosis.

Phenylephrine is the first-line agent for the management of spinal anesthesia-induced hypotension. However, due to its unavailability in our country, ephedrine which is known to carry a higher risk of inducing fetal acidosis was used instead [26].

A randomized controlled trial comparing different infusion regimens of phenylephrine and ephedrine to maintain maternal blood pressure during cesarean delivery found that as the proportion of phenylephrine decreased and that of ephedrine increased, there was a corresponding increase in the incidence of hypotension and nausea/vomiting. Concurrently, fetal pH and base excess decreased, umbilical artery oxygen content declined, and umbilical vein PO_2 increased [27]. Similarly, another study evaluating umbilical artery pH and standard base excess in 337 consecutive elective cesarean sections performed under spinal anesthesia identified ephedrine administration and its interaction with the duration of hypotension as significant contributing factors [28]. Therefore, while maternal hypotension rates did not differ significantly between the groups in our study, the use of ephedrine to manage hypotension may have contributed to the lower pH and PO_2 values observed. As umbilical cord blood gas parameters such as pH and PO_2 can be influenced by numerous variables including parity, smoking status, fetal characteristics, and intraoperative ephedrine use [29], future studies incorporating larger sample sizes and controlling these confounders are warranted to elucidate these associations.

The current study has some limitations that should be shared. Group selection is a limitation of our study. We

cannot randomly assign our patients to either ERAS pathway or standard care. Since we have just started to implement ERAS protocol into our clinical practice, not all the OBGYNs support the ERAS approach. Therefore, we recruited patients who received standard care as the control group. Due to the nature of the intervention, randomization of group assignment and blinding of investigators were not possible. So, the results could have been influenced by information and selection bias particularly during the antenatal education period in addition to performance, measurement, and detection bias during data collection. Even though systematic reviews of elective CS comparing ERAS protocols with conventional care favor ERAS implementation to achieve better maternal outcomes [30, 31], our prospective comparative study was unique in that it provided improved maternal and neonatal outcomes associated with breastfeeding.

In conclusion current ERAS protocol with its preoperative, intraoperative, and postoperative components demonstrated improved maternal ObsQoR-11 scores with Likert scale, less PONV and antiemetic requirement, reduced LOS, shorter time elapsed to 1st flatus, mobilization, urinary catheter removal, less pain scores and extra analgesic requirement with better neonatal outcomes without any adverse effects. We believe routine use of ERAS for elective CS would be a comprehensively favorable practice for better maternal and neonatal outcomes in obstetrics. Further ERAS research in high risk parturient and/or emergency cases would be valuable for best practice.

Abbreviations

CSE	Combined Spinal Epidural
DM	Diabetes Mellitus
ERAS	Enhanced Recovery after Surgery
LOS	Length of stay
NICU	Newborn Intensive Care Unit
ObsQoR	Obstetric Quality-of-Recovery
PONV	Postoperative Nausea and Vomiting
PCEA	Patient Controlled Epidural Analgesia
PROM	Patient-Reported Outcome Measures
QoR	Quality-of-Recovery
SOAP	Society for Obstetric Anesthesia and Perinatology
TTN	Transient Tachypnea of the Newborn
VAS	Visual Analog Scale

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Author contributions
MGÖ: Designed and conducted the study, data collection, wrote manuscript. BG: Designed and conducted the study, reviewed and interpreted data, wrote manuscript, overall supervision MB: Reviewed and interpreted maternal data. IMH: Reviewed and interpreted neonatal data. All authors (MGÖ, BG, MB, IMH) reviewed the manuscript. Authors' Contributions Concept-design: MGÖ, BG. Data collection: MGÖ, MB Data analysis and interpretation: MGÖ, BG, MB, IMH Manuscript draft: BG, MGÖ Critical review of content: BG, IMH. Final approval and responsibility: MGÖ, BG, MB, IMH.

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Data availability
Availability of data will be provided when requested from the corresponding author or the 1st author.

Declarations

Ethics approval and consent to participate
We do declare that Gazi University *Ethics Committee approval* (Gazi University Protocol Record Decision number: 502/Date: 31.05.2021) and written informed consent from patients to participate in the study were obtained and indicated in the methods section.

Consent for publication
Consent for publication was obtained.

Competing interests
The authors declare no competing interests.

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