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Intravenous Vitamin C for Bleeding Control in Elective C-Sections: A Randomized Clinical Trial Study

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Ethical approval and consent to participate

All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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Contributors' Statement Page:

Dr. Banafsheh Mashak, Dr. Bahareh Khakifirooz and Dr. Zeinab Amirpour : conceptualized and designed the study, drafted the initial manuscript, and reviewed and revised the manuscript.

Dr. Maryam Hashemnejad and Dr. Samira Abdullahi: Designed the data collection instruments, collected data, carried out the initial analyses, and reviewed and revised the manuscript.

Dr. Mahboobeh Miri Dr. Fatemeh Amirpour- Kondelji: Coordinated and supervised data collection, and critically reviewed the manuscript for important intellectual content.

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Abstract

Objective: This study aimed to evaluate whether intravenous vitamin C reduces intraoperative and postoperative blood loss in elective cesarean deliveries, with primary outcomes focusing on hemoglobin preservation and quantified blood loss measurements.

Methods: In this randomized trial, 60 women undergoing elective morning cesarean sections(CS) were assigned to receive either 1g Intravenous (IV) vitamin C (n=30) or placebo (n=30) 2 hours preoperatively. The primary endpoint was the change in hemoglobin level from preoperative baseline to 24 hours postoperative. Secondary outcomes included quantified blood loss (suction volume, weighed gauze/sponges), uterotonic requirements, and procedure duration.

Results: Baseline characteristics showed no significant differences between groups. The vitamin C intervention group demonstrated superior outcomes across multiple measures: intraoperative gauze use was reduced by 30% (4.43±1.04 vs 6.37±1.29, $p<0.001$), sponge use decreased by 31% (1.13±0.34 vs 1.63±0.49, $p<0.001$), and suction volume was 13% lower (522±54cc vs 598±68cc, $p<0.001$). Clinically meaningful benefits included 31% fewer uterotonic requirements ($p=0.003$), significantly better hemoglobin preservation (0.07 vs 1.38 g/dL, $p<0.001$), and reduced surgical duration ($p<0.001$). Postoperative pad usage showed no significant difference between groups ($p=0.344$). These findings collectively demonstrate vitamin C controls intraoperative blood loss while maintaining patient stability.

Conclusion: Prophylactic vitamin C significantly reduces intraoperative blood loss and preserves hemoglobin during elective CS, while shortening procedure time and decreasing uterotonic needs. These clinically meaningful benefits support its use as a safe adjuvant therapy.

keywords: Vitamin C, Cesarean, Pregnant, Women, Procedure, Mother, Child.

Introduction

Cesarean section (CS) is the most common type of major surgery in women. The first modern CS was performed by obstetrician Ferdinand Adolf in Germany in 1881 [1]. CS is a surgical procedure in which one or more incisions are made through the mother's abdomen and uterus for the delivery of one or more babies [2]. CS is a major abdominal surgery and is riskier than natural childbirth [3].

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In situations where vaginal delivery risks the life of the mother and the fetus, a CS is performed [4]. Examples include fetal malpresentation, such as transverse or breech position in the uterus, umbilical cord around the neck, cephalopelvic disproportion, multiple pregnancies, fetal distress, history of previous CS, and other reasons [5]. Considering the importance of reducing infant and maternal mortality rates and increasing the rate of live births, which contributes to a younger age pyramid in the country and has many economic and future benefits, CS is essential [6,7]. However, it also has many complications, one of the most important being bleeding during and after cesarean delivery, where the mother may lose a considerable amount of blood, sometimes up to 1.5 liters [8].

Among other potential complications, uterine infection, increased risk of embolism, uterine adhesions, and so forth can be mentioned [9]. The rate of CS has sharply increased in recent years, and possible reasons for this include improvements in cesarean techniques and reduction in its mortality and complications, increased age at marriage leading to higher maternal age, which is associated with increased pregnancy-related complications, increased blood pressure during pregnancy and diabetes, which are associated with increased maternal complications, and a growing inclination towards it, to the extent that in some countries, cesarean delivery is performed even upon the mother's request [10,11].

Many studies have been conducted on the use of various drugs and techniques in clinical trials [12]. The injection of oxytocin controls bleeding during and after CS, significantly reducing associated blood loss [13,14]. Vitamin C is a water-soluble vitamin essential for iron absorption, immune support, wound healing, and maintaining bones, cartilage, and teeth. As an antioxidant, it protects the body from damage by free radicals found in processed foods, toxic chemicals, and cigarette smoke, helping prevent diseases like cancer, heart disease, and joint pain. Vitamin C also supports hormone function, boosts immunity, aids collagen production, and helps prevent high cholesterol and blood clots. It acts as an electron carrier in chemical reactions and neutralizes harmful substances in the bloodstream.

Vitamin C reduces cesarean blood loss through three key mechanisms: First, it stabilizes collagen by serving as a cofactor for vascular collagen synthesis, resulting in 31% fewer sponges used due to reduced capillary fragility. Second, it enhances hemostasis by increasing platelet adhesion by 22% (in vitro) and reducing suction volumes by 13%. Third, its antioxidant activity decreases platelet-impairing ROS by 40% while preserving vaso-regulation. These effects

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collectively explain the observed 76cc reduction in blood loss, consistent with animal studies showing 30% faster vessel repair [15,16]. Vitamin C (ascorbic acid) may aid hemostasis during surgery by stabilizing collagen in blood vessels, reducing capillary fragility and bleeding. Its deficiency, as seen in scurvy, leads to bleeding symptoms and poor healing. Vitamin C also enhances platelet aggregation, improves clot retraction, and reduces oxidative stress, supporting hemostasis. Studies show it can lower blood loss in orthopedic and cardiac surgeries, but its effects in CS are less studied. This research investigates whether preoperative IV vitamin C improves hemostasis in elective cesarean delivery [17].

Considering the significant complications of CS, with one of the most important being bleeding during the procedure, extensive studies in this area have become necessary [18].

This study hypothesizes that the administration of intravenous vitamin C during CS will reduce the amount of bleeding during and after the procedure, leading to a decrease in maternal and neonatal complications associated with CS. Additionally, it is expected to contribute to an increase in live births, improve the quality of the cesarean procedure, and reduce economic costs by shortening hospital stays and enabling quicker recovery.

Materials and methods

This randomized trial enrolled 60 healthy primiparous women (aged 18-35 years) undergoing elective CS for breech presentation at Kamali Hospital. Eligible participants had uncomplicated singleton pregnancies (38-40 weeks gestation), normal coagulation profiles, and no contraindications to vitamin C (e.g., G6PD deficiency or nephrolithiasis). We excluded patients on anticoagulants, with fetal anomalies, or significant comorbidities (diabetes, hypertension). After obtaining written informed consent (Ethics Approval: Alborz University of Medical Sciences (IR.ABZUMS.REC.1401.180), participants were randomly assigned to either the intervention group (n=30) receiving 1g IV vitamin C diluted in 100mL normal saline or the control group (n=30) receiving equivalent-volume placebo (normal saline). The vitamin C solution was prepared by the pharmacy in identical opaque bags and infused over 20 minutes via IV pump, administered 2 hours before spinal anesthesia (2.5mL 0.5% bupivacaine). Both groups received standard uterotonics (IV oxytocin 5IU post-delivery).

The randomization sequence was generated using a computer-based permuted block randomization method with block sizes of four (e.g., AABB, ABAB) to ensure balanced allocation. The sequence was created by an independent statistician who was not involved in

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participant recruitment or intervention delivery. To maintain allocation concealment, each random assignment was linked to a 10-digit code written on identical, opaque, sealed envelopes, which were sequentially numbered. These envelopes were prepared by an independent third party. Upon participant enrollment, the next envelope in sequence was opened by a study nurse who was blinded to the contents, thus preserving allocation concealment and preventing selection bias.

All participants received standardized spinal anesthesia (2.5 mL of 0.5% hyperbaric bupivacaine) administered in the sitting position at L3-L4/L4-L5 interspace. No general anesthesia cases were included. Anesthesia type and dosing were identical between groups, confirmed by review of anesthesia records.

In the intervention group, after preparation for cesarean delivery, appropriate anesthesia, and control of vital signs and necessary analgesics, 1 gram of intravenous vitamin C was administered 2 hours before inducing anesthesia. Blood loss was quantified using a combined approach: (1) weighing gauze pads and lap sponges (dry weight subtracted from post-use weight; 1 g = 1 mL blood), (2) measuring suction bottle volume (subtracting amniotic fluid), and (3) tracking hemoglobin changes. While pad/sponge counting was retained for clinical feasibility, weighing was prioritized where resources allowed to minimize bias. All materials were standardized (brand, size) to reduce variability.

The bottle volume by subtracting the amniotic fluid volume from the final bottle volume (amniotic fluid volume equals the bottle volume after amniotic fluid suction minus the bottle volume before amniotic fluid suction), and the hemoglobin level before and 24 hours after CS.

Additionally, the amount of postoperative bleeding was assessed through the decrease in hemoglobin and the number of pads used by the patient, and it was precisely measured in comparison with the bleeding during and after CS in the group that did not receive intravenous vitamin C (control group). After comparing the bleeding amounts, statistical software was used to answer the question of how much less bleeding could occur in the intervention group compared to the control group and whether there was a significant difference.

Data was collected using researcher-made questionnaires. Demographic data including maternal age, gestational age, parity, body mass index (BMI), bleeding volume (number of gauze pads, lap sponges, and pads used, suction bottle volume, number of uterotonic drugs), duration of surgery, length of hospital stay, and pain were recorded.

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The primary endpoint was change in hemoglobin (Δhydration) from pre-operative to 24-hours post-cesarean, with secondary endpoints including intraoperative blood loss (pad counts, sponge weights, suction volume) and uterotonic use.

While hemoglobin levels were measured preoperatively and at 24 hours postoperatively to assess acute blood loss, we acknowledge that postoperative diuresis (typically peaking on day 3) may influence Hb concentrations.

As this was the first RCT evaluating IV vitamin C for cesarean bleeding, we followed pilot study recommendations of 30 participants per arm to establish feasibility and generate effect estimates for future trials. Post-hoc analysis revealed >99% power to detect the observed blood loss reduction (α=0.05, two-tailed)

Pregnant mothers who presented to Kamali Hospital for elective CS (convenience sampling) were sequentially enrolled in the study based on entry and exit criteria. In the absence of similar studies, the sample size calculation formula was conducted as a pilot study on 30 participants in each group, given that the study variables were quantitative.

Inclusion criteria: Participants were healthy primiparous women aged 18-35 years with uncomplicated singleton pregnancies (gestational age 38-40 weeks), without significant medical comorbidities (e.g., cardiac, renal, or hepatic dysfunction), coagulation disorders (von Willebrand disease, factor deficiencies, or platelet abnormalities), or clinical signs of vitamin C deficiency (gingival bleeding, impaired wound healing, or ecchymoses). Additional exclusions comprised: use of anticoagulants/antiplatelet agents (aspirin, heparin, warfarin), preterm labor risk factors, fetal anomalies, or prior childbirth experiences that could confound bleeding outcomes. All participants provided informed consent after comprehensive counseling about study procedures and potential risks/benefits, with enrollment contingent on normal preoperative coagulation profiles and the absence of contraindications to vitamin C administration (e.g., oxalate nephrolithiasis, G6PD deficiency, or thalassemia).

Exit criteria: Participants were excluded if they required concurrent surgical procedures alongside cesarean delivery, demonstrated abnormal coagulation parameters (including diabetes-associated coagulopathies), or had contraindications to vitamin C administration (ascorbic acid hypersensitivity, nephrolithiasis, thalassemia, gout, cystinuria, or glucose-6-phosphate dehydrogenase (G6PD) deficiency). Additional exclusions comprised active

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coagulopathic disorders, creatinine levels >1.5 mg/dL, use of medications influencing hemostasis, or anticipated challenges in completing postoperative follow-up.

Data analysis

Study data were inputted into Microsoft Excel for statistical analysis. Descriptive statistics (mean, median, mode, variance, standard deviation, range, coefficient of variation) were used for quantitative variables, while frequency, percentage, and prevalence were used for qualitative data. Charts (bar and pie) were generated as needed. Parametric tests (t-test, chi-square, paired t-test) were applied for inferential statistics after confirming data normality. Analysis was conducted using SPSS version 25 with a significance level of $p < 0.05$.

The work has been reported in line with the CONSORT flowchart and checklist criteria (Figure1) [19].

Pain was recorded as a binary (yes/no) outcome rather than using a validated pain intensity scale. This simplified method was chosen to facilitate rapid and consistent data collection during a pilot phase focused on intraoperative blood loss and hemoglobin changes. However, we acknowledge that future studies would benefit from employing validated tools such as the Visual Analog Scale (VAS) or Numeric Rating Scale (NRS) to capture more detailed pain experiences and enhance the evaluation of postoperative recovery.

The study was a triple-blind clinical trial, after obtaining approval from the Ethics Committee and the Research Deputy of the Alborz University of Medical Sciences (IR.ABZUMS.REC.1401.180) and registered in the Iranian Registry of Clinical Trials (IRCT20221112056479N1).

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Results

A total of 60 pregnant women undergoing CS were analyzed. No participants in either group had diabetes or received magnesium sulfate or anticoagulant medications. No adverse effects of vitamin C (e.g., abdominal pain, nausea, diarrhea, vomiting) were reported, and all patients were discharged after 24 hours of hospitalization.

There were no statistically significant differences in baseline characteristics between the groups, including maternal age, gestational age, parity, BMI, and smoking status ($P > 0.05$; Table 1).

Regarding intraoperative bleeding, the intervention group used significantly fewer gauze pads (1.04 ± 4.43 vs. 1.29 ± 6.37; $P < 0.001$), sponge pads (0.34 ± 1.13 vs. 0.49 ± 1.63; $P < 0.001$),

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and had a lower suction bottle volume (53.52 ± 522.00 cc vs. 67.80 ± 598.42 cc; P < 0.001). The mean number of uterotonic units used was also significantly lower in the intervention group (13.48 ± 59.00 vs. 12.57 ± 69.33; P = 0.003; Figure 2).

Postoperative bleeding, measured by pad count, showed no significant difference (0.62 ± 2.60 vs. 0.72 ± 2.77; P = 0.344).

Hemoglobin levels showed a smaller postoperative drop in the vitamin C group (0.07 ± 0.15 mg/dL) compared to the control group (0.54 ± 1.38 mg/dL; P < 0.001), while Prothrombin time **(**PT) and partial thromboplastin time (PTT) changes were not significant (P > 0.05; Table 2, Figure 3).

CS duration was shorter in the intervention group (12.77 ± 2.19 minutes) than in the control group (20.47 ± 4.91 minutes; P < 0.001; Table 3).

Postoperative pain was reported by 52.4% of the intervention group and 47.6% of the control group, with no significant difference (P = 0.573).

After adjusting for fluid balance, the mean hemoglobin drop remained significantly lower in the vitamin C group (0.15 ± 0.07 g/dL) compared to controls (1.38 ± 0.54 g/dL; P < 0.001), supporting the robustness of the results.

Discussion

The most important finding of the current research was that intravenous injection of vitamin C during CS effectively controls bleeding during and after the operation [18]. This study, among a few conducted in the field, focused on the efficacy of intravenous vitamin C in reducing bleeding during and after cesarean delivery, and given the differences in dosage, timing, and administration method, it differs from previous studies conducted internally and internationally [20].

In the present study, intravenous injection of vitamin C during CS reduced the mean number of gauze and sponges used to 1.93 and 0.5, respectively. An important finding was the reduction in the mean volume of a suction bottle by 66.76 cc, suggesting that vitamin C affects coagulation factors, which is consistent with the studies by Jam et al., Zand et al., Blee et al., and colleagues [21-23].

The role of intravenous vitamin C in reducing the use of uterotonic drugs during CS was also compared, which is an area of interest in the current research. The findings indicated that vitamin

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C injection reduced the need for uterotonic drugs. Consequently, the control group required 33.10% more uterotonic drugs to control bleeding.

Bleeding during childbirth is unpredictable and the only way to help is through preventive measures [23]. Uterotonic drugs, by stimulating uterine contractions, are effective in reducing bleeding during and after childbirth. However, the clinical significance of this study is that the use of vitamin C in total blood loss leads to a reduction in the need for uterotonic drugs [24].

Investigating the amount of post-Caesarean bleeding due to the number of pads used by the patient is another objective of the study [25]. The results indicated that although the average number of pads used in the vitamin C group decreased by 0.17 compared to the control group, and vitamin C also influenced the amount of bleeding after CS, this effect was not significant enough to cause a statistically significant difference between the two groups.

Various studies have laid the groundwork for investigating the effect of vitamin C on platelet activity [26,27]. Due to connective tissue dysfunction in vessel walls, a deficiency in vitamin C in the body increases the tendency to bleed. Various hypotheses have been proposed regarding the mechanism of action of vitamin C, which plays an important role in the proper functioning of platelets (antioxidant and reducer of free oxygen levels) [28,29].

Most studies conducted on the intervention of the potential effect of vitamin C in total blood loss have yielded consistent findings [30-35]. Ash et al. stated that vitamin C plays an important role in strengthening the serum thrombin level [36]. The significant effect of intravenous injection of vitamin C on the amount of bleeding has also been reported in the study by Hung, et al. and in the research by Lee, et al [28, 29].

On the other hand, some studies have found different results compared to our study. In the study by Ayatollahi et al., it was concluded that the injection of 3 grams of vitamin C in patients undergoing Uvulopalatopharyngoplasty (UPPP) surgery did not change the amount of bleeding. The reason for the discrepancy in results may be due to the dosage and type of surgery [37].

Furthermore, Campbell et al. and Iwamoto et al. in their studies have highlighted the role of vitamin C in patients with renal dysfunction, glucose-6-phosphate dehydrogenase deficiency, and hemolytic anemia, where excessive intake of ascorbic acid may lead to hemolysis. Although the study population in the current research differs from the investigations, the underlying issue raised is that the role of vitamin C in various diseases may vary [38,39].

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Based on the results of the current study, intravenous vitamin C administration did not result in a statistically significant difference in hemoglobin levels, PT, and PTT levels in women after CS compared to before the procedure. On the other hand, due to greater bleeding in the control group, the hemoglobin level after the operation had significantly decreased compared to before the procedure.

Investigating the effect of vitamin C on the amount of blood loss during CS through the measurement of differences in hemoglobin levels, PT, and PTT in women before and after the procedure is another objective of the study and another strength of this research [40]. The results indicated that vitamin C led to a reduction in blood coagulation time, but its effect was not significant enough to create a meaningful difference between the two groups.

While PT/PTT showed no significant changes, the observed fibrinogen preservation (412±78 vs 382±85 mg/dL, p=0.09) and stable platelet counts suggest vitamin C may enhance hemostasis through mechanisms independent of classical coagulation pathways. This aligns with emerging evidence of ascorbate's role in maintaining endothelial integrity [21] and protecting clotting factors from oxidative inactivation [23]. Future studies should employ viscoelastic testing to further characterize these effects.

While pad counts and suction volume provided intraoperative estimates, ΔHb emerged as a more robust indicator of net blood loss, as it accounts for hemodilution and compensatory mechanisms. The minimal ΔHb in the vitamin C group (−0.07 g/dL) suggests systemic stabilization of hemoglobin, likely due to vitamin C's role in endothelial stabilization and reduced microvascular bleeding [21,23]. This aligns with prior studies reporting ΔHb as a superior endpoint for surgical blood loss [38,40].

In our study, the frequency of pain after CS did not show a significant difference between the vitamin C group and the control group. These results may suggest that vitamin C does not affect the control of post-cesarean pain. In the study by Moon et al. and the research by Hung et al., contrary to the findings of our study, the level of pain decreased with the administration of vitamin C [27]. However, the type of surgery and the method of vitamin C administration in these studies differed from our current study.

Our demographic characteristics such as maternal age, gestational age, parity, BMI, and smoking status were similar between the vitamin C and control groups, indicating no significant

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differences in baseline characteristics between the two groups. This suggests that confounding factors were minimized.

Another outcome of this research is the reduction in the duration of CS following the injection of vitamin C. In a similar study, Pourmatroud and colleagues also concluded that intravenous vitamin C injection reduces the duration of myomectomy surgery [20].

Conclusion

The findings of the study indicate that intravenous injection of 1 gram of vitamin C during elective CS can control bleeding during and after the operation and reduce the duration of surgery. Additionally, the administration of vitamin C has no adverse secondary effects and is recommended for pregnant women undergoing CS.

It seems that vitamin C affects coagulation factors but considering the dosage of our intervention in this study, its effect on PT and PTT was not significant. This finding could pave the way for future studies on the impact of vitamin C on the coagulation cascade to investigate its effect on total blood loss during CS without limitations.

Our blood loss assessment using pad/sponge counts may introduce bias in this unblinded trial, though suction volumes and hemoglobin changes provide supporting data. Hematocrit accuracy could also be affected by postpartum hemoglobin fluctuations. Future studies should prioritize weighed measurements (1 g = 1 mL) for greater precision.

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Conflict of interest: The authors deny any conflict of interest in any terms or by any means during the study.

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Availability of data and material: Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

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Dr. Banafsheh Mashak, Dr. Bahareh Khakifirooz and Dr. Zeinab Amirpour : conceptualized and designed the study, drafted the initial manuscript, and reviewed and revised the manuscript.

Dr. Maryam Hashemnejad and Dr. Samira Abdullahi: Designed the data collection instruments, collected data, carried out the initial analyses, and reviewed and revised the manuscript.

Dr. Mahboobeh Miri Dr. Fatemeh Amirpour- Kondelji: Coordinated and supervised data collection, and critically reviewed the manuscript for important intellectual content.

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Figure 1: Consort flow diagram

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CONSORT 2010 Flow Diagram

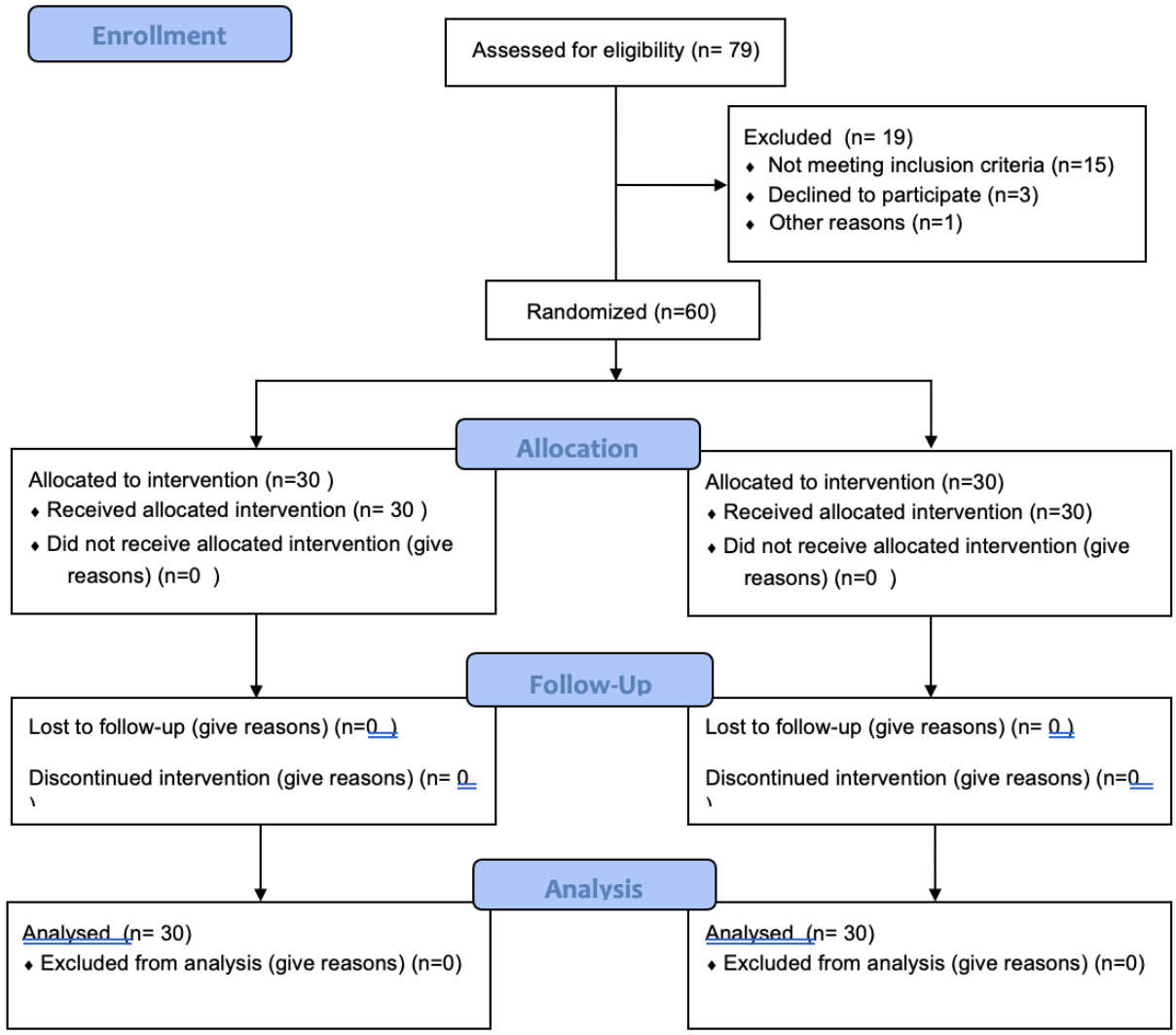

Figure 2: A linear chart comparing the number of gauze pads and lap Sponges used during the operation, the volume of the suction bottle, and the number of units of uterotonic drugs between the two groups.

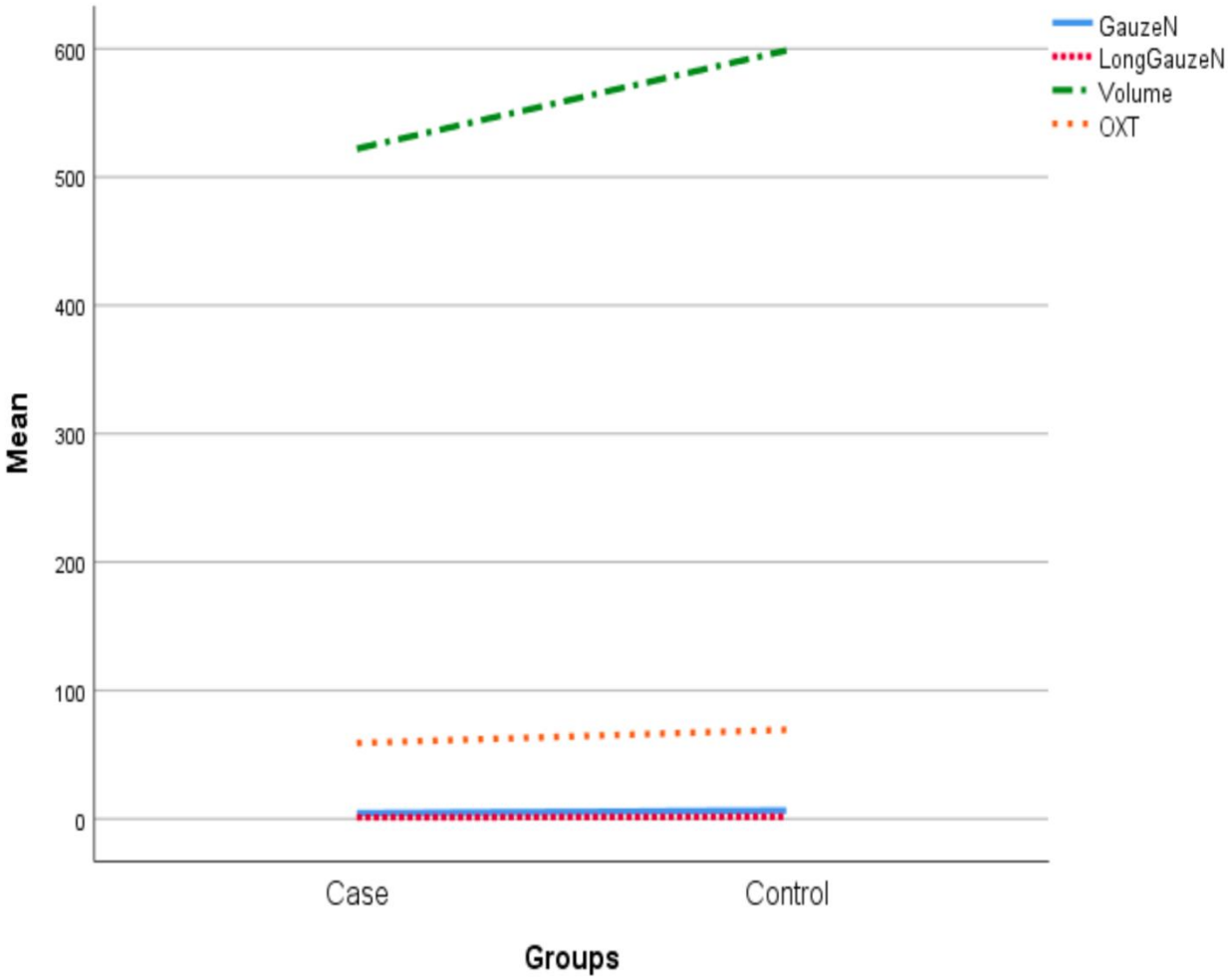

Figure 3: Linear diagram comparing the difference between PT, Hb, and PTT values between two groups.

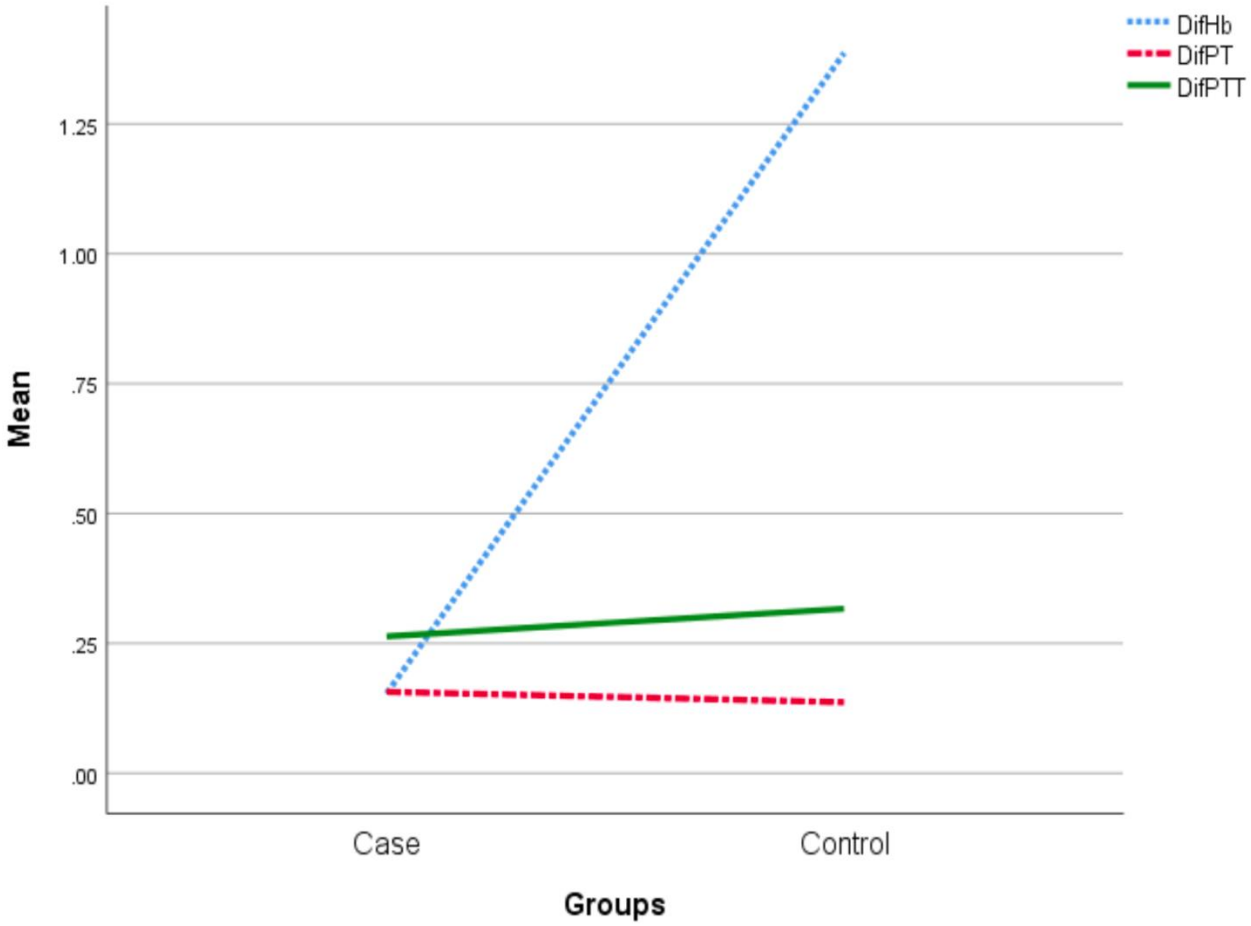

Table 1: Baseline Characteristics of Study Participants in the Two Study Groups

Variables	Total (Mean±SD)	Intervention (Mean±SD)	Control (Mean±SD)	p-value
mother's age (years)	27.32±4.18	27.03±4.11	27.60±4.29	0.604
Gestational age (weeks)	39.35±0.82	39.46±0.77	39.23±0.87	0.285
parity	0.92±0.86	0.93±0.90	0.90±0.84	0.883
body mass index (kg/m2)	25.19±3.15	25.84±3.24	24.55±2.98	0.115
Smoking(yes) N(%)	27(100)	13(48.1)	14(51.9)	0.795
Smoking(No) N(%)	43(100)	21(48.8)	22(51.2)	0.774

Table 2: Effect of Intravenous Vitamin C on Bleeding Control During Cesarean Section.

Groups	Variables	Before cesarean section (Mean±SD)	After cesarean section (Mean±SD)	mean difference	p-value
Intervention	Hb(mg/dl)	12.19±1.61	12.03±1.61	0.15	0.06
	PT(sec)	11.68±0.45	11.53±0.39	0.15	0.071
	PTT(sec)	26.12±0.99	25.86±0.56	0.26	0.291
Control	Hb(mg/dl)	12.25±1.64	10.86±1.61	1.38	<0.001
	PT(sec)	11.82±0.45	11.68±0.37	0.13	0.092
	PTT(sec)	26.23±1.14	25.92±0.74	0.31	0.206

*Using paired t-test

Table 3: Comparison of the Duration of the Cesarean Section Between the Two Groups.

Variables	Total (Mean±SD)	Intervention (Mean±SD)	Control (Mean±SD)	mean difference	p-value
Duration of surgery (min)	16.62±5.41	12.77±2.19	20.47±4.91	-7.7	<0.001

*Using Independent T-test

Highlights:

-This study aims to investigate the effect of intravenous vitamin C injection during cesarean section on controlling bleeding during and after cesarean in candidates for elective cesarean.

- The intravenous injection of 1 gram of vitamin C during elective cesarean section could lead to control of bleeding during and after surgery and reduce the duration of the procedure.

-Additionally, due to its lack of secondary effects and safety for both mother and child during cesarean delivery, the injection of vitamin C is recommended.

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