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Temporary clamping of the uterine arteries versus coventional technique for the prevention of postpartum hemorrage during cesarean section: a randomized controlled trial study

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Abstract

Background Cesarean sections are the most common abdominal surgical interventions worldwide, with increasing rates in both developed and developing countries. Postpartum (hemorrhage PPH) during cesarean sections can lead to maternal morbidity, prolonged hospital stays, and increased mortality rates. Although various non-surgical measures have been recommended for PPH prevention, surgical techniques such as uterine artery ligation and embolization have been used to manage PPH effectively.

Objective This study aimed to evaluate the effectiveness of a surgical technique based on the temporary bilateral clamping of uterine arteries to reduce blood loss during cesarean sections.

Methods A longitudinal prospective, randomized, controlled study was conducted with a preliminary population group of 180 patients at the University Hospital Regional de Málaga from November 2023 to January 2024. The study protocol was approved by the Ethics Committee of the Regional University Hospital of Malaga (protocol 1729-N-23 and registred with ISRCTN15307819|| http://www.isrctn.org/, Date submitted 12 June 2023 ISRCTN 15307819). The patients were divided into two groups based on whether the clamping technique was applied during their cesarean sections. The study assessed hemoglobin levels before and after surgery, hospitalization durations, and the prevalence of anemia at discharge as the primary outcomes.

Results The patients who underwent the clamping technique demonstrated significant reductions in hemoglobin differences (0.80 g/dL) compared to the control group (1.42 g/dL). The technique also resulted in shorter hospital stays (3.02 days vs. 3.90 days) and a lower prevalence of anemia at discharge (76.2% vs. 60%).

Conclusion Temporary clamping of uterine arteries during cesarean sections appears to be an effective measure for preventing postpartum hemorrhaging, reducing hospital stays, and decreasing the prevalence of anemia at

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discharge. Further research with larger sample sizes and standardized indications is warranted to confirm the benefits and potential broader applications of this technique.

Trial registration ISRCTN 15,307,819.

Keywords Uterine artery clamping, Surgical maneuvers, Cesarean bleeding, Bleeding prevention

Background

At present, cesarean sectionsare the most common abdominal surgical interventions in both developed and developing countries, with rates increasing progressively. In the United States, in recent decades, there has been an increase in the cesarean section rate, from 5.50% in 1970 and from 21% in 1980 to 32.10 in 2021 [1, 2].

It is estimated that blood loss during cesarean sections is typically double that of vaginal deliveries, which inevitably implies an increase in morbidity, hindering maternal clinical recovery and leading to increased hospital stays [3].

Postpartum hemorrhage (PPH) during a cesarean section is defined as blood loss of >1000 ml, or, as stated by the American College of Obstetrician Gynecologists (ACOG) in 2017, that which is accompanied by signs and/or symptoms of hypovolemia in the first 24 h after childbirth [4]. PPH is present in 1–10% of all deliveries and continues to be the leading cause of maternal death, being responsible for 80,000 deaths in 2015 [5].

PPH continues to be the leading cause of maternal morbidity and mortality in most countries of the world, and this is despite the efforts at all levels and the recommendations made by all scientific societies both for its prevention and treatment. Regarding prevention, the FIGO 2022 recommendations for the management of PPH set out a series of measures that could reduce the number of cases of PPH.

These recommendations were based nearly exclusively on pharmacological measures such as the perfusion of 10 IU of oxytocin in the third stage of labor, the use of carbetocin(100 μg IM/IV), the combination of ergometrine and oxytocin, and the use of misoprostol 400–600 μg oral/rectal, as well as uterine massage. Despite this, we have continued to maintain high rates of PPH, with the consequent problems that derive from it(e.g., ICU admissions, blood transfusions, increased hospital stays, severe anemia, and even maternal mortality).

The risk factors that have been associated with PPH are classically known as the four Ts (atony, trauma, debris retention, and coagulopathy), but most cases occur unexpectedly [6, 7].

The prevention of blood loss during cesarean sections could improve the rates of maternal morbidity and recovery in the general population subjected to this technique, and it could also reduce the rate of PPH, thereby reducing the risks of maternal mortality and severe morbidity, especially in developing countries.

Until now, the recommendations for the prevention of PPH in cesarean sections are based on non-surgical measures such as the administration of uterotonic drugs such as Oxytocin and Carbetocin [8], as well as on physical measures such as uterine massage [9].

However, for the treatment of PPH, in addition to tamponade measures and uterine artery embolization, different surgical techniques have been described in the literature, including compression sutures (e.g., the B-Lynch and Hayman techniques), as have techniques based on the ligation of the vessels that are responsible for blood supply to the uterus (e.g., uterine artery ligation, joint ligation of the uterine arteries and pelvic infundibulum, and sequential devascularization techniques, as well as hypogastric ligation).

The main objective of vascular ligation in the treatment of PPH, in the context of atony, is to reduce the blood supply that reaches the uterus. As a first step, bilateral uterine artery ligation frequently achieves this objective, being a technique that is easy to apply [10, 11]. Recent studies have shown that bilateral uterine artery ligation has no impacts on ovarian reserves and does not affect the future fertility of women [12–14].

In 2022, Wufen et al. published a study that assessed the effects of uterine embolization and ligation in the treatment of PPH during cesarean sections on the flow and function of the uterine and ovarian arteries, and they concluded that the techniques did not worsen function and even led to slight improvements [15].

In the field of obstetrics, different similar techniques have been used for the management of postpartum hemorrhages especially in cases of placenta accreta [16].

In the field of gynecology mainly, but also in the field of obstetrics, uterine artery embolization and the use of compression bands (tourniquets) and uterine artery ligation have long been employed to prevent blood loss in uterine gynecological surgeries, especially in myomectomies with good results in terms of decreased bleeding.

Our objective, based on all of the above, was to evaluate whether, by means of a surgical technique based on the temporary bilateral clamping of both uterine arteries, we could reduce uterine blood supply during cesarean sections and thus prevent blood loss.

Our manuscript includes a statement indicating that the study adheres to the CONSORT guidelines, as required.

Methods

This work was a longitudinal, prospective, quaisi-experimental study. The study was conducted in accordance with the Declaration of Helsinki of the WorldHealth Organization. The study protocol was approved by the Ethics Committee of the Regional University Hospital of Malaga. (protocol 1729-N-23 and registred with ISRCTN15307819|| http://www.isrctn.org/, Date submitted 12 June 2023) the date of first registration was 20/11/2023. All patients included in the study were correctly informed of the entire process and subsequently signed the informed consent. A preliminary population group with 180 patients were selected as a vat the Regional University Hospital of Malaga from October 2023 to January 2024. The patients were divided into two groups based on whether the clamping technique was applied during their cesarean sections. We decide to include all the patients that a cesarean section has been indicated in our service in order to approach the most as possible the real situation of the normal population attended in our hospital. These patients were divided into two homogeneous population groups. The patients were randomized by year of birth, even years for the study group, and odd years for the standard care group. Regardless of the assigned group, the cesarean sections were carried out by different hospital gynecologist of the staff.

Inclusion and exclusion criteria

The gestational criteria were pregnant woman, aged between 18 and 45 years, with gestational ages of between 34 and 42 weeks.

We did not consider adopting any exclusion criteria due to a risk factor for hemorrhagic disease since our objective at the beginning was to evaluate the efficacy of this technique in this type of patient as well.

The allocation to the study group versus the control group was made independently of the hemorrhagic risk factor due to the multiple factors that can influence this age of the patient, elective versus urgent cesarean, nulliparity versus multiparity, singleton versus twin pregnancy, etc.) Our aim was to analyze later how these independently grouped factors were influenced by whether or not clamping was performed, as will be seen in the analysis of the results.

All the selected patients were previously provided with an informed consent in which they were informed about the possibility of performing the technique during the cesarean section prior to it being carried out.

Surgical technique

The surgical technique was performed by the differents gynecologists of the delivery team of the hospital, all of them with extensive experience in performing cesarean sections, not finding it necessary to make any discrimination or exclusion in this regard given the homogeneity in the surgical experience of the same.

In the study group, after fetal extraction and delivery of the placenta, we proceeded to exteriorize the uterus in order to clearly expose both uterine arteries and avoid injuries to neighboring structures. Both uterine arteries were temporarily compressed approximately 2 cm below the hysterotomy using an atraumatic vascular clamp (i.e., a DeBakey artery clamp) (Fig. 1).

Once the correct placement of the clamp had been verified, as shown in Fig. 2, the cavity was checked and the hysterotomy was sutured. Both in the study group and in the control group, the hysterorrhaphy technique was performed using continuous monolayer sutures. It was planned that the clamping time wouldn't exceed 10 min, and in the case where it did, intermittent decompression would be used.

Once the hysterorrhaphy had been performed, both vascular clamps were removed after verifying a correct hemostasis. After removing the clamps, we inspected the area of application to verify that no accidental anatomical injury had occurred. Finally, the uterus was reintroduced into the abdominal cavity, and the cesarean section was completed according to the usual technique.

In all cases, the incisions made were of the Pfannenstiel type. As uterotonic pharmacological prophylaxis, it was established that 10 IU Oxytocin (Syntocinon®) would be administered intravenously.

During the surgeries, we recorded whether any surgical complications occurred, along with the diagnoses of uterine atony and whether surgical or pharmacological measures were needed to treatment hemorrhages.

To assess the efficacy of clamping on blood loss during surgery, we used as a parameter the difference in hemoglobin values, measured in mg/dl, prior to surgery compared to a determination made 24 h post-surgery.

We found that the quantification of hemorrhage by counting compresses, blood collection in the surgical field (mixed with amniotic fluid), etc., as has been done in other studies [17], offers great variability and subjectivity, so we consider more objective the measurement of the loss by analytical control pre and post cesarean section.

In the postoperative period, prior to a patient's discharge, we recorded whether there was any type of puerperal complication, the presence of anemia and, if so, its severity, whether transfusion of hematological derivatives was required, and the days of admission after the cesarean section.

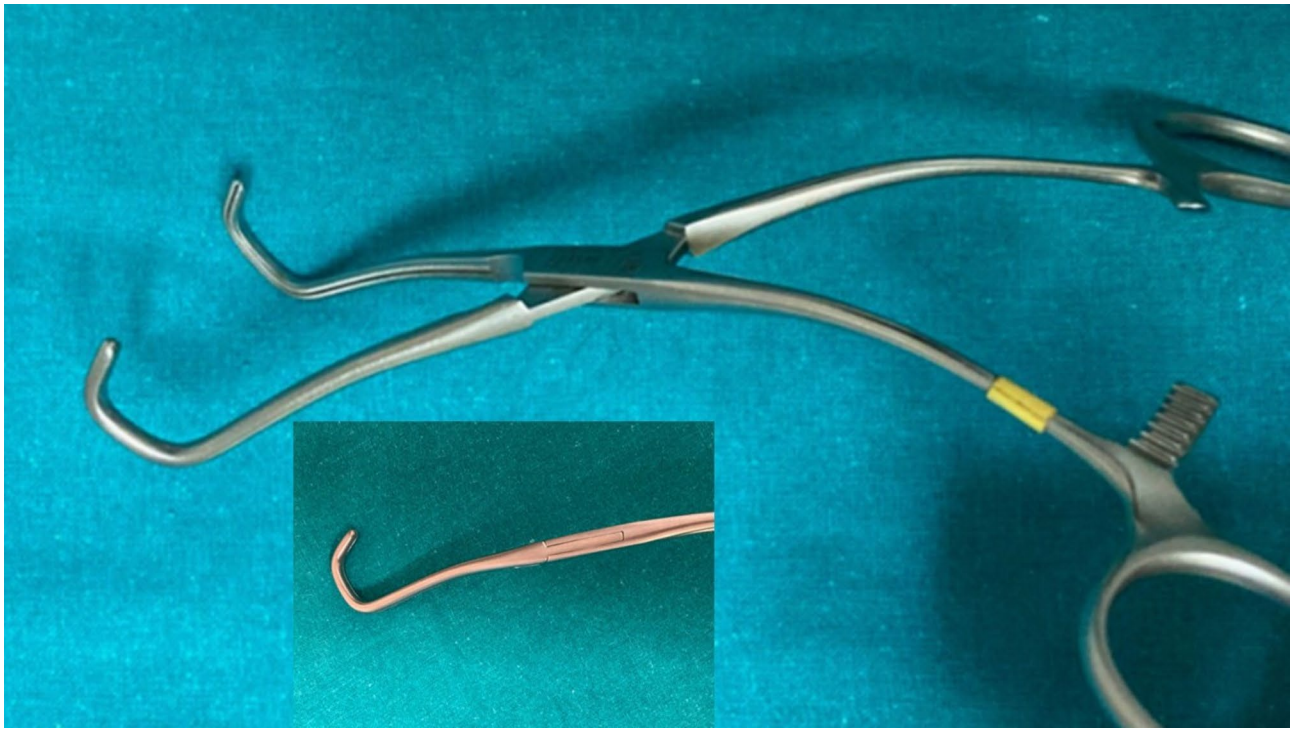

Fig. 1 Atraumatic vascular clamp

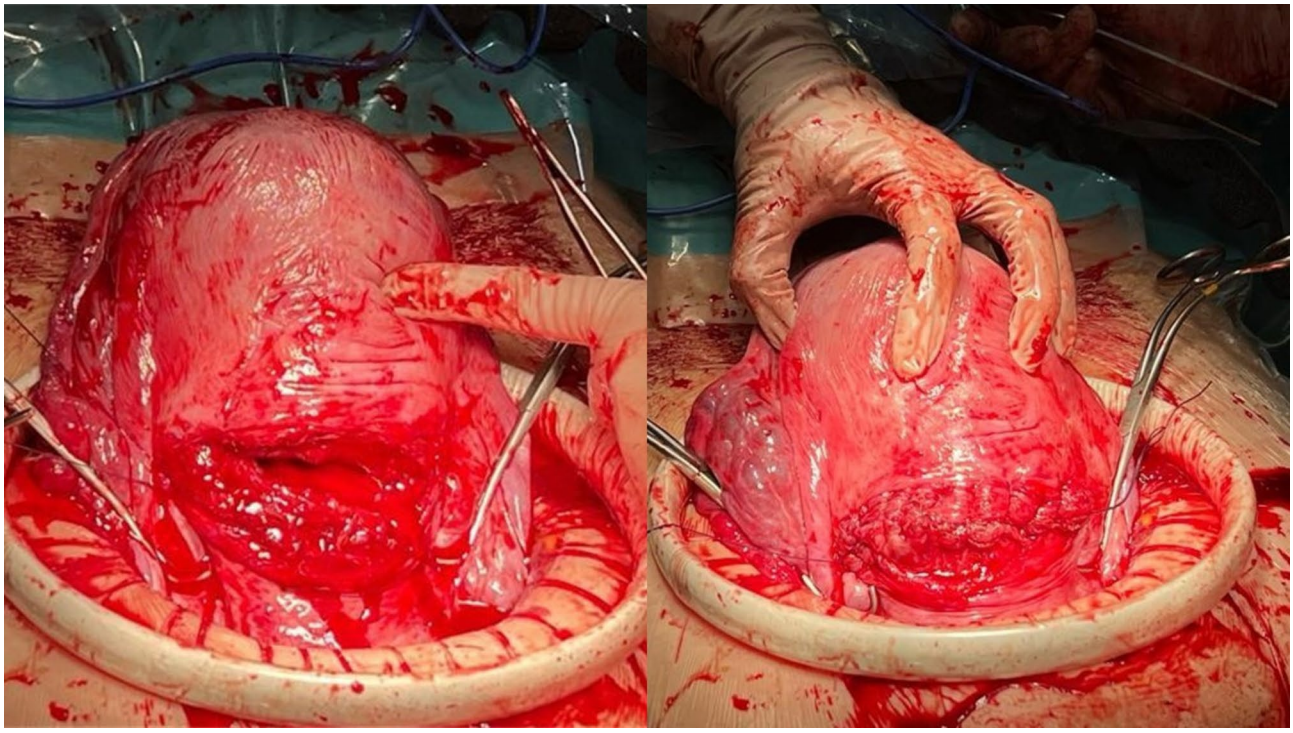

Fig. 2 Correct placement of the clamp

Table 1 Description of the sample under study

Age	**33.5 ± 5.5 years**	
Parity	Nulliparous	73 (40.5%)
	Multiparous	107 (59.5%)
Previous uterine surgeries		57 (31.9%)
Placenta previa		4 (2.2%)
Twins		10 (5.6%)
Gestational hypertension		20 (11.1%)
Severe preeclampsia		2 (2.7%)
Non-severe preeclampsia		5 (1.1%)

We do not consider it necessary to collect data such as apgar score, fetal weight or umbilical cordon pH of newborns .

The data supporting the findings of this study are available through the authors, but restrictions apply to the availability of these data, which were used under license from the Ethics Committee of the Regional University Hospital of Malaga and the research institute IBIMA of Malaga for the current study and therefore are not publicly available. However, the data are available from the authors upon reasonable request and with permission from the Ethics Committee of the Regional University Hospital of Malaga and the research institute IBIMA of Malaga.

Statistical analysis

The sample size for comparing a treatment group versus a control group is calculated in these cases to take into account the magnitude of blood loss considered clinically important, the level of significance, statistical power, and the variability of the variable of interest.

The bivariate analysis was performed using a test for independent samples and an ANOVA statistical test with a confidence level of 95% and a p-value of <0.05.

Results

Of the total of 180 women included in the study, 45.00% ($n=81$) had the clamping technique applied during their cesarean section.In this study, no patients were excluded from the sample.(Table 1).

After studying the two groups, neither the control group nor the group of cases that underwent clamping presented significant differences in terms of their demographic characteristics as the groups were similar.

In relation to these factors, both groups were similar, with no differences found except in relation to previous uterine surgery, with a greater number of these patients in the clamping group (22.20% vs. 8.30%).(Table 1).

In the analysis of the results for assessing the efficacy of the clamping technique, we took into account the indications for cesarean section, grouping them into three categories: those cesarean sections indicated for previous uterine surgery (e.g., previous cesarean section or myomectomy), elective cesarean sections performed for indications other than the previous one, and urgent cesarean sections performed for different reasons (e.g., non-progression of labor, induction failure, suspected risk of fetal loss, and suspicion of fetal pelvic disproportion), as listed in Table 2.

Table 2 Type of surgery

TOLAC (One time previous cesarean scar) ≥ 2	**57 (31.9%)**
Scheduled cesarean sections	77 (42.8%)
Urgent cesarean sections	46 (25.3%)

Table 3 Indications in the cesarean section cases/controls

	Cases (clamping)	**Control (no clamping)**
Cesarean sections for previous uterine surgeries	42 (23.3%)	15 (8.3%)
Elective cesarean sections	18 (10%)	59 (32.8%)
Urgent cesarean sections	21 (11.7%)	25 (13.9%)

Table 4 Hemoglobin differences (pre- vs. post-surgery)

	Clamping(*)*N*(%)
Yes	**No**
87(45.0)	99 (55.0)
	Hemoglobin difference (pre- and post-surgery) Mean (SD)
0.80 (0.82)	1.42 (1.00)

($p<0.05$)

Regarding the distribution of the different indications in the groups studied, as expected given the differences between the demographic characteristics of both groups, the percentage of cesarean sections indicated for previous uterine surgeries was higher in the clamping group (23.30% vs. 8.30%).

Likewise, we found differences in the percentages of cesarean section performed urgently, with a higher percentage in the control group (10.00% vs. 32.80%). Of this group of indications, there were only 10 patients who had previous cesarean sections that did not know this was an indication for an elective cesarean section.(Table 3).

The results obtained in terms of the differences in the mean values of pre- and post-surgical hemoglobin showed that these values were significantly lower in the women in-whom the clamping technique was applied (SD of 0.82) compared to those in whom it was not applied (1.42) (SD of 1.00) ($p<0.05$) (Table 4).

Regardless of the surgical indications, the hemoglobin levels pre- and post-surgery were significantly lower for the groups in which the technique was applied compared to the groups in which it was not. The most pronounced difference was observed in the urgent cesarean section with clamping group (1.14; SD of 1.19) vs. the urgent cesarean section without clamping group (1.75; SD of 1.03) (Table 5).

Table 5 Indications for cesarean sections and hb differences before and after surgery

	N(%)	Hemoglobin difference (pre-post)
Cesarean section indication (*)		Media (DS)
Previous surgery with clamping	42 (23.3)	0.71 (0.57)
Previous surgery without clamping	15 (8.3)	0.85 (0.65)
Urgent cesarean section with clamping	18 (10.0)	1.14 (1.19)
Urgent cesarean section without clamping	59 (32.8)	1.75 (1.03)
Elective without clamping surgery	21 (11.7)	0.70 (0.84)
Elective without surgery without clamping	25 (13.9)	1.00 (0.78)

Figure 3 complements the conclusions drawn from Tables 4 and 5. The curves show the positive effect of clamping on hemoglobin levels before and after delivery to the extent that that which refers to the women in whom the technique was applied is systematically above the curve adjusted to the cases in which it was not applied, and it is closer to the di-agonal that indicates the values in which there were no variations in hemoglobin levels be-fore and after delivery.

With few exceptions, the differences found in the mean Hb values were greater in the urgently indicated cesarean sections with the clamp group compared to the control groupIf attention is focused on the differences in hemoglobin levels pre- and post-surgery according to indication (Fig. 4), then the estimated regression lines for all indications in cases in which clamping was not performed were below those estimated for the cases in which clamping was not performed. For those in whom the technique was performed, visualizations are reflected in Tables 4 and 5.

When analyzing the other objective variable of our study, days of the puerperium (Table 6), the use of the clamping technique also led to statistical significance.

It was found that regardless of the indication for cesarean section, hospital stays were significantly reduced for the patients who had received the clamping technique. This difference was especially significant in the group of elective cesarean sections, being 3.38 (SD of 1.02) in the clamping group compared to 4.76 (SD of 3.81) in the control group, with a difference of1.22 days ($p<0.05$) (Table 7).

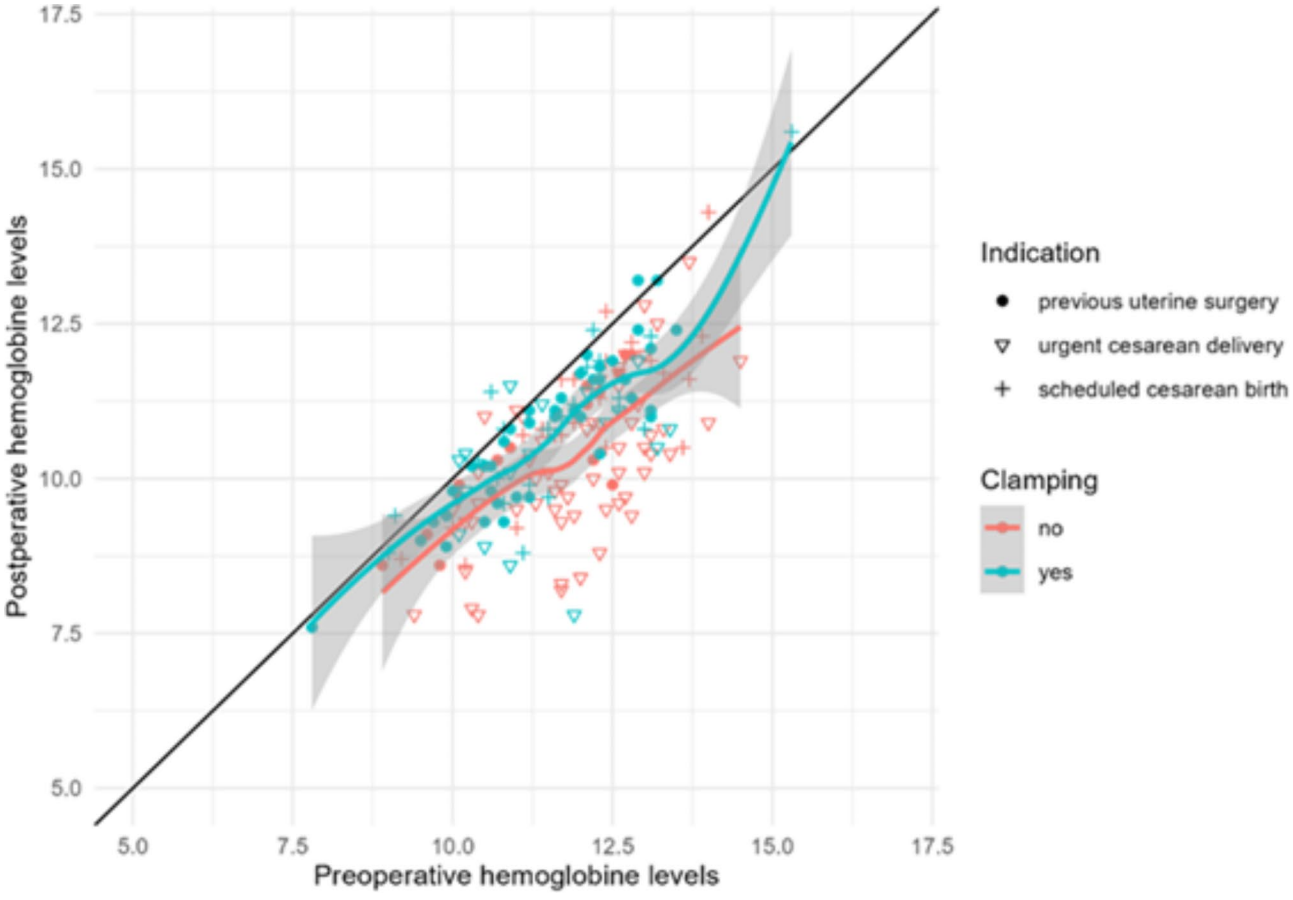

Fig. 3 Hemoglobin levels by uterine artery clamping and cesarean birth indications

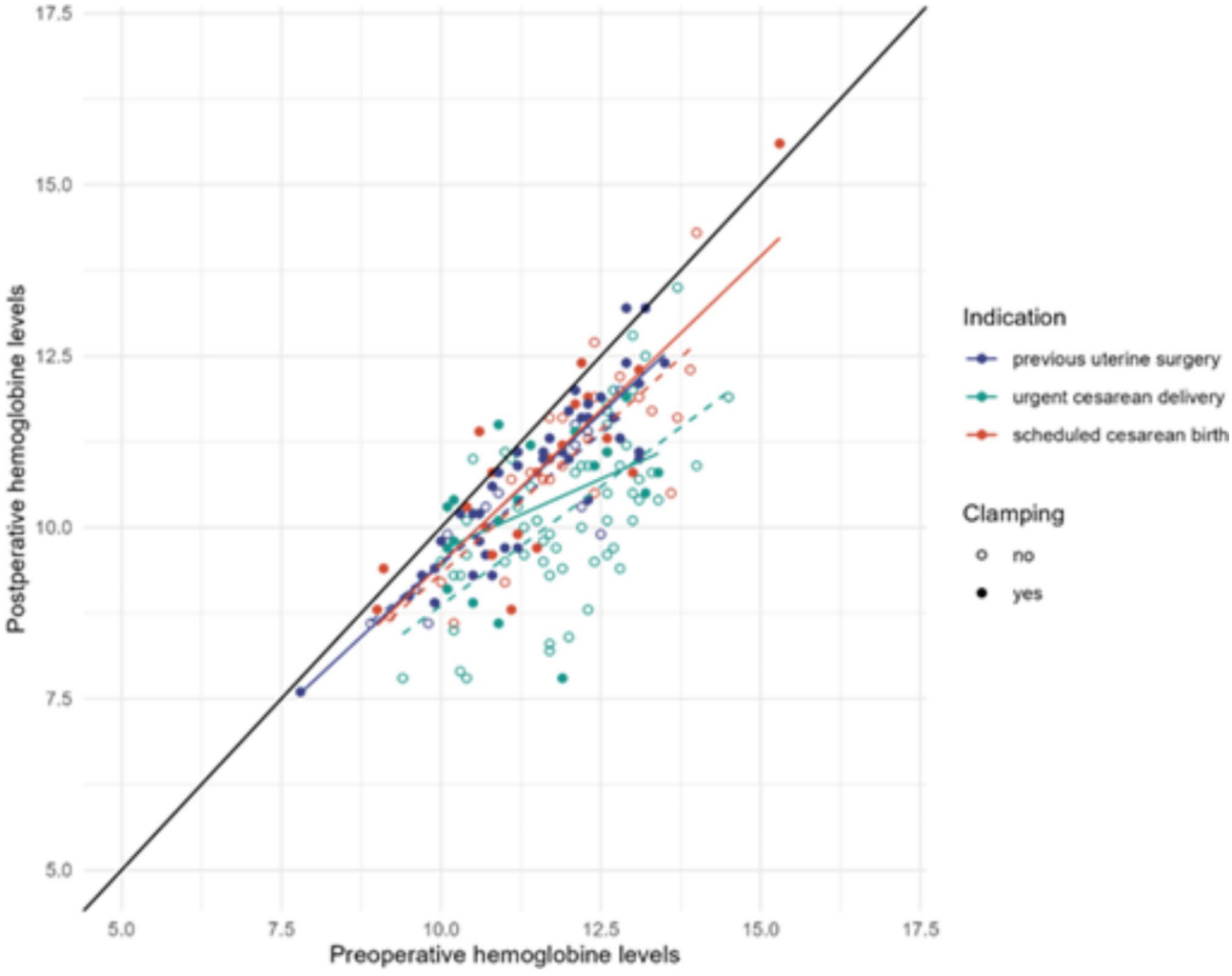

Fig. 4 Hemoglobin levels by uterine artery clamping and cesarean birth indications

Table 6 Days of puerperium

	N(%)	Days of puerperium Mean (SD)
Clamping (*)		
Yes	87 (45.0)	3.02 (0.87)
No	99 (55.0)	3.90 (2.40)

Table 7 Indications for cesarean sections and hospital stays

Cesarean section indication (*)	*N*	Days of puerperium
Previous surgery with clamping	42 (23.3)	2.81 (0.80)
Previous surgery without clamping	15 (8.3)	3.67 (2.74)
Urgent cesarean section with clamping	18 (10.0)	3.11 (0.68)
Urgent cesarean section without clamping	59 (32.8)	3.59 (1.22)
Elective surgery with clamping surgery	21 (11.7)	3.38 (1.02)
Elective surgery without clamping	25 (13.9)	4.76 (3.81)

($p<0.05$)

Figure 5 contrasts the durations of puerperium with the indications for the patients that underwent clamping and for those that did not undergo clamping. Once again, in line with Tables 6 and 7, it can be seen that the stays tended to be prolonged for the women that did not undergo clamping, and they constitute the most extreme cases in the graph.

None of the independent variables included in the bivariate analysis of postpartum anemia showed statistically significant differences at a confidence level of 95% (p-value of <0.05) (Table 8). However, this could have been due to the number of cases included in the sample. Despite this non-significance, more favorable results were observed for the group in which the clamping technique was applied. In the case of the women in whom the clamping technique was applied, there was a reduction of nearlyfour% points for suffering postpartum anemia, or 28.40%, compared to those women in whom the technique was not applied (32; 30%).

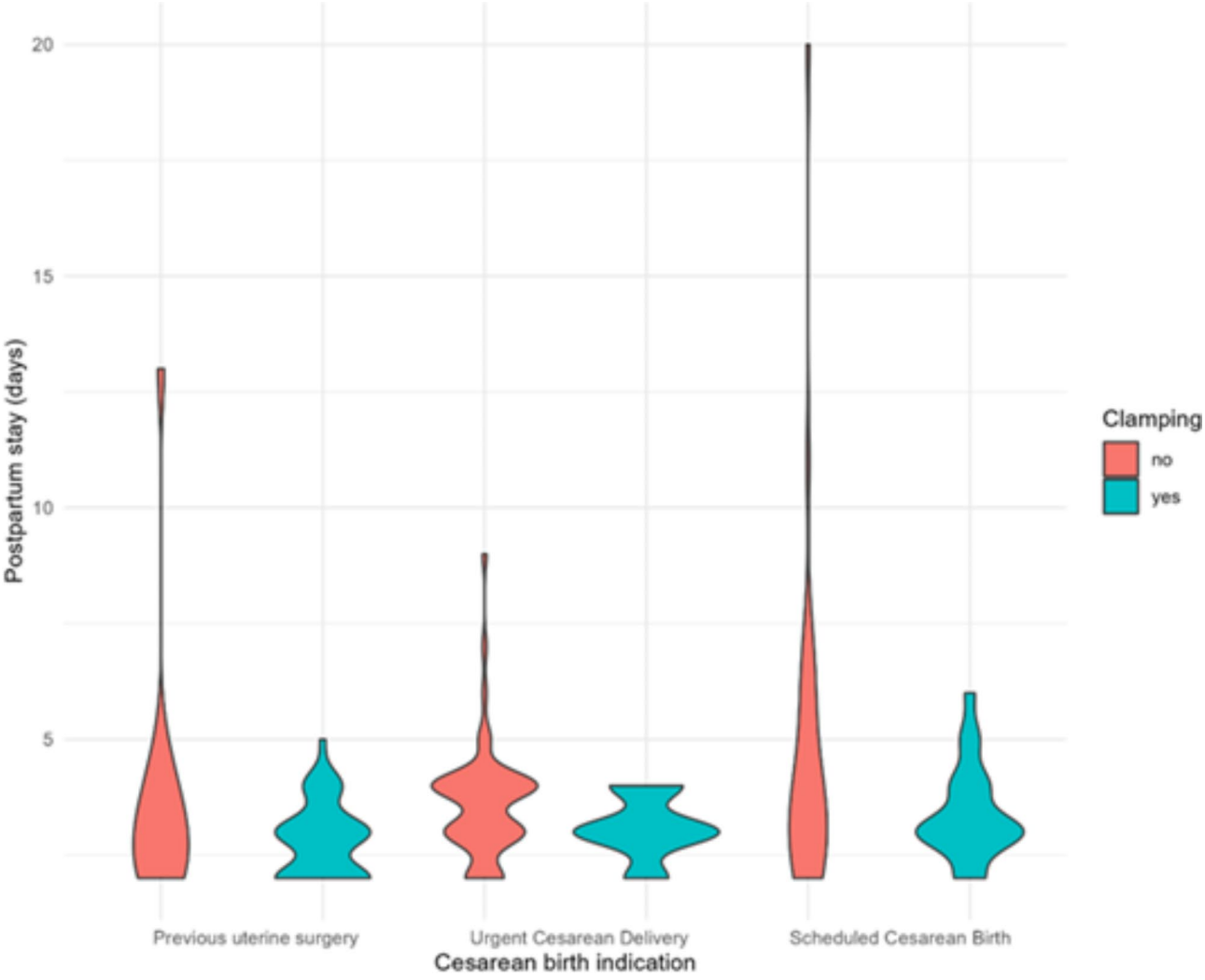

Fig. 5 Length of postpartum stay by cesarean indications

Table 8 Postoperative anemia

Clamping (*)	Postoperative anemia	
	No/Hb > 10	Yes/HB < = 10
	% (n)	% (n)
Yes	71.60 (58)	28.40 (23)
No	67.70 (67)	32.30 (33)

Note: *, significant at a confidence level of 95% (p-value of < 0.05)

Lastly, Fig. 6 shows the percentages of women according to postoperative hemoglobin levels depending on the indication and whether or not clamping was performed. The faintest colors reflect the lowest hemoglobin values after delivery, and the darkest color reflect the highest levels. In women with previous cesarean sections, the percentage of patients with higher hemoglobin levels is clearly higher for the women who underwent clamping. Thus, more than half had hemoglobin values above 11, and 76.20% had values above 10. In contrast, only 60% of those patients who did not undergo clamping maintained these levels.

The differences were less evident for these cases of urgent cesarean sections. In the upper range, the benefit of clamping did seem to be appreciated, but in the lower values, it was inverted and, in fact, the percentage of women with clamping who have severe anemia was somewhat higher (in any case, it was a single case, and it simply represented a larger proportion of the subgroup being considered).

In the last group of women (i.e., elective without surgery), there was no clear evidence of the benefit of clamping in the variable considered, although among those whohad not received clamping, there were some women with hemoglobin levels below eight, a situation which did not occur in any of the clamping cases (Table 9).

As shown in Table 10, we found a decrease in the number of patients who had required blood transfusions with

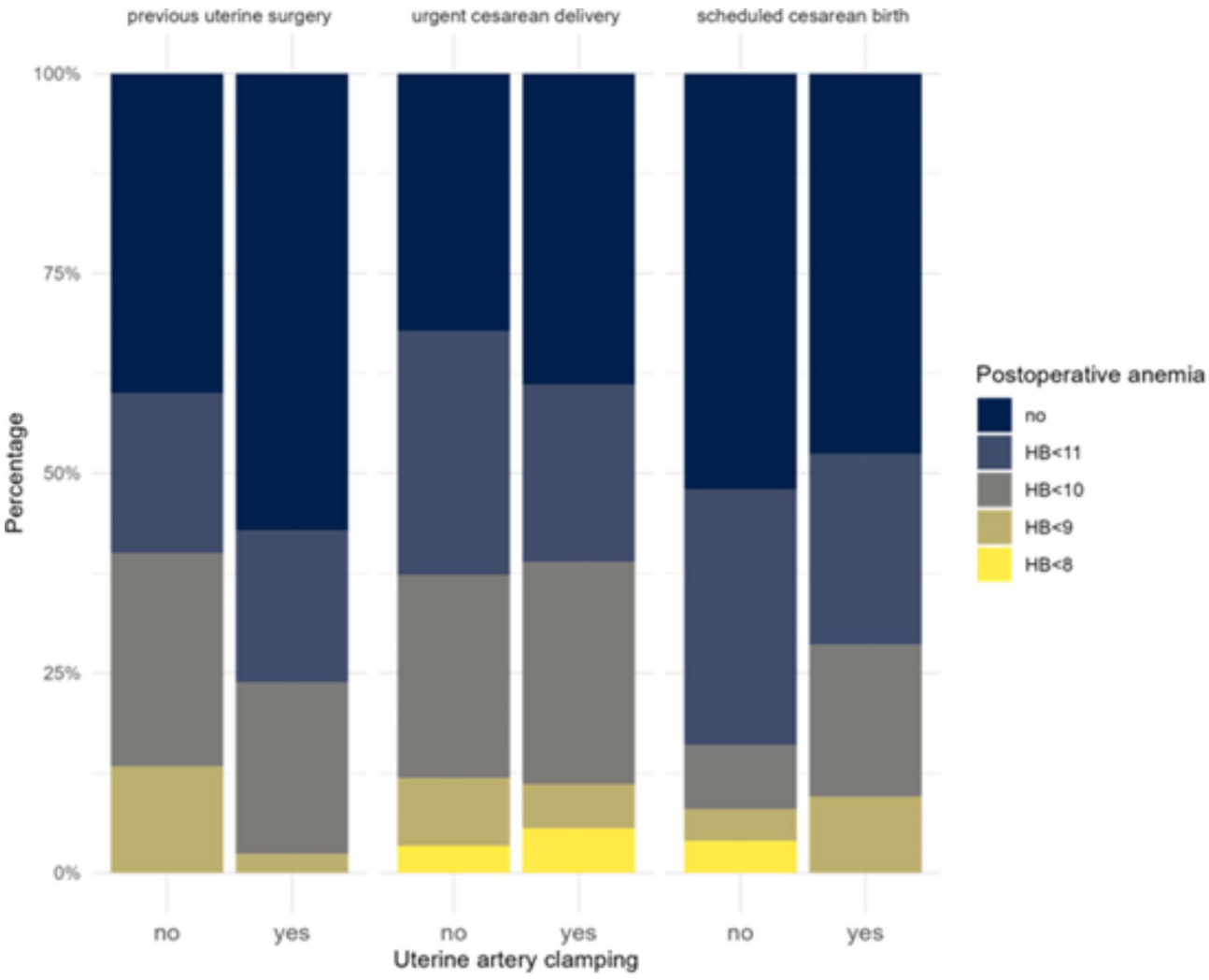

Fig. 6 Percentages of postoperative degrees of anemia by clamping and cesarean birth indications

Table 9 Indications for cesarean sections and postoperative anemia rates

Indication	Hb > 10% (*n*)	Hb < = 10% (*n*)
Cesarean section/previous surgery	71,90 (41)	28,10 (16)
Urgent cesarean section	62,30 (48)	37,70 (29)
Elective without surgery	78,30 (36)	21,70 (10)
Indication by clamping		
Previous surgery with clamping	76,2 (32)	23,8 (10)
Previous surgery without clamping	60,0 (9)	40,0 (6)
Urgent cesarean section with clamping	61,1 (11)	38,9 (7)
Urgent cesarean section without clamping	62,7 (37)	37,3 (22)
Elective surgery with clamping surgery	71,4 (15)	28,6 (6)
Elective without surgery without clamping	84,0 (21)	16,0 (4)

Table 10 Postoperative blood transfusion**s**

Clamping	Yes % (*n*)	No % (*n*)
Yes	1.12 (1)	98.88 (88)
No	7.69 (7)	92.31 (84)

packed red blood cells after their cesarean sections in the study group compared to the control group in a 7:1 ratio.

In none of the cases was it necessary to perform any additional surgical technique (placental bed sutures, bilateral uterine artery ligation, and B-Lynch suture) to control the hemorrhage, so this factor was not taken into account when analyzing the results.

Linear regression models

Variable differences in hemoglobin levels pre- and post-surgery

The adjusted R2 value of the linear regression model indicated that 21.72% of the variance in the hemoglobin levels pre-surgery vs. post-surgery was explained by the variables introduced in the model.

Statistical significance was observed for the difference in the hemoglobin levels and pre- and post-partum as the related to not receiving the clamping technique (Table 11), that is, not performing the clamping technique

Table 11 Linear regression model for the differences between the pre- and post-surgery hb levels

Hb difference Variable	Model 1 95% CI	*P*	Model 2 95% CI	*P*
Clamping				
Yes (ref.)				
No	0.40 (0.12–0.69)	0.006	0.15 (-0.36–0.67)	0.557
Indication				
Cesarean section/previous surgery (ref.)				
Urgent cesarean section	0.76 (0.42–1.09)	0.000	0.51 (0.30–0.99)	0.037
Elective without surgery	0.12 (-0.23–0.48)	0.492	0.80 (-0.38–0.54)	0.731
Cesarean section indication				
No clamping *Previous cesarean surgery(ref.)				
No clamping * Urgent cesarean section			0.48 (-0.20–1.17)	1.39
No clamping * Elective no surgery			0.21 (-0.51–0.94)	0.58

implied an increase of 0.4 units in the estimated difference between the pre- and post-surgery hemoglobin levels ($P=0.000$). The same happened in the case of urgent cesarean sections, where there was a positive and significant association which indicated that in the cases in which c-sections were carried out, there was an increase of 0.76 units in the difference obtained between the subtraction of the pre and post-partum hemoglobin levels ($P=0.000$), with the rest of the variables being equal.

Figure 7 shows that although the results for the women who received clamping were generally more satisfactory, the only significant difference between the women with and without clamping was observed in the group of those who had undergone urgent cesarean sections. The question of significance was largely due to the size of the sample. It would be expected that with a larger sample size, significant differences could be found in the other two indication groups.

In the case of the linear regression model that considered postpartum days as the de-pendent variable, an adjusted R2 value of only 8% was observed, that is, only this percent-age of the variance of the postpartum days variable was explained by the variables entered into the model. Despite this low percentage, the positive effect of applying the clamping technique in reducing postpartum hospitalization time stands out, keeping the rest of the variables controlled. In the case of those women to whom this technique was not applied, the estimated days of puerperium increased by 0.86 units ($P=0.006$) compared to those who had received it. The same happened in the case of the women included in the elective category without surgery for the indication variable, in which

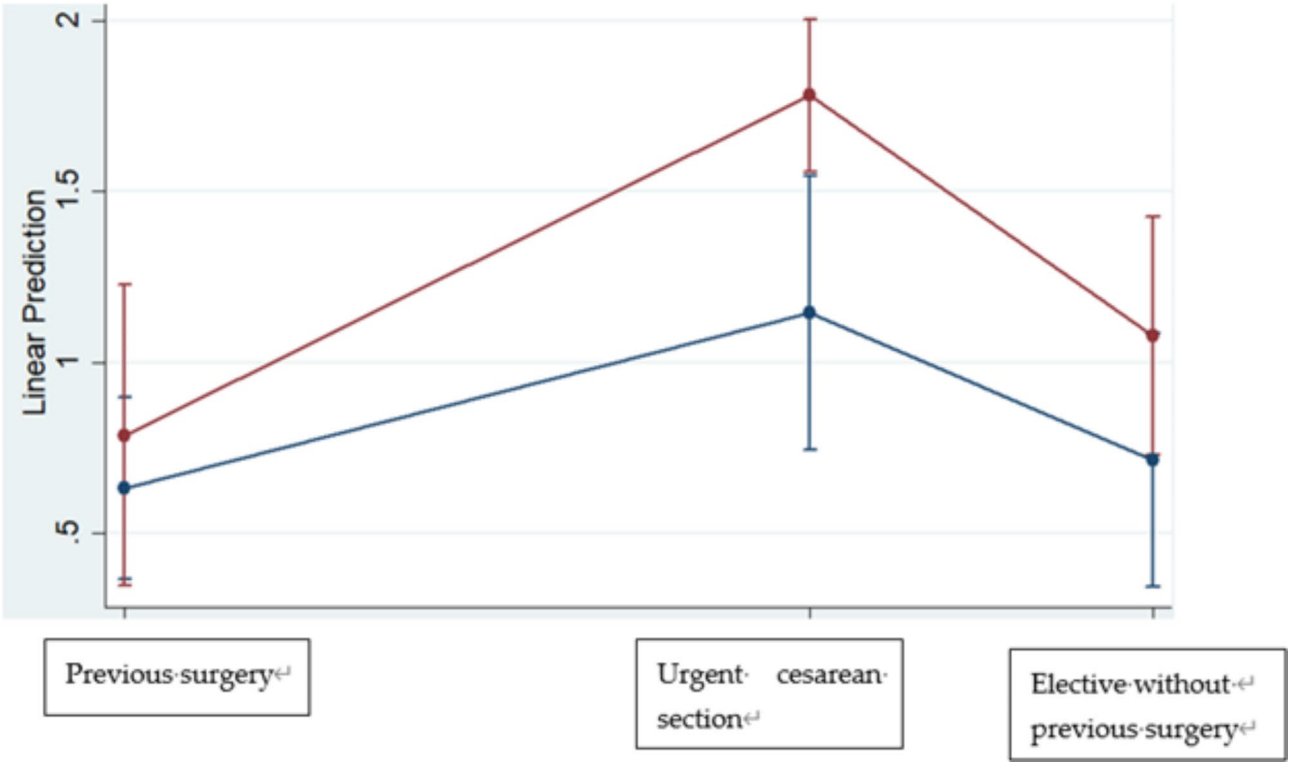

Fig. 7 Adjusted predictions of indications/clamping with 95% CIs, with the differences be-tween the pre- and post-surgery Hb levels

there was an increase of 0.77 units in the days of postpartum stays required (P=0.048).

Of the 81 patients who underwent clamping, none of them experienced any type of notable surgical accident.

In the same way, in Fig. 8, we can see that although the interaction was not significant, the estimated values for the days of puerperium, keeping the other variables at their means, showed how the women in the 'elective without surgery' situation that did not have clamping were the ones with the longest estimated hospital stay times (4.75 days). The group with less than the estimated stays corresponded to the group of those who had undergone previous surgeries with clamping (2.90).

Discussion

PPH continues to be the leading cause of maternal morbidity and mortality in most countries of the world.

All recommendations for its prevention to date have been directed to the use of pharmacological measures.

For this reason, we must study the possibility of adopting new measures—not necessarily pharmacological—that can help in the prophylaxis of PPH. In this sense, surgical techniques aimed at temporary compression of the uterine arteries have been tested as a treatment for PPH [18, 19].

Multiple authors such as Tomoaki et al. have used tourniquets as a bleeding prevention system in gynecological surgery [20].

Erin et al. recently proposed the use of intermittent clamping of the uterine arteries in low-risk cesarean sections with the aim of reducing blood loss, presenting an average blood loss of 267.3±131 ml in the clamping group compared to 390±116.4 ml in the control group [19].

With this same objective, in November 2023, we began our work consisting of evaluating whether bilateral clamping of the uterine arteries in low-risk cesarean sections could be a recommended prophylactic measure in order to reduce blood loss. To do this, we evaluated blood loss through pre- and post-surgical Hb levels, the mean hospital stay after cesarean section, and the percentage of patients with anemia at discharge.

In our study, when assessing the difference in Hb before and after surgery, we found that the clamped patients presented a reduction in the difference between these two values (0.80 (0.82) vs. 1.42 (1.00)), which would imply a reduction in blood loss of 0.62 g/dl. The only work that has evaluated a technique similar to the one proposed in our study is that carried out by Erin et al. [21], where the difference in Hb before and after surgery was 1.2±0.6 g/dl in the study group compared to 1.9±0.7 g/dl in the control group. Although the differences between the

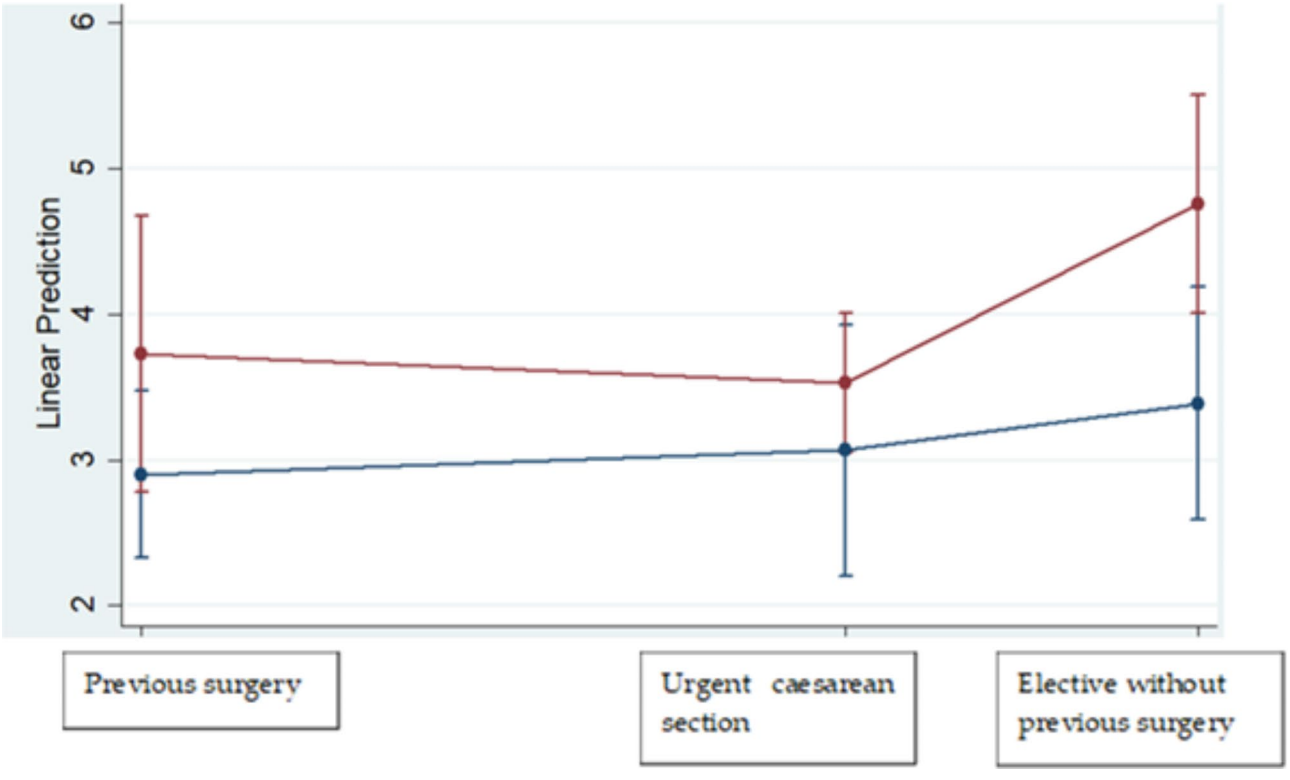

Fig. 8 Adjusted prediction of indications/clamping with 95% Cis, with the days of puerperium

two groups were similar in both works(0.62 vs. 0.70 g/dl), we high-lighted that the amounts of blood loss in the study groups were appreciably less (0.8 vs. 1.2 (found in Erin's study group)). It should be noted that there were differences in how much the surgical technique was performed. In the study by Erin, clamping was performed prior to delivery of the placenta, while in our study, clamping took place once delivery had occurred [21]. Our group decided to perform it this way since accessing the uterine arteries adequately and safely required externalization of the uterus. For this, given that most of the surgical approach was performed through a Pfannestield incision, we found that said externalization was more difficult when the delivery had not been performed beforehand.

If we analyze the composition of both groups based on the indications for cesarean sections, we can see how in the clamping group, a greater number of patients whose indications were performed electively or by previous uterine surgeries were selected compared to the control group, where there were more cases of urgent indications. In our opinion, the possibility of blood loss was greater in the elective surgeries since most of them were indicated in primiparous women with breech presentations, assuming a thicker uterine segment and, consequently, presenting a greater tendency toward bleeding. Likewise, we estimated that the risk of blood loss could be higher in cesarean sections performed due to previous uterine surgeries compared to those performed urgently, and these were mostly indications due to non-progression of labor or a failure of induction while presumably presenting thinner uterine segments.

In relation to analyzing the post-surgical hospital stays, we found that there was a significant reduction in the days of stay in the group that underwent clamping (3.02 (0.87) vs. 3.90 (2.40)), and thus a reduction in stay of 0.8 days was achieved.

This benefit was even greater in the group of cesarean sections that were electively indicated (3.38 (1.02) vs. 4.76 (3.81)), where the hospital stays were reduced by 1.38 days.

As could be seen in our study when assessing the rate of anemia at discharge, we were able to observe that the number of women diagnosed with postpartum anemia and requiring treatment at discharge was significantly lower in the patients in clamping group, where more than half of the patients had hemoglobin values above 11 and 76.2% had values above 10 compared to 60% of the patients in the control group.

As can be seen in Fig. 6, which shows the levels of anemia in the different groups, the clamping group had superior rates superior compared to the control group. This decrease in the number of patients with anemia at discharge would have impacts not only on improving the clinical recovery rates of the patients but also on decreasing the cost of treatments prescribed at discharge.

Regarding blood transfusions, seven cases of blood transfusions were recorded in the control group compared to one case in the group that underwent clamping.

Although we value the option of studying the possible influence that this technique could have on ovarian reserves and the reproductive futures of patients, after reviewing the articles in the scientific literature that studied the ligation, clamping, or embolization of the uterine arteries in gynecological surgery for the prophylaxis and treatment of PPH in obstetric patients, the null repercussions that this procedure could have in this regard [12, 15] appear to have been demonstrated, especially when performing our technique, where the clamping time was very short and did not exceed 10 min.

Wufen et al., in their work in 2022, explored the efficacy as well as the repercussions of ligation and embolization as a treatment for post-cesarean PPH, assessing the flow in-dices of the ovarian arteries both at the ultrasound level and at the levels of FSH, LH, and estradiol (E2), which demonstrated the adequate recovery of ovarian function after per-forming both techniques [22].

Regarding the surgical time, we considered that the time required for clamping was widely compensated by the shorter time spent in performing the uterine closure by offering a more visible surgical field due to the reduction in bleeding.

In our work, the sample size, because it was a preliminary study group, was one of our limitations that could be improved in future studies. Likewise, as we have discussed, in the control group, the proportion of urgent cesarean sections was higher than that ofthe control group. We believe that it would be appropriate in future studies to homogenize the samples regarding this indication.

This technique has been performed by different professionals, and so this favors the reproducibility of the technique, though there may be a surgeon-dependent factor in the results that could not be assessed in our study.

The strength of our study lies in the fact that in spite of the limited sample, the results are very clearly in favor of carrying it out, and the statistical analysis suggests that the results could be better with a larger sample.

This study presents a series of limitations or weaknesses such as the difficulty in taking into account all the factors that influence the increase in bleeding during cesarean section, which makes it difficult to differentiate between them, the need to resort to an indirect parameter such as the measurement of pre and post-surgery hemoglobin values to analyze the results given the variability that a direct measurement of blood loss could offer, as well as the variability that could result from the intervention of multiple professionals in the study.

As a result of our findings we have tried to answer a number of questions regarding this technique:

First, in which patients can it be applied? In general it could be applied in all types of caesarean sections, except perhaps those in the access to the uterine arteries due to an adherent syndrome.Still we consider it appropriate to reserve it for those patients who are assumed a high risk of hemorrhaging or anemia.

Secondly, Who can perform it? Since it is an easily achievable technique, we consider that it is within the reach of any obstetrician accustomed to performing caesarean sections.No specific prior training is necessary.

Thirdly, Where the technique could be applied? This technique can be performed in any hospital where deliveries are performed.

Lastly, When the technique could be performed? The technique should be considered before the appearance of hemorrhagia, in a prophylactic manner in all cesareans that consider us with high risk of hemorrhagic.

Conclusions

The application of temporary clamping of the uterine arteries during cesarean section after fetal delivery may be an effective measure for the prevention of postpartum hemorrhage, as well as reducing hospital stays and anemia rates at discharge. This could offer us an estimable medical and economic benefits.

Compared to other surgical techniques described above, such as the tourniquet, this technique is more easily performed and remains effective regardless of the surgical time and does not need to be readjusted to maintain reduced blood flow.

The absence of complications found and the ease of performing this technique, given its possible benefits, suggests that we carry out a greater number of studies that confirm its benefits, and thus, we will be able to establish whether it would be generally applicable or if its use should be restricted to certain areas or indications.

Supplementary Information

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Supplementary Material 1

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Author contributions
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Data available on request from the authors: The data that support the findings of this study are available from the corresponding author, [lorenasabonet@gmail.com], upon reasonable request.

Declarations

Ethics approval and consent to participate
Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Ethics Committee of the Regional University Hospital of Malaga (protocol 2797-N-23).

Consent for publication
N/A.

Competing interests
The authors declare no competing interests.

Informed consent
Informed consent was obtained from all subjects involved in the study.

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