Journal of Obstetrics, Gynecology and Cancer Research | ISSN: 2476-5848

Pelvic Congestion Syndrome Following Salpingectomy Compared to Tubal Ligation at Time of Caesarean Section: A Randomized Clinical Trial

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Article Info

10.24200/jogcr.10.10.770

Received: 2025/04/11
Accepted: 2025/05/17
Published Online: 01 Sep. 2025

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ABSTRACT

Background & Objective: Permanent tubal sterilization during cesarean section is a reliable method of contraception. It is done either by bilateral tubal ligation or bilateral salpingectomy according to the surgeon's preference. To evaluate the effects of tubal ligation versus bilateral salpingectomy during cesarean section in terms of pelvic venous congestion.

Materials & Methods: A randomized clinical trial was conducted from January to August 2024 at Ain Shams University hospitals. Sixty-four pregnant women undergoing Cesarean section and requesting permanent contraception were randomized into two groups: tubal ligation (n=32) and bilateral salpingectomy (n=32). Postoperative evaluation after ten weeks included a structured symptom questionnaire and transvaginal duplex ultrasound assessment for signs of pelvic venous congestion.

Results: Ultrasound findings showed dilated pelvic plexus veins in 13.3% of the tubal ligation group and 6.9% of the salpingectomy group (P=0.671). Crossing veins in the myometrium were present in 36.7% of tubal ligation patients versus 24.1% of salpingectomy patients. Duplex waveform changes during Valsalva's maneuver were detected in 13.8% of the tubal ligation group and 7.1% of the salpingectomy group (P=0.670). The mean ovarian vein diameter measured 4.07±0.74 mm in the tubal ligation group compared to 3.83±0.85 mm in the salpingectomy group (P=0.253).

Conclusion: There were no significant differences between those getting bilateral salpingectomy during a cesarean section and those undergoing tubal ligation in terms of intraoperative and postoperative outcomes, menstrual abnormalities, or pelvic venous congestion. Bilateral salpingectomy demonstrated similar safety to tubal ligation in terms of operative complications, menstrual cycle disturbances, and pelvic pain.

Keywords: Salpingectomy, Tubal ligation, Caesarean section

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1. Introduction

Permanent contraception at the time of cesarean section is commonly achieved through tubal sterilization, a surgical method to prevent future pregnancy. It is typically carried out either by tubal ligation, where a portion of each fallopian tube is surgically tied and cut, or by bilateral salpingectomy, where the entire fallopian tube is removed, depending on the surgeon's preference **(1,2)**.

Recent studies have revealed that bilateral salpingectomy may offer the additional benefit of reducing the risk of high-grade serous ovarian carcinoma **(1)**. This has encouraged a shift among surgeons towards performing salpingectomy as a risk-reducing procedure, based on growing evidence that the fallopian tubes are the site of origin for many cases of high-grade serous ovarian carcinoma **(2,3)**.

Post-tubal Ligation Syndrome (PTLS) is a debated condition that may present with chronic pelvic pain, menstrual irregularities, dysmenorrhea, and dyspareunia. Though its existence remains controversial, PTLS is diagnosed clinically after ruling out other causes and can significantly affect quality of life **(4,5)**.

Although venography remains the gold standard for diagnosing pelvic congestion syndrome, duplex ultrasound is generally used as the initial imaging modality due to its accessibility and non-invasive nature **(1)**.

Given these evolving clinical concerns, the present study was conducted to compare the impact of bilateral salpingectomy versus bilateral tubal ligation performed during Caesarean section, focusing specifically on

pelvic congestion symptoms assessed by patient-reported outcomes and sonographic findings.

2. Materials and Methods

Study Design and Setting

This randomized clinical trial, which involved 64 pregnant women who had caesarean sections and requested tubal sterilization as a permanent method of contraception, was carried out at the tertiary care hospital at Ain Shams University hospitals from January to August 2024 after receiving approval from the ethical committee and written consent from the patients.

The inclusion criteria for the trial were as follows:

Participant Eligibility

1. Inclusion Criteria

Females undergoing caesarean section and requesting tubal sterilization as a permanent method of contraception with maternal 30 years or older to minimize the risk of sterilization regret, which has been consistently shown to be higher in younger women.

Research consistently shows that women who undergo sterilization before age 30 are significantly more likely to regret the procedure later in life, particularly if they experience changes in marital status, loss of a child, or evolving reproductive goals **(5)**.

2. Exclusion Criteria

Previous history of tubal surgery or oophorectomy (changes in blood flow), presence of congenital anomalies or malformations in fallopian tubes or ovaries, women diagnosed with pelvic congestion, High likelihood of lost to follow up and the inability to provide good data.

Sample Size Justification

Sample size was calculated using G*Power® version 3.1.9.2, setting the power at 0.84 and the significance level (α) at 0.05. Data from previous reports **(6)** indicated that the incidence of pelvic congestion syndrome post tubal ligation was 30%. Assuming a rate of reduction of 26% in women undergoing salpingectomy, calculation according to these values produced a minimal sample size of 64 women to be randomized equally to both groups. Assuming a dropout rate of 15%, a minimum drop-out inflated sample size of approximately 72 women was needed.

Randomization

Using a computer-generated method, participants were randomly assigned at a 1:1 ratio to either bilateral salpingectomy or bilateral tubal ligation. Procedure allocation for each patient was made in sequentially numbered sealed opaque envelopes. The surgeon handling the case was informed.

Study Procedures: The following were provided to each participant:

Surgical Intervention

All procedures were performed by senior residents under consultant supervision.

Recognizing the Fallopian tube's fimbriated end. It was grasped by a Babcock or Allis forceps.

Tubal Ligation (Parkland Technique)

Tubal ligation was done by Parkland technique. Electrocautery is used to create an opening in an avascular area of the mesosalpinx. After cutting the section (at least 2 cm) using scissors, two absorbable suture ties (2-0 Vicryl) were inserted into the incision and utilized to ligate its proximal and distal ends.

- **Bilateral Salpingectomy**

Salpingectomy was done by clamping, division and ligation using absorbable suture material (2-0 Vicryl) and excising the tube till it's isthmic part by scissors.

Hemostasis was ensured at the incised edges.

Participants undergoing salpingectomy had their fallopian tubes sent for pathological examination to confirm transection and exclude malignancies.

Postoperative assessment

Follow up visit after ten weeks.

- **Symptom Questionnaire**

At 10 weeks postoperatively, participants completed a standardized symptom questionnaire assessing:

- Menstrual irregularities (heavy bleeding, amenorrhea, irregular cycles).
- Pelvic pain: characterized as dull, throbbing, noncyclical pain, worsened by prolonged standing or walking, and punctuated by intermittent sharp pains.

Symptom presence was recorded as binary (Yes/No).

The 10-week postoperative follow-up was chosen as an optimal time point because it allows sufficient duration for post-surgical recovery, stabilization of menstrual patterns, and emergence of subacute symptoms such as pelvic pain or cycle irregularities, without being so delayed that recall bias or loss to follow-up becomes a concern.

- **Sonographic Evaluation**

All participants underwent transvaginal duplex ultrasonography performed by a blinded radiologist (Assistant Lecturer, Radiology Department).

The radiologist interpreting postoperative imaging was blinded to participants' group assignments to ensure objective evaluation of findings. Imaging data were anonymized and labeled with coded identifiers that concealed allocation status.

Ultrasound Methodology

- Machine: Samsung UGEO WS80A with a 5-7 MHz transvaginal probe.
- Pre-scan: Participants emptied their bladders and were positioned lithotomy-style.
- **Ultrasound Measurements (7)**
  - **Ovarian vein diameter** (normal <6 mm).
  - **Presence of pelvic varices**: Dilated, tortuous veins >6 mm around ovaries and uterus.
  - **Crossing veins**: Detection of veins traversing the myometrium.
  - **Duplex waveform changes**: Monitored during Valsalva maneuver in ovarian and internal iliac veins.

All scans adhered to standardized protocols to minimize interobserver variability.

Outcome measures

1- **Primary outcome:** Symptoms of pelvic venous congestion assessed by a Questionnaire.

2- **Secondary outcome:** intraoperative complications and ultrasound findings.

Ethical Considerations

The study was conducted under the ethical principles outlined in the Declaration of Helsinki. Ethical approval was obtained from the Institutional Review Board (IRB) of Ain Shams University prior to study initiation (approval number: [MS 296/2024]).

All participants provided written informed consent after receiving a detailed explanation of the study's objectives, procedures, potential risks, and benefits. Confidentiality of patient information was strictly maintained; all data were anonymized and stored securely. Participants retained the right to withdraw from the study at any time without any effect on their standard medical care.

Conflict of interest

The candidates stated that they had no conflicts of interest and that they had covered the study's costs.

Statistical Analysis

The analyses were done with Windows v20.0 of SPSS. For numerical parametric variables, the data should be given as range, mean, and standard deviation; for numerical non-parametric variables, as range, median, and inter-quartile range; or as number and % for categorical variables. After that, appropriate statistical analyses were used.

3. Results

The demographic characteristics of the study participants are summarized. The mean age in the tubal ligation group was significantly higher than that in the salpingectomy group (38.28±3.27 years vs. 36.47±3.12 years; P=0.027). However, there were no significant differences between the groups regarding Body Mass Index (BMI) (31.50±2.81 kg/m² vs. 30.78±3.99 kg/m²; P=0.408) or gestational age at delivery (36.91±1.25 weeks vs. 36.88±1.41 weeks; P=0.926). (Table 2)

There were no statistically significant differences between the tubal ligation and salpingectomy groups regarding reproductive history variables. A majority of participants in both groups had a parity of three or more, accounting for 84.3% of the tubal ligation group and 87.5% of the salpingectomy group (P=0.363). Previous cesarean sections were reported in 68.7% of the tubal ligation group and 81.3% of the salpingectomy group (P=0.813). Similarly, the proportion of women with previous vaginal deliveries was identical in both groups at 43.7% (P=0.639). Abortions were reported in 25% of the tubal ligation group and 31.2% of the salpingectomy group (P=1.000). Only one case of previous vesicular mole was reported in the salpingectomy group, with no cases in the tubal ligation group (P=1.000) (Table 3).

At 10 weeks postoperatively, no significant differences were observed between the two groups in terms of menstrual irregularities or pelvic pain. In the tubal ligation group, 53.3% (16/30) reported no menstrual irregularities compared to 51.7% (15/29) in the salpingectomy group (P=1.000). Heavy menstrual bleeding was reported by 10.0% (3/30) of the tubal ligation group and 6.9% (2/29) of the salpingectomy group (P=1.000). Notably, a considerable number of participants in both groups had not yet resumed menstruation by the follow-up period (36.7% vs. 41.4%, respectively; P=1.000). Regarding pelvic pain, 10.0% (3/30) of women in the tubal ligation group and 24.1% (7/29) of those in the salpingectomy group reported symptoms, though the difference was not statistically significant (P=0.181) (Table 4).

Table 1. Comparison of Demographic and Clinical Characteristics

	tubal ligation		salpingectomy		t test		
	Mean	SD	Mean	SD	t	P-value	sig.
Age	38.28	3.27	36.47	3.12	t=2.27	0.027	S
BMI	31.50	2.81	30.78	3.99	t=0.83	0.408	NS
Gestational age	36.91	1.25	36.88	1.41	t=0.09	0.926	NS

Table 2. Comparison of Parity, Previous Cesarean Sections, and Other Reproductive History

Variables		tubal ligation		salpingectomy		Linear By Linear association		
		N	%	N	%	value	P value	sig.
Parity	2	5	15.6%	4	12.5%	χ^2 =1.09	0.363	NS
	3	7	21.9%	14	43.8%			
	4	14	43.8%	10	31.3%			
	5	5	15.6%	4	12.5%			
	6	1	3.1%	0	0.0%			
Previous CS	0	5	15.6%	4	12.5%	χ^2 =0.1	0.813	NS
	1	5	15.6%	2	6.3%			
	2	7	21.9%	9	28.1%			
	3	3	9.4%	10	31.3%			
	4	6	18.8%	6	18.8%			
	5	5	15.6%	1	3.1%			
	6	1	3.1%	0	0.0%			
vaginal deliveries	0	18	56.3%	18	56.3%	χ^2 =0.32	0.639	NS
	1	3	9.4%	6	18.8%			
	2	5	15.6%	4	12.5%			
	3	3	9.4%	2	6.3%			
	4	3	9.4%	2	6.3%			
Abortions	0	24	75.0%	22	68.8%	χ^2 =0.03	1.000	NS
	1	4	12.5%	6	18.8%			
	2	3	9.4%	4	12.5%			
	3	1	3.1%	0	0.0%			
Previous vesicular mole	no	32	100.0%	31	96.9%	Fisher exact test	1.000	NS
	yes	0	0.0%	1	3.1%			

Table 3. Comparison of Menstrual Irregularities and Pelvic Pain

Variables		tubal ligation		salpingectomy		Test of sig.		
		N	%	N	%	value	P-value	sig.
Menstrual irregularity	no irregularities	16	53.3%	15	51.7%	Fisher exact test	1.000	NS
	not yet menstruating	11	36.7%	12	41.4%			
	heavy menstrual bleeding	3	10.0%	2	6.9%			
Pelvic Pain	No	27	90.0%	22	75.9%	Fisher exact test	0.181	NS
	Yes	3	10.0%	7	24.1%			

Table 4. Comparison of Intraoperative and Postoperative Outcomes

Variables		tubal ligation		salpingectomy		Test of sig.		
		Mean	SD	Mean	SD	value	P-value	sig.
ovarian vein diameter		4.07	0.74	3.83	0.85	t=1.16	0.253	NS
		N	%	N	%			
duplex waveform change	no	25	86.2%	26	92.9%	Fisher exact test	0.670	NS
	yes	4	13.8%	2	7.1%			
crossing veins in myometrium	no	19	63.3%	22	75.9%	χ^2=1.09	0.296	NS
	yes	11	36.7%	7	24.1%			
dilated veins in pelvic plexus	no	26	86.7%	27	93.1%	Fisher exact test	0.671	NS
	yes	4	13.3%	2	6.9%			
blood transfusion	no	28	93.3%	26	89.7%	Fisher exact test	0.671	NS
	yes	2	6.7%	3	10.3%			
Septic wound	no	29	96.7%	28	96.6%	Fisher exact test	1.000	NS
	yes	1	3.3%	1	3.4%			

Transvaginal duplex ultrasound evaluation revealed no statistically significant differences between the groups regarding pelvic venous congestion markers. The mean ovarian vein diameter was 4.07±0.74 mm in the tubal ligation group compared to 3.83±0.85 mm in the salpingectomy group (P=0.253). Duplex waveform changes during Valsalva maneuver were noted in 13.8% (4/29) of the tubal ligation group and 7.1% (2/28) of the salpingectomy group (P=0.670). Crossing veins in the myometrium were observed in 36.7% (11/30) of the tubal ligation group and 24.1% (7/29) of the salpingectomy group (P=0.296). Dilated veins within the pelvic plexus were identified in 13.3%

(4/30) of the tubal ligation group and 6.9% (2/29) of the salpingectomy group (P=0.671).

The rates of intraoperative and postoperative complications were low and comparable between the two groups. Blood transfusion was required in 6.7% (2/30) of the tubal ligation group and 10.3% (3/29) of the salpingectomy group (P=0.671). Septic wound complications were rare, occurring in 3.3% (1/30) of tubal ligation cases and 3.4% (1/29) of salpingectomy cases (P=1.000).

4. Discussion

The growing body of research indicates that most epithelial ovarian malignancies originate in the fallopian tube, which raises the possibility that salpingectomy might be a useful preventive measure **(8)**. Considering evidence suggesting reduced ovarian cancer risk, major organizations now recommend salpingectomy during benign gynecologic surgeries **(9)**.

The best way to maximize the use and potential impact of salpingectomy is to sterilize the patient during cesarean birth. According to Powell et al., some 650,000 postpartum sterilizations are carried out each year, most of them during cesarean birth. Nevertheless, there is a lack of prospective research on this total salpingectomy situation, and theoretical worries about the possibility of increased problems due to the increased blood supply to the gravid uterus remain **(10)**.

Consequently, this study evaluated whether bilateral salpingectomy during Caesarean section affects pelvic venous congestion or postoperative complications compared to tubal ligation.

This randomized clinical experiment involved 64 pregnant women who had caesarean sections and requested tubal sterilization as a long-term means of contraception. It was carried out at the tertiary care hospital at Ain Shams University hospitals between January and August of 2024.

The average age of the tubal ligation group was found to be significantly higher than that of the salpingectomy group, with an average age of 38.28 years compared to 36.47 years (P=0.027), based on both demographic and clinical parameters. Nonetheless, there were not significant differences in the two groups' gestational ages or Body Mass Index (BMI). Except for age, this suggests that the two groups' overall health and pregnancy-related characteristics were somewhat similar.

When analyzing reproductive history, including parity and previous cesarean section history, no significant differences were found between the two groups. The distribution of vaginal deliveries and abortion rates also showed no notable differences. This suggests that both tubal ligation and salpingectomy groups had similar reproductive backgrounds, and the type of sterilization procedure did not seem to influence these variables.

The study also investigated menstrual irregularities and pelvic pain. The results showed no significant difference between the groups regarding the prevalence of these issues. This finding indicates that neither tubal ligation nor salpingectomy had a major impact on menstrual patterns or pelvic discomfort post-surgery.

According to Duncan et al., a retrospective study involving 160 pregnant women compared the surgical outcomes of patients undergoing bilateral salpingectomy (salpingectomy group) with those undergoing partial salpingectomy (partial salpingectomy group) during cesarean delivery. The study found that there was no statistically significant difference in the frequency of menstrual irregularities (27.3% vs 27%; P>0.99), dysmenorrhea (27.7% vs 48.6%; P=0.36), dyspareunia (9.1% vs 8.1%; P>0.99), dissatisfaction with one's quality of life (18.2% vs 16.2%; P>0.99), and the number of women who regretted (9.1% vs 18.9; P=0.80) **(9)**.

In terms of intraoperative and postoperative outcomes, factors such as ovarian vein diameter, duplex waveform changes, crossing veins in the myometrium, and dilated veins in the pelvic plexus were measured. None of these outcomes showed significant differences between the two groups. Furthermore, no significant differences were seen in the incidence of infected wounds or blood transfusions, indicating that the hazards associated with these operations are comparable both during and after surgery.

These results are consistent with earlier research. To determine whether performing a salpingectomy in place of standard tubal ligation for sterilization at the time of cesarean delivery increases operating time or complication rates, Garcia et al. enrolled 44 women in a randomized controlled noninferiority trial. The trial's findings also showed that there was no difference between the two intervention cohorts in terms of estimated blood loss, change in hematocrit, need for transfusion, wound infection, length of stay, or readmission, and there was no significant increase in complications **(8)**.

In addition, Yang et al., carried out a systematic review and meta-analysis to assess the safety profile and viability of complete salpingectomy during cesarean delivery in women seeking permanent sterilization. Their findings indicated that bilateral salpingectomy and partial salpingectomy were similar in terms of estimated total blood loss, transfusion requirements, surgical complications, risk of hemorrhage after delivery, surgical site infection, ICU admission, hospitalization requirement, short-term ovarian reserve, and sterilization surgery completion rate **(11)**.

Furthermore, Herman et al., found no surgical problems happened throughout the study period in a

trial including 46 pregnant women who were randomized to get a bilateral salpingectomy or a tubal ligation. The rate of postoperative complications and the post-operative hemoglobin drop did not differ statistically between the groups (1.1±1.07 vs. 0.85±1.01 gr/dL, P=0.39). Lastly, there was no a significant difference in the groups' mean length of stay in the hospital following surgery **(12)**.

Another research by Shinar et al., found that following a practice shift to institute salpingectomy at a tertiary medical facility, there was no increase in operating time or complication rates in 149 cesarean sterilization operations, including 50 salpingectomies **(13)**.

Powell et al., conducted a large retrospective cohort analysis that included over 6,000 sterilizations at the time of cesarean birth. The study failed to find any significant difference in the complication rates between salpingectomy and tubal ligation. 206 salpingectomies were performed, and the overall operating time was 9.5 minutes greater than that of a cesarean birth with tubal ligation **(10)**.

According to Herman et al., 46 women who were randomized to bilateral salpingectomy or conventional partial salpingectomy for sterilization at the time of cesarean birth or postoperatively, including the ovarian reserve, did not experience an elevated risk of surgical complications **(12)**, which is consistent with our data. This aligns with the findings of Subramaniam et al., **(14)**.

The effect of salpingectomy in reducing the risk of ovarian cancer is yet speculative, and the exact extent of this benefit is uncertain, despite encouraging results from large retrospective cohort studies **(15,16)**. In a large Danish case control research, Madsen et al., find a 42% ovarian cancer risk decrease with salpingectomy compared with 13% for tubal ligation **(16)**. Bilateral salpingectomy has been found to be more beneficial, with a 65% reduction in risk recorded by Falconer et al., in a large Swedish population. Salpingectomy has advantages beyond preventing cancer **(15)**.

Failures do happen, even though the typical tubal ligation approach (via postpartum partial salpingectomy) has the lowest pregnancy rates of any technique. Pregnancies following bilateral complete salpingectomy are confined to case reports, suggesting that full salpingectomy may be more successful due to its more extirpative nature. Complete salpingectomy may provide benefits, thus as long as there are no new risks, it should be adopted as a routine procedure **(17,18)**.

As a result of increasing evidence that ovarian cancer may have its origins in the fallopian tubes, salpingectomy is now routinely performed during hysterectomy or other sterilization procedures to lower the chance of getting ovarian cancer **(11)**.

Overall, this trial demonstrates that there is no significant difference in pelvic venous congestion or other key clinical outcomes between tubal ligation and salpingectomy. While the tubal ligation group was slightly older on average, this age difference did not appear to affect the overall safety and efficacy of the procedures. Both sterilization methods were similarly safe and effective, providing important guidance for clinical decisions on pelvic health after Caesarean delivery.

The findings support the growing practice of offering salpingectomy as a sterilization option during cesarean deliveries, particularly in light of its potential to reduce ovarian cancer risk as suggested by previous research **(15,16)**. Clinicians can confidently present both procedures as safe choices with minimal impact on postoperative recovery or pelvic health. Moreover, considering the potential benefits of salpingectomy in reducing cancer risk, it may be advantageous to incorporate this option more routinely in sterilization practices, provided there are no contraindications or increased risks for the patient.

The absence of a statistically significant difference in Pelvic Congestion Syndrome (PCS) between the salpingectomy and tubal ligation groups in this study may be attributed to several factors related to follow-up timing, outcome prevalence, and diagnostic sensitivity.

Firstly, the 10-week follow-up period may have been too short to fully capture the onset of chronic conditions such as PCS. Pelvic congestion often presents as a long-term or slowly developing disorder, and many of its symptoms-like chronic pelvic pain or varicose changes-may not become clinically evident within such a brief postoperative window. While the 10-week point was chosen to balance recovery time with follow-up feasibility, it likely only allowed detection of acute or early subacute manifestations, not the full scope of PCS symptoms, which may require several months or even years to evolve **(8)**.

Secondly, PCS appeared to be relatively uncommon in both groups. According to the study's findings, the incidence of clinical or sonographic indicators of PCS, such as dilated pelvic veins or altered duplex waveforms, was low ranging between 7% and 13% across groups. Such a low frequency of events reduces statistical power and makes it more difficult to detect meaningful differences between the interventions, especially with a limited sample size of 64 participants. Moreover, the observed effect sizes between groups were small and unlikely to reach significance without a much larger cohort **(8,9)**.

Lastly, the sensitivity of the diagnostic modality used-transvaginal duplex ultrasound-may have played a role in underdetecting subtle PCS features. Although this method is non-invasive and widely accessible, it is known to be operator-dependent and less sensitive than the gold standard of venography or more advanced

imaging techniques like MR venography. Certain vascular anomalies or deeper varices could be missed using ultrasound alone, leading to an underestimation of PCS prevalence in both groups **(10)**.

Strengths of the study

The randomized clinical trial design, which is the gold standard in clinical research, and the fact that no patients were lost to follow-up throughout the study period are the study's strong qualities. The study's findings are consistent with existing research, enhancing its credibility and supporting the conclusions drawn about the safety of both procedures.

Study limitations

It is important to consider the study's limitations when interpreting the results. First of all, because it is a single center study rather than a multicentric one and has a smaller sample size than earlier research, there is a significant possibility of publication bias. Secondly, we did not evaluate the FSH, LH and AMH as a predictor of ovarian function affection. Thirdly, the follow-up period might be relatively short postoperatively, limiting the ability to evaluate long-term outcomes such as the risk of ovarian cancer or the recurrence of pelvic pain.

5. Conclusion

This randomized clinical trial demonstrated that bilateral salpingectomy performed during Caesarean section is as safe and effective as bilateral tubal ligation regarding intraoperative and postoperative outcomes, including pelvic congestion symptoms and menstrual disturbances. Importantly, salpingectomy did not increase the risk of pelvic venous congestion or operative complications.

Given its comparable safety profile and the added potential benefit of reducing the future risk of ovarian cancer, bilateral salpingectomy should be considered a preferred option for permanent sterilization during Caesarean delivery when clinically feasible. Future large-scale, multicenter studies with extended follow-up are encouraged to validate and expand upon these findings.

6. Declarations

Acknowledgments

The authors sincerely thank the medical and nursing staff of Ain Shams University Hospitals for their invaluable assistance during patient care and data collection. We are grateful to the participants who generously gave their time and cooperation to make this study possible.

Ethical Considerations

The study was conducted in accordance with the Declaration of Helsinki and received ethical approval from the Institutional Review Board of Ain Shams University (Approval No. MS 296/2024). All participants provided written informed consent after being fully informed of the study's purpose, procedures, risks, and benefits. Participation was voluntary, and patients retained the right to withdraw at any time without affecting their medical care. The procedures involved- tubal ligation and salpingectomy- are established clinical practices and posed minimal risk.

Authors' Contributions

Mayar Ziad Ibrahim Kamal and Yasser Mostafa Mahmoud El-Refaey: Conceptualization, study design, data collection, manuscript drafting. Osama Ismail Kamel and Tarek Tamara: Surgical procedures, patient enrollment, critical revision of the manuscript. Osama Ismail Kamel, Mayar Ziad Ibrahim Kamal and Yasser Mostafa Mahmoud El-Refaey: Radiological evaluation, sonographic data acquisition, manuscript editing. Mayar Ziad Ibrahim Kamal and Yasser Mostafa Mahmoud El-Refaey: Statistical analysis, data interpretation, literature review. All authors contributed to data analysis and interpretation, critically revised the manuscript, approved the final version, and agreed to be accountable for all aspects of the work.

Conflict of Interest

The authors declared no conflict of interest.

Fund or Financial Support

Every author has stated that no organization provided financial support for the work they submitted.

Financial relationships: All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work.

Other relationships: Each author has stated that no other relationships or activities appear to have had any impact on the work that was turned in.

Confidentiality of Data

The authors declare that they have followed the protocols of their work center on the publication of data from patients.

Protection of Human and Animal Subjects

The authors have all stated that they have no financial ties to any organizations that would be interested in the work they have contributed, either currently or over the last three years.

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How to Cite This Article:

Kamel, O.I., Tamara, T., Kamal, M.Z.I., El-Refaey, Y.M.M. Pelvic Congestion Syndrome Following Salpingectomy Compared to Tubal Ligation at Time of Caesarean Section- a Randomized Clinical Trial. J Obstet Gynecol Cancer Res. 2025;10(10):770-8.

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