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Original Research Article

A prospective cohort study to determine effectiveness of cystoinflation to prevent bladder injury in women with previous caesarean section

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ABSTRACT

Background: The rising rate of caesarean sections (C-sections) has led to an increase in associated surgical complications, particularly urinary bladder injuries in patients with dense pelvic adhesions. Repeat C-sections elevate the risk of such injuries due to adhesions between the bladder and uterus. Cystoinflation, or retrograde bladder filling with saline, has been proposed to improve visualization and reduce injury risk, but its application in C-sections is underexplored. The present study aimed to evaluate the effectiveness of intraoperative cystoinflation in reducing urinary bladder injury during C-sections in women with previous caesarean deliveries and dense pelvic adhesions.

Methods: This prospective cohort study was conducted at MGM medical college and MTH hospital, Indore, over 12 months (October 2022-October 2023). A total of 240 women undergoing C-sections with dense adhesions were divided into two groups: group 1 (n=120) with cystoinflation, and group 2 (n=120) without. Primary outcome was bladder injury; secondary outcomes included blood loss; duration of surgery, complications, and hospital stay.

Results: Bladder injuries occurred in 3.3% of patients in group 2 and none in group 1 ($p < 0.001$). Urinary tract infections and micturition issues were also significantly lower in the cystoinflation group. Mean hospital stay was shorter in group 1 (4.10 ± 0.42 days) than in group 2 (4.88 ± 1.86 days, $p < 0.001$). Blood loss and operative time showed non-significant trends favouring cystoinflation.

Conclusions: Cystoinflation is a safe, simple, and effective technique that significantly reduces bladder injury and postoperative complications during C-sections in high-risk women. Its routine use in such cases is recommended.

Keywords: Caesarean section, Bladder injury, Cystoinflation, Pelvic adhesions, Urinary tract complications

INTRODUCTION

Caesarean section (C-section) delivery has become one of the most commonly performed surgical procedures worldwide, accounting for nearly 21% of all births globally, with projections estimating a rise to 29% by 2030.^{1,2} In India, this trend is similarly reflected, with caesarean delivery rates increasing from 8.5% in 2005-06 to 21.5% in 2019-21, as reported by the national family health survey.^{1,3} While C-sections are lifesaving in cases of

obstetric emergencies, the rising rates of primary and repeat C-sections have contributed to a growing number of procedure-related complications.

One such complication is urinary bladder injury, an uncommon but significant event, particularly in women undergoing repeat C-sections.^{4,5} With each successive surgery, pelvic adhesions-especially between the bladder and the anterior uterine wall-become more pronounced, increasing the technical difficulty of the procedure and elevating the risk of bladder trauma.⁶

The incidence of bladder injury during C-section has been reported to range from 0.08% to 0.94%, and is notably higher in repeat caesareans, where it can reach up to 0.6% compared to 0.19% in primary cesareans.^{7,8}

Bladder injuries most commonly occur during entry into the peritoneal cavity or while creating the bladder flap. Adhesions not only obscure surgical planes but also complicate dissection, especially in cases of prior caesarean delivery. Adhesion rates between the bladder and uterus post-caesarean have been reported to range from 24% to 73%, depending on the number of prior surgeries.⁹⁻¹² The consequences of bladder injury can be severe, leading to urinary tract infections, prolonged catheterization, vesicouterine or vesicovaginal fistulas, and extended hospitalization, all of which significantly impact the physical and psychological well-being of patients.¹³⁻¹⁶

To reduce the risk of such injuries, various strategies have been explored. These include preoperative catheterization, methylene blue dye testing, and experimental techniques such as the omission of bladder flap formation. However, these methods have shown limited success in patients with dense adhesions. One promising technique emerging in gynecological and urological surgery is cysto-inflation, which involves retrograde filling of the bladder with saline to help delineate its margins. By enhancing the visibility of the bladder, particularly in cases with dense adhesions, cysto-inflation may reduce the risk of inadvertent injury during dissection.^{11,17}

Studies by Saaqib et al and Naseeb et al have demonstrated that cysto-inflation significantly reduces the incidence of bladder injury and intraoperative blood loss.^{11,17} Similarly, O'Hanlan et al reported complete prevention of bladder injuries during laparoscopic gynecological surgeries using CO₂ cysto-insufflation.¹⁸ Despite these encouraging findings, literature on the use of cysto-inflation during C-sections remains scarce, especially in the Indian context. Given the high burden of caesarean deliveries in India and the associated risk of bladder injury in repeat surgeries, there is an urgent need for local evidence to assess preventive interventions.

Therefore, the present study is designed as a prospective cohort analysis to determine the effectiveness of cysto-inflation in preventing urinary bladder injury during C-section in women with a history of previous caesarean deliveries. The findings aim to support safe surgical practices and contribute to improved maternal outcomes in resource-limited settings.

METHODS

After obtaining approval from the institutional ethical committee of MGM medical college and MTH hospital, Indore, this prospective cohort study was conducted in the department of obstetrics and gynaecology over a period of 12 months, from 1st October 2022 to October 2023. A total

of 240 pregnant women scheduled for C-section were enrolled in the study. Eligible participants were screened in the labor room or operation theatre, and written informed consent was obtained prior to inclusion. Women found to have dense pelvic adhesions during C-section were included as per pre and peri-op inclusion criteria.

The sample size was calculated using OpenEpi (Version 3) open-source calculator. Assuming a margin of error of 3%, a proportion of error of 2.8%, and a 95% confidence interval, the minimum required sample size was 117 per group. To account for possible dropout or exclusions, 120 patients per group were enrolled.

Participants were allocated into two groups based on whether cysto-inflation was performed intraoperatively: Group 1 (n=120): Cysto-inflation performed and group 2 (n=120): Cysto-inflation not performed.

Inclusion criteria

Preoperative inclusion criteria

Healthy pregnant women of any age, with gestational age between 38 and 40 weeks (confirmed by dating scan), history of previous C-section with suspected dense adhesions and written informed consent provided were included.

Perioperative inclusion criteria

Patients with dense pelvic adhesions with a Tulandi adhesion score >4, adhesions obscuring the bladder and lower uterine segment, making identification of the empty bladder difficult, inability to exteriorize the uterus without adhesiolysis and adhesions encountered either upon entry into the peritoneal cavity or during bladder flap creation were included.

Exclusion criteria

Patients with refusal to participate or consent not given, obstructed labor, ruptured uterus and no adhesions found during C-section were excluded.

Procedure

All patients underwent preoperative evaluation, including general and obstetric history, physical examination, and routine investigations. Spinal anesthesia was administered under aseptic precautions, and patients were catheterized prior to surgery. After entry into the peritoneal cavity, if dense adhesions were encountered, cysto-inflation was performed in the intervention group. A total of 300 mL of normal saline was retrograde-filled into the bladder using a standard infusion set attached to the catheter's inlet port. The urine outlet port was clamped with an artery forceps to retain the saline.

Adhesiolysis was then performed using sharp dissection, maintaining a safe distance from the distended bladder margins. In the control group, C-section was performed conventionally without cystoinflation. Any complications

related to previous uterine scar, including adhesions, uterine rupture, as well as bladder injury, were managed intra-operatively as per the institutional protocol (Figure 1).

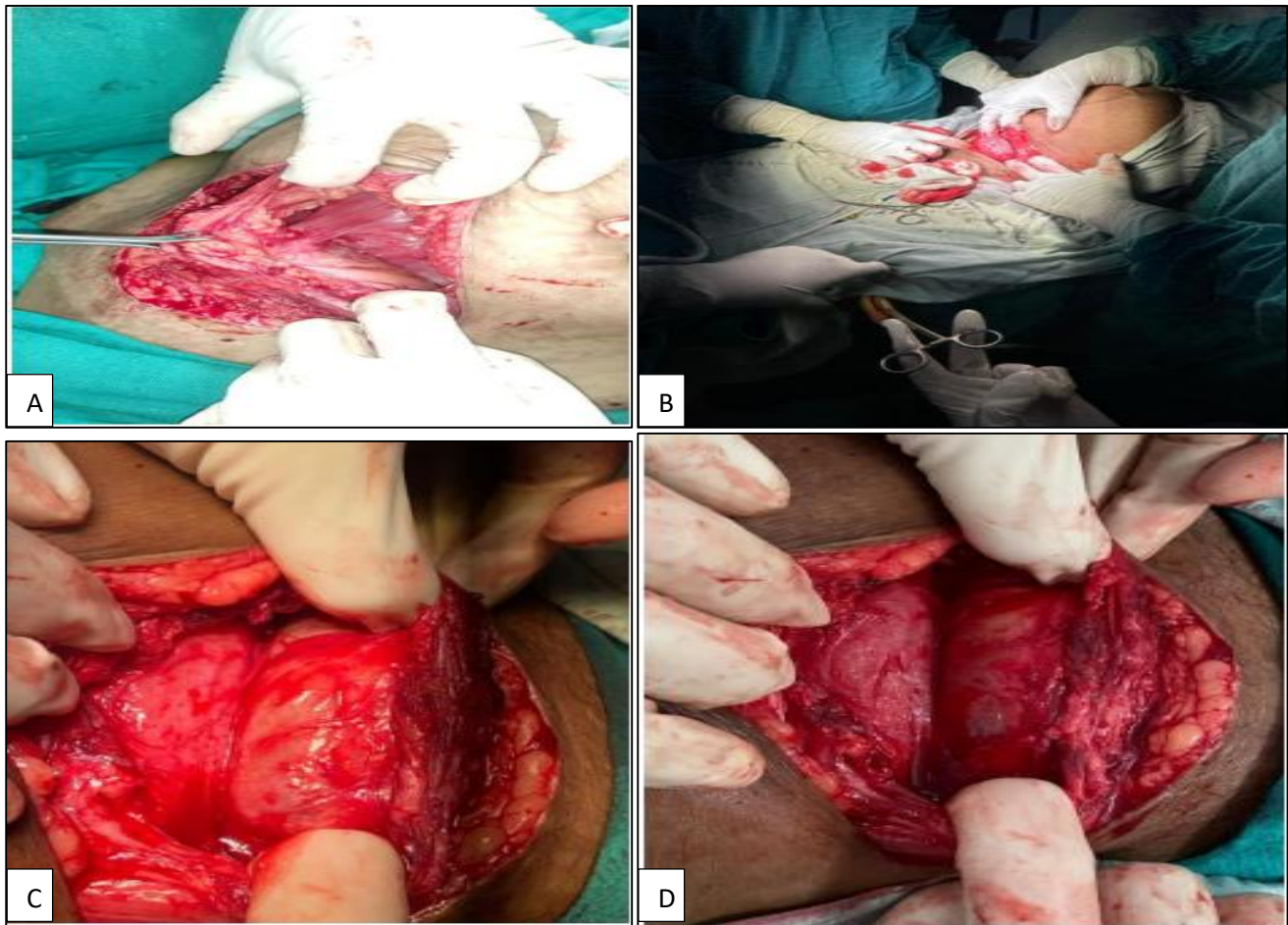


Figure 1 (A-D): Cystoinflation procedure.

Outcome measures

The primary outcome was the incidence of intraoperative bladder injury. Secondary outcomes included blood loss, operative time, intraoperative complications, and maternal and neonatal outcomes. The correlation between previous cesarean scar status and intraoperative findings was also assessed.

Statistical analysis

Data were entered into Microsoft excel and analyzed using SPSS version 25.0. Descriptive statistics were used to summarize demographic and clinical characteristics. Continuous variables were expressed as mean±standard deviation (SD) and compared using Student's t-test or ANOVA where appropriate. Categorical variables were expressed as frequency and percentage and compared using Chi-square or Fisher's exact test. A $p < 0.05$ was considered statistically significant.

RESULTS

The present study included 240 pregnant women with dense pelvic adhesions, equally distributed between two groups: group 1 (with cystoinflation) and group 2 (without cystoinflation). The demographic and obstetric variables between the two groups were found to be comparable, indicating appropriate baseline matching. The mean age of participants in both groups was similar (27.2 ± 3.33 years in group 1 and 27.59 ± 3.44 years in group 2), with no statistically significant difference ($p = 0.381$). The majority of the participants (81.3%) belonged to the 20-30 year age group, which reflects the common reproductive age group in which caesarean deliveries are performed. Regarding gravida status, most subjects were either gravida 2 (43.8%) or gravida 3 (41.7%), and no significant difference was found between groups ($p = 0.582$), suggesting similar obstetric histories. In terms of parity, the majority had parity 1 (64.2%), followed by parity 2 (32.5%), with only a few women having parity 3 (3.3%). The distribution of parity was also statistically similar between the two groups

($p=0.962$). The number of living children was predominantly one in both groups (65.8%), and the differences between groups were again statistically non-significant ($p=0.961$). A majority of the subjects (73.3%) had no history of abortion, with small proportions reporting one, two, or three prior abortions. There was no statistically significant difference in abortion history between the groups ($p=0.909$) (Table 1).

The mean gestational age at delivery was slightly higher in group 2 (38.91 ± 0.81 weeks) compared to group 1 (37.97 ± 1.01 weeks), though this difference was not statistically significant ($p=0.068$). The distribution of previous C-sections (1, 2, or 3) was identical in both groups, confirming comparable surgical history ($p=1.000$). Adhesion locations were similar between groups, with uterus and bladder being the most common site (30%) (Table 2 and Figure 2).

The mean Tulandi adhesion score was marginally higher in group 2, indicating denser adhesions, but the difference was not statistically significant ($p=0.157$). Birth weight was also comparable between groups, with most neonates weighing ≥ 2.5 kg (88.3%; $p=0.228$). The mean duration of surgery and intraoperative blood loss were slightly lower in the cystoinflation group, but these differences were not statistically significant ($p=0.111$ and $p=0.080$, respectively). However, postoperative complications showed a clear difference (Table 2).

Group 2 (no cystoinflation) had significantly higher rates of bladder injury (3.3%), urinary tract infection (12.5%), and micturition problems (9.2%), whereas these were much lower or absent in group 1 ($p<0.001$). Furthermore, the mean hospital stay was significantly shorter in the cystoinflation group (4.10 ± 0.42 days) compared to group 2 (4.88 ± 1.86 days), with a $p<0.001$, indicating better postoperative recovery (Table 2 and Figure 3).

Table 1: Demographic and obstetric characteristics of study subjects.

Variables		Group 1, (n=120) (%)	Group 2, (n=120) (%)	Total, (n=240) (%)	P value
Mean age (in years)		27.2 $\pm$ 3.33	27.59 $\pm$ 3.44		0.381
Age group (in years)	20-30	99 (82.5)	96 (80.0)	195 (81.3)	0.620
	>30	21 (17.5)	24 (20.0)	45 (18.8)	
Gravida	G2	52 (43.3)	53 (44.2)	105 (43.8)	0.582
	G3	53 (44.2)	47 (39.2)	100 (41.7)	
	G4	15 (12.5)	20 (16.7)	35 (14.6)	
Parity	P1	78 (65.0)	76 (63.3)	154 (64.2)	0.962
	P2	38 (31.7)	40 (33.3)	78 (32.5)	
	P3	4 (3.3)	4 (3.3)	8 (3.3)	
Living children	L1	78 (65.0)	80 (66.7)	158 (65.8)	0.961
	L2	38 (31.7)	36 (30.0)	74 (30.8)	
	L3	4 (3.3)	4 (3.3)	8 (3.3)	
Abortion history	A0 (None)	87 (72.5)	89 (74.2)	176 (73.3)	0.909
	A1	27 (22.5)	25 (20.8)	52 (21.7)	
	A2	5 (4.2)	4 (3.3)	9 (3.8)	
	A3	1 (0.8)	2 (1.7)	3 (1.3)	

Table 2: Clinical, surgical, and postoperative parameters of study subjects.

Parameters	Group 1, (n=120) (%)	Group 2, (n=120) (%)	Total, (n=240) (%R)	P value	Statistical test
Mean gestational age (weeks)	37.97 $\pm$ 1.01	38.91 $\pm$ 0.81	–	0.068	Independent t test
Previous C sections					
One	77 (64.2)	77 (64.2)	154 (64.2)	1.000	Chi-square
Two	39 (32.5)	39 (32.5)	78 (32.5)		
Three	4 (3.3)	4 (3.3)	8 (3.3)		
Most common adhesion site	Uterus and bladder (31.7%)	Uterus and bladder (28.3%)	–	0.765	Chi-square
Mean Tulandi score	7.53 $\pm$ 2.82	8.07 $\pm$ 3.09	–	0.157	Independent t-test
Birth weight ≥ 2.5 kg	103 (85.8)	109 (90.8)	212 (88.3)	0.228	Chi-square
Mean duration of C section (min)	49.95 $\pm$ 10.72	47.58 $\pm$ 12.23	–	0.111	Independent t-test
Complications					
Bladder injury	0 (0.0)	4 (3.3)	4 (1.7)	<0.001*	Chi-square

Continued.

Parameters	Group 1, (n=120) (%)	Group 2, (n=120) (%)	Total, (n=240) (%R)	P value	Statistical test
Urinary tract infection	3 (2.5)	15 (12.5)	18 (7.5)		
Micturition problem	2 (1.7)	11 (9.2)	13 (5.4)		
No complications	115 (95.8)	90 (75.0)	205 (85.4)		
Mean duration of hospital stay (days)	4.10±0.42	4.88±1.86	–	<0.001*	Independent t-test
Mean blood loss (mL)	588.83±50.91	600.54±52.39	–	0.080	Independent t-test

*Statistically significant.

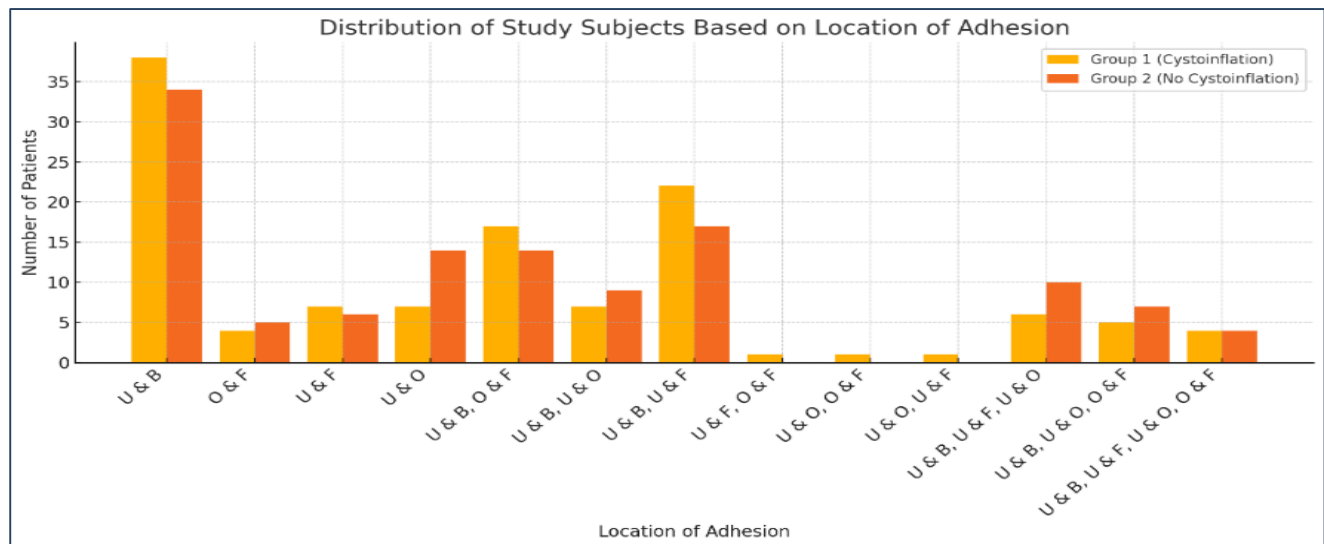


Figure 2. Distribution of study subjects based on location of adhesion.

*U-Uterus, B-Bladder, O-Omentum, F-Fascia.

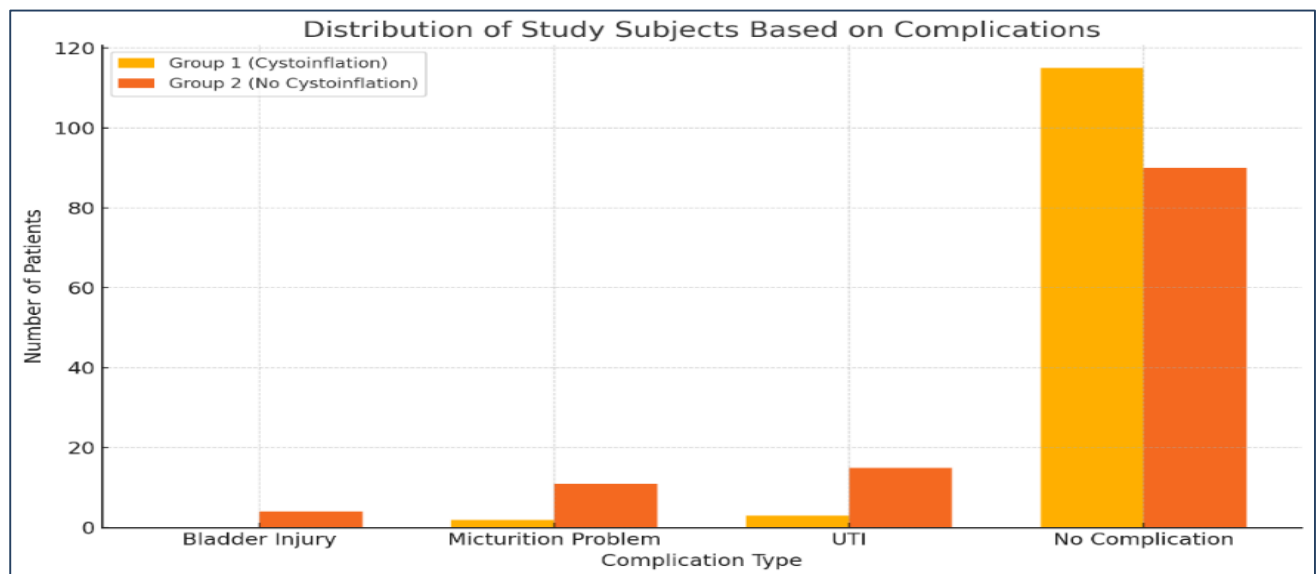


Figure 3: Distribution of study subjects based on complications.

DISCUSSION

In both developed and developing nations, C-section rates and hospital-based deliveries have shown a marked increase over the past few decades. This trend has been

accompanied by a rise in intraoperative complications, particularly urinary tract injuries. Among these, bladder injury is of significant concern during repeat cesarean deliveries, mainly due to the presence of dense pelvic adhesions that obscure anatomical landmarks and complicate dissection. It is estimated that up to 1.5% of

women with a history of prior C-section may sustain bladder injury. Supporting this, a study conducted by El-Mogy et al in Egypt reported a higher incidence of urological injuries during obstetric surgeries compared to gynecological procedures (63.6% vs. 36.1%).¹⁹

The risk of bladder injury increases with adhesions that distort the normal anatomical relationship between the bladder and uterus. In this context, retrograde bladder filling-known as cystoinflation-has been proposed as a technique to delineate bladder margins by distending the bladder and elevating it from the operative field, potentially reducing inadvertent injury. However, limited clinical research has assessed the real-world effectiveness of cystoinflation in C-sections. This prospective cohort study was therefore undertaken to determine whether cystoinflation reduces the incidence of bladder injuries and intraoperative blood loss, without contributing to additional urological complications.

In the present study, the majority of patients undergoing C-section were in the reproductive age group, with 81.3% aged between 20 and 30 years. The mean age was 27.2 ± 3.33 years in the cystoinflation group and 27.59 ± 3.44 years in the non-cystoinflation group, with no significant difference ($p=0.381$). These results are in line with earlier studies by Naseeb et al and Hussain et al who reported comparable age distributions.^{11,20} Obstetric variables, including gravida, parity, number of living children, abortion history, and gestational age, were also statistically comparable between the two groups. Most women were multigravida, and 73.3% had undergone one previous cesarean delivery. These findings further align with data from Naseeb et al reinforcing the demographic uniformity of both cohorts.¹¹

Perioperatively, the location of adhesions-predominantly between the uterus and bladder-did not differ significantly between groups. The mean Tulandi adhesion score, used to quantify adhesion severity, was slightly higher in the non-cystoinflation group (8.07 ± 3.09) compared to the cystoinflation group (7.53 ± 2.82), though the difference was not statistically significant ($p=0.157$). The mean duration of surgery was marginally longer in the cystoinflation group (49.95 ± 10.72 minutes vs. 47.58 ± 12.23 minutes), yet this too was not statistically significant ($p>0.05$). A similar trend was reported by Özcan et al indicating that cystoinflation, despite adding a procedural step, does not significantly prolong surgical time.⁷

Neonatal outcomes were reassuring, with the majority of infants in both groups having a birth weight ≥ 2.5 kg. There was no statistically significant difference in fetal outcomes, confirming that cystoinflation does not adversely impact neonatal well-being.

One of the most striking findings of this study was the reduction in intraoperative and postoperative complications among women in the cystoinflation group.

Bladder injury occurred in 3.3% of cases in the non-cystoinflation group, but no such injuries were reported in the cystoinflation group ($p<0.05$). Additionally, urinary tract infections and micturition problems were significantly more frequent in the non-cystoinflation group (12.5% vs. 2.5% and 9.2% vs. 1.7%, respectively). These findings are consistent with those reported by Naseeb et al. (2023) and Hussain et al both of whom documented a higher incidence of urological complications when cystoinflation was not utilized.^{11,20} Abd El-Gaber et al similarly reported that bladder injuries were significantly more common in women with deflated bladders (13.1%) than in those who underwent cystoinflation (5.2%) ($p=0.001$).⁸ Saaqib et al further emphasized that cystoinflation enhances the visualization of bladder margins, particularly in patients with dense pelvic adhesions.¹⁷

Another noteworthy observation was the significantly shorter hospital stay in the cystoinflation group (4.10 ± 0.42 days) compared to the non-cystoinflation group (4.88 ± 1.86 days, $p<0.001$). This suggests a faster recovery and fewer postoperative issues, mirroring findings by Özcan et al and Naseeb et al who also reported reduced hospitalization times and associated healthcare costs in the cystoinflation groups.^{7,11} Although the difference in intraoperative blood loss between the two groups was not statistically significant (588.83 ± 50.91 mL vs. 632.00 ± 66.53 mL, $p=0.080$), the trend suggests a potential benefit of cystoinflation in reducing vascular injury. Supporting this, Özcan et al and Matsubara et al found that bladder inflation may reduce the need for blood transfusions during surgery.^{7,21}

This study is among the few Indian investigations exploring the role of cystoinflation in C-sections complicated by dense adhesions. Conducted at a high-volume tertiary care center, it contributes valuable evidence to support the utility of this technique. Nevertheless, limitations exist, including its single-center design, moderate sample size, and potential variability in surgical expertise-necessitating caution in generalizing the findings. Further multicenter research with larger sample sizes and standardized techniques is recommended to confirm these results, assess long-term outcomes, and evaluate cost-effectiveness.

In summary, cystoinflation offers a viable and evidence-based preventive measure for minimizing bladder injury during C-sections in select high-risk populations and holds potential for inclusion in updated clinical guidelines and obstetric surgical practices.

CONCLUSION

This prospective cohort study demonstrates that cystoinflation is a safe and effective technique for minimizing bladder injury during C-sections in women with placenta previa and dense pelvic adhesions. By improving bladder margin delineation, it reduces the

likelihood of intraoperative urological injuries and associated postoperative complications. Patients who underwent cystoinflation experienced fewer complications, shorter hospital stays, and smooth recovery, without any negative impact on neonatal outcomes. These advantages position cystoinflation as a valuable addition to surgical practice in selected high-risk cases.

Given its simplicity, safety profile, and clinical benefits, cystoinflation warrants consideration for routine use in C-sections complicated by pelvic adhesions. Broader studies with standardized protocols are encouraged to further support its inclusion in evidence-based obstetric guidelines.

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Conflict of interest: None declared

Ethical approval: The study was approved by the Institutional Ethics Committee of MGM Medical College and MTH Hospital, Indore [Letter no: EC/MGM/FEB-23/46]

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