Original Article

DOI: 10.7860/IJARS/2026/84440.3118

Surgery Section

Comparison of Haemodynamic Effects and Uterotonic Efficacy of Intravenous Oxytocin Administered as Bolus versus Infusion in Elective Caesarean Delivery: A Prospective Observational Study

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ABSTRACT

Introduction: Postpartum Haemorrhage (PPH) remains a leading cause of maternal morbidity and mortality worldwide. Oxytocin is the first-line uterotonic agent used during caesarean delivery to prevent uterine atony. However, the optimal mode of administration-intravenous bolus versus infusion- remains controversial due to differences in haemodynamic responses and adverse effect profiles.

Aim: To compare the haemodynamic effects and uterotonic efficacy of intravenous oxytocin administered as a bolus versus infusion in women undergoing elective caesarean delivery under spinal anaesthesia.

Materials and Methods: This prospective observational study was conducted in the Department of Anaesthesia at S.S. Institute of Medical Sciences and Research Centre, Davangere, Karnataka, India, between September 2015 and August 2017. A total of 60 parturients aged 20-35 years with American Society of Anaesthesiologists (ASA) physical status I or II scheduled for elective caesarean delivery were included. Based on the discretion of the attending anaesthesiologist, patients received oxytocin either as an intravenous infusion (Group 1, n=30) or as an intravenous bolus (Group 2, n=30). Haemodynamic parameters were recorded at one, three, and five minutes following oxytocin administration. Uterine tone, requirement for additional uterotonic agents, and adverse effects were also documented.

Results: The mean age was comparable between Group 1 and Group 2 (26.8±3.2 vs 25.9±3.6 years; p-value=0.28), with the majority of patients classified as ASA I (80%). At one minute post-administration, Group 2 demonstrated a significantly greater reduction in mean arterial pressure (MAP) compared to Group 1 (77.0±6.4 vs 83.7±5.9 mmHg; p-value=0.020). Uterine tone at three and five minutes was comparable between the groups (p-value >0.05). Additional uterotonics were required in nine patients (30%) in Group 2 compared to six patients (20%) in Group 1. Adverse effects such as nausea and vomiting were more frequent in Group 2 (5 patients, 16.7%) than in Group 1 (2 patients, 6.7%).

Conclusion: Intravenous oxytocin infusion provides uterotonic efficacy comparable to bolus administration with better early haemodynamic stability and fewer immediate adverse effects.

Keywords: Maternal haemodynamics, Pregnancy outcome, Postpartum haemorrhage, Spinal anaesthesia, Uterine atony

INTRODUCTION

The PPH continues to be a major contributor to maternal morbidity and mortality worldwide and remains a significant challenge in obstetric practice [1,2]. Uterine atony is the leading cause of PPH following caesarean delivery, highlighting the importance of effective prophylactic uterotonic therapy during the intraoperative period [1]. With the global rise in caesarean section rates, optimising strategies to prevent uterine atony has become increasingly important. Oxytocin is the first-line uterotonic agent recommended for the prevention and management of uterine atony during caesarean delivery [1-3]. It exerts its effect by stimulating uterine smooth muscle contraction through oxytocin receptors, which are upregulated toward term pregnancy, making the uterus highly responsive to the drug [1,2]. Oxytocin may be administered as a rapid intravenous bolus or as a slow intravenous infusion. Several studies have demonstrated that bolus administration is associated with transient but clinically relevant cardiovascular effects, including hypotension, tachycardia, reduced systemic vascular resistance, nausea, and flushing [4-7]. These haemodynamic changes are of particular concern in parturient undergoing spinal anaesthesia, where sympathetic blockade may further impair cardiovascular compensation [6-8].

In contrast, intravenous infusion of oxytocin has been proposed as a safer alternative, providing a gradual onset of uterine contraction with improved haemodynamic stability [3,9]. Comparative studies have reported fewer adverse cardiovascular effects with infusion-based administration while maintaining adequate uterotonic efficacy [4,10]. Data comparing haemodynamic responses and uterotonic effectiveness in routine elective caesarean delivery are particularly scarce in resource-limited settings. The study aimed to compare the haemodynamic effects and uterotonic efficacy of intravenous oxytocin administered as a bolus versus infusion in parturient undergoing elective caesarean delivery under spinal anaesthesia.

MATERIALS AND METHODS

This prospective observational study was conducted in the Department of Anaesthesia at S.S. Institute of Medical Sciences and Research Centre, Davangere, Karnataka, India, a tertiary care teaching hospital, between September 2015 and August 2017. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Approval was obtained from the Institutional Ethics Review Board (IERB No. 117-2015) prior to initiation of the study. No formal sample size calculation was performed. The study

included all eligible parturients undergoing caesarean delivery during the study period who satisfied the inclusion criteria.

Inclusion criteria: Women aged 20-35 years with ASA physical status I or II were included in the study.

Exclusion criteria: Patients with conditions likely to influence cardiovascular responses or uterine tone, including hypertension, preeclampsia, diabetes mellitus, cardiovascular disease, placenta previa, multiple gestation, active labour, ruptured membranes, or known hypersensitivity to oxytocin, were excluded from the study.

Study Procedure

Based on the treating anaesthesiologist's discretion, patients received either oxytocin as an intravenous infusion (Group 1, n=30) or as an intravenous bolus (Group 2, n=30). Group 1 received three International Units (IU) of oxytocin diluted in 100 mL of normal saline administered intravenously over three minutes, while Group 2 received three IU of oxytocin administered intravenously as a bolus over 15 seconds. The dose and methods of administration were consistent with previously published studies evaluating oxytocin use during caesarean delivery [3-5].

All patients were instructed to fast for at least six hours before surgery. On arrival in the operating room, an 18-gauge intravenous cannula was secured and standard monitoring including electrocardiography, non invasive blood pressure measurement, and pulse oximetry was instituted. Baseline heart rate and blood pressure were recorded. Patients were preloaded with Ringer's lactate solution at 10 mL/kg. Spinal anaesthesia was administered at the L3-L4 intervertebral space using a 23-gauge Quincke needle, and 2 mL of 0.5% hyperbaric bupivacaine was injected intrathecally. Adequate sensory blockade was confirmed before the start of surgery.

Haemodynamic parameters including heart rate, and mean arterial pressure were recorded at baseline and at 1, 3, and 5 minutes following oxytocin administration. Uterine tone was assessed by the attending obstetrician at three and five minutes using a five-point subjective scale, as described in earlier studies [4,11]. The requirement for additional uterotonics and the occurrence of adverse effects such as nausea, vomiting, flushing, or hypotension were documented.

STATISTICAL ANALYSIS

Data were entered into Microsoft Excel and analysed using the Statistical Package for the Social Sciences (SPSS) version 23.0. Continuous variables were expressed as mean±standard deviation, and categorical variables as frequencies and percentages. Comparisons were performed using the independent t-test for continuous variables and the Chi-square test for categorical variables. A p-value of <0.05 was considered statistically significant.

RESULTS

The mean age was comparable between the two groups, with no statistically significant difference [Table/Fig-1].

Variable	Group 1	Group 2	p-value
Age (years, mean±SD)	26.8±3.2	25.9±3.6	0.28#
Age 19-25 years	10 (33.3%)	19 (63.3%)	0.03*
Age 26-30 years	18 (60.0%)	9 (30.0%)	
Age >30 years	2 (6.7%)	2 (6.7%)	
ASA I	23 (76.7%)	25 (83.3%)	0.52*
ASA II	7 (23.3%)	5 (16.7%)	

[Table/Fig-1]: Sociodemographic and baseline characteristics.
#Independent t-test; *: Chi-square test

Early haemodynamic changes between the two groups at one minute following oxytocin administration showed that Group 2 demonstrated a significantly greater reduction in systolic blood pressure, diastolic blood pressure, and mean arterial pressure compared to Group 1 [Table/Fig-2].

Parameters	Group 1	Group 2	p-value
Heart rate (bpm)	88.4±9.2	92.6±10.1	0.068
Systolic Blood Pressure (SBP) (mmHg)	112.6±8.4	106.3±9.1	0.037
Diastolic Blood Pressure (DBP) (mmHg)	71.8±6.9	66.1±7.3	0.018
Mean Arterial Pressure (MAP) (mmHg)	83.7±5.9	77.0±6.4	0.020

[Table/Fig-2]: Haemodynamic parameters at one minute.
Independent t-test

Comparison of heart rate and mean arterial pressure between the two groups at 3 and 5 minutes following oxytocin administration showed no statistically significant differences [Table/Fig-3].

Parameters	Time	Group 1	Group 2	p-value
Heart rate	3 mins	86.9±8.7	88.1±9.0	0.42
Heart rate	5 mins	85.2±8.1	86.0±8.5	0.61
MAP	3 mins	82.4±5.6	81.2±5.9	0.34
MAP	5 mins	81.9±5.4	81.7±5.2	0.88

[Table/Fig-3]: Haemodynamics at 3 and 5 minutes.

Uterine tone scores between Group 1 and Group 2 at three and five minutes after oxytocin administration were similar in both groups with no statistically significant differences observed [Table/Fig-4].

Time	Group 1	Group 2	p-value
3 minutes	3.7±0.5	3.6±0.6	0.48
5 minutes	4.2±0.4	4.1±0.5	0.44

[Table/Fig-4]: Uterine tone scores.
Independent t-test

A higher proportion of patients in Group 2 required additional uterotonics and experienced adverse effects such as nausea, vomiting, flushing, and hypotension compared to Group 1 [Table/Fig-5].

Outcome	Group 1	Group 2	p-value
Additional uterotonics	6 (20.0%)	9 (30.0%)	0.37
Nausea	2 (6.7%)	5 (16.7%)	0.23
Vomiting	1 (3.3%)	4 (13.3%)	0.16
Flushing	2 (6.7%)	6 (20.0%)	0.13
Hypotension	1 (3.3%)	5 (16.7%)	0.08

[Table/Fig-5]: Additional uterotonics and adverse effects.
Chi-square test

DISCUSSION

The principal finding of the present study was that intravenous bolus administration of oxytocin resulted in significantly greater early haemodynamic instability, particularly within the first minute following administration. These findings are consistent with previous investigations demonstrating that rapid bolus injection of oxytocin may produce transient hypotension and tachycardia secondary to peripheral vasodilation and reduction in systemic vascular resistance [4,6,7]. Such haemodynamic effects are further accentuated in parturients receiving spinal anaesthesia because of sympathetic blockade and limited compensatory cardiovascular mechanisms [6-8].

Similar observations were reported by Badheka JP et al., who demonstrated a significant rise in heart rate and a greater fall in mean arterial pressure in the bolus group compared with infusion during elective caesarean delivery [12]. Their study also documented more frequent ECG changes and cardiovascular instability in patients receiving bolus oxytocin.

However, by three and five minutes after administration, haemodynamic parameters in present study were comparable between groups, indicating that the disturbances were transient. These findings align with earlier studies suggesting that infusion-based administration allows for a gradual pharmacodynamic effect

and reduces abrupt cardiovascular fluctuations [3,9,11]. Thomas JS et al., and Langesæter E et al., similarly reported fewer and less pronounced reductions in mean arterial pressure with infusion regimens compared to bolus dosing [4,6].

More recently, Shastri HA et al., compared low-dose bolus (2 IU) followed by infusion versus infusion alone and found that although the bolus-plus-infusion group demonstrated a greater rise in heart rate at five and 15 minutes, differences in mean arterial pressure were not statistically significant between groups [13]. Their findings reinforce the concept that even low-dose bolus administration can produce measurable early cardiovascular changes, though these may not always reach statistical significance.

Importantly, uterotonic efficacy in the present study, assessed using uterine tone scores and requirement for additional uterotonics, was comparable between the two groups. Previous randomised trials and systematic reviews have demonstrated that lower or gradually administered doses of oxytocin are sufficient to achieve adequate uterine contraction due to increased oxytocin receptor sensitivity at term pregnancy [5,9]. Sheehan SR et al., also reported no significant difference in blood loss when oxytocin was administered as bolus plus infusion versus bolus alone [3].

Although a higher proportion of patients in the bolus group required additional uterotonics and experienced adverse effects such as nausea, vomiting, flushing, and hypotension, these differences did not reach statistical significance. This trend was consistent with earlier reports linking bolus oxytocin administration to increased maternal side effects [4,7,10]. Badheka JP et al., similarly observed more ECG changes and cardiovascular disturbances in the bolus group [12].

Limitation(s)

The study had certain limitations that should be acknowledged. As a prospective observational study, allocation to bolus or infusion groups was based on the anaesthesiologist's discretion rather than randomisation, which may introduce selection bias. The sample size was relatively small and drawn from a single tertiary care centre, potentially limiting the generalisability of the findings. Haemodynamic parameters were assessed only during the early post-administration period, and longer-term cardiovascular effects were not evaluated. Uterine tone assessment was subjective, relying on obstetrician evaluation. Larger, randomised controlled trials with standardised dosing protocols are required to confirm these findings.

CONCLUSION(S)

Intravenous bolus administration of oxytocin is associated with greater early haemodynamic disturbances, particularly transient reductions in blood pressure, compared with infusion-based administration. Overall, oxytocin infusion appears to be a safer alternative to bolus administration during elective caesarean delivery under spinal anaesthesia, offering improved early haemodynamic stability without loss of therapeutic effectiveness.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Sep 23, 2025
- Manual Googling: Mar 05, 2026
- iThenticate Software: Mar 11, 2026 (1%)

ETYMOLOGY: Author Origin

EMENDATIONS: 7

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval Obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **Sep 18, 2025**
Date of Peer Review: **Jan 05, 2026**
Date of Acceptance: **Mar 12, 2026**
Date of Publishing: **Jul 01, 2026**