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Oxytocin-Induced Hemodynamic Changes in Women Undergoing Cesarean Section with Spinal Anesthesia

Mian Habib Ullah[1], Mubashar Iqbal[2], Majid Javed[3], Ubaid Ullah[4], Umair Akbar[5], Haider Umar[6]

[1,3,4,6] Anesthesia Department, College of Medical Technology, Bacha khan Medical College Mardan, KPK
[2] Forensic Chmesitry, GC University, Lahore, Punjab
[5] Biotechnology Department, Bacha Khan University, Charsadda, Corresponding Author, Email: umairakbar377@gmail.com

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Abstract

Oxytocin is routinely used during cesarean sections (CS) to promote uterine contraction; however, its administration is associated with hemodynamic changes that may affect maternal outcomes. This study aimed to evaluate the effects of oxytocin on blood pressure and heart rate and identify predictors of hypotension in women undergoing CS. A prospective observational study was conducted on 60 women undergoing elective or emergency CS under spinal anesthesia. Data collected included demographic variables, obstetric history, preoperative vital signs, oxytocin administration details (dose, route, timing), and hemodynamic parameters. Changes in systolic blood pressure (SBP), diastolic blood pressure (DBP), and heart rate (HR) were monitored, along with the occurrence of hypotension, bradycardia, and associated side effects. Chi-square test, one-way ANOVA, and logistic regression analyses were performed to determine significant associations and predictors of hypotension. The majority of participants were aged 26–30 years (33.3%) and had normal weight (41.7%). Oxytocin was administered most commonly via intravenous bolus (41.7%), with 50% receiving it within 5 minutes post-delivery. Hemodynamic changes were noted, with 63.3% showing a decrease in SBP and 70% a decrease in DBP. Hypotension was observed in 41.7% of cases, with most episodes lasting 1–3 minutes (20%). Logistic regression identified obesity (OR=2.5; 95% CI: 1.1–5.8; p=0.03) and oxytocin doses >20 IU (OR=3.2; 95% CI: 1.4–7.5; p=0.005) as significant predictors of hypotension. Side effects occurred in 33.3% of participants, predominantly nausea (13.3%) and headache (11.7%). Oxytocin was considered safe in 83.3% of cases. Oxytocin administration during CS is associated with significant hemodynamic changes, including hypotension and tachycardia. Higher doses and obesity are key predictors of hypotension. Careful monitoring and dose titration are recommended to improve maternal safety.

Keywords: Oxytocin, Cesarean Section, Hypotension, Hemodynamic Changes,

Introduction

Oxytocin is commonly provided during cesarean sections to induce uterine contractions and avert postpartum bleeding. Nonetheless, numerous women subsequently endure discomfort, nausea, and thoracic pain. The symptoms are ascribed to the pronounced circulatory dose-dependent effects of oxytocin, which include ECG ST-depression, elevated heart rate (HR), stroke volume, and cardiac output (CO), along with reductions in systemic vascular resistance and arterial blood pressure (BP). Comprehensive analyses of the acute hemodynamic response reveal an elevation in heart rate (HR) and reductions in systemic vascular resistance and blood pressure (BP) within 30–40 seconds following a 5 U oxytocin statim bolus, accompanied by a

subsequent increase in cardiac output (CO), followed by a rebound decline in HR and a gradual restoration of BP. Oxytocin possesses a half-life of merely 1–6 minutes, and more recently, the prolonged-acting oxytocin analogue carbetocin has been approved for the prevention of postpartum hemorrhage (PPH). Carbetocin is an octapeptide that operates through the same molecular mechanisms as oxytocin, although possesses a half-life of approximately 40 minutes (10, 11). A solitary intravenous administration of carbetocin at 100 µg induces uterine contractions within 2 minutes, lasting approximately 60 minutes, whereas oxytocin elicits contractions after 16 minutes. Unlike oxytocin, carbetocin is thermally stable and does not require refrigeration for storage. Owing to its brief duration, oxytocin is frequently administered multiple times at CS, which may lead to receptor desensitization and a diminished uterotonic action, hence elevating the risk of hypotension and cardiovascular adverse effects. Prophylactic carbetocin has demonstrated superiority over oxytocin in several meta-analyses for its efficacy in preventing postpartum hemorrhage, the necessity for extra uterotonics, and blood transfusions, while maintaining a comparable safety profile. Oxytocin and carbetocin exhibit comparable physical adverse effects, including nausea, flushing, vomiting, headache, tremor, and chest discomfort; however, a comprehensive meta-analysis revealed that carbetocin is associated with a reduced incidence of vomiting (18). Concerning cardiovascular adverse effects, we identified merely three randomized controlled trials that compared hemodynamic variations as the primary endpoint (9, 19, 20). In two of these investigations, patients were observed for a maximum of 8 minutes post-drug administration, despite carbetocin's impact duration of 1 hour (9, 19). The third trial lacked a definitive baseline assessment for comparing medication effects (20). The prolonged duration of carbetocin's actions raises concerns over its potential for more persistent cardiovascular adverse effects compared to oxytocin. The pharmacological effects on the cardiovascular system can be thoroughly examined by studying the characteristics of pulse wave (PW) curve contours, which are influenced by the propagation of the forward percussion PW through the artery vascular tree and the subsequent reflection of the tidal PW from distal arteries. The features of pulse wave (PW) can be assessed by digital pulse wave analysis (DPA), a swift, noninvasive, and operator-independent photoplethysmographic technique. The DPA approach has been tested against invasive aortic measurements and demonstrates a strong correlation with radial pulse applanation tonometry (21, 22). The DPA approach may evaluate cardiac ejection time and differentiate between tonus variations in large and small arteries. In elective cesarean section, we observed that oxytocin induces global arterial vasodilation and has a direct negative chronotropic effect, resulting in enhanced left ventricular ejection power, alongside electrocardiographic ST alterations (23). A same pattern of peripheral vasodilation and elevated cardiac output was observed with DPA following oxytocin administration during elective first trimester uterine surgery, accompanied by mild ST segment alterations. Prior research comparing the hemodynamic effects of carbetocin and oxytocin has not demonstrated any significant differences.

Methodology

Study Design and Setting

This was a prospective observational study conducted in the obstetric unit of a tertiary care hospital over a period of six months, from January to June 2025. The study was designed to evaluate the hemodynamic effects of oxytocin administration during cesarean section (CS) and assess associated maternal outcomes.

Study Population

A total of 60 women undergoing elective or emergency cesarean section were enrolled in the study. Inclusion criteria included pregnant women aged 18–40 years, undergoing CS under spinal anesthesia, and receiving oxytocin for uterine contraction. Exclusion criteria were women with known cardiovascular diseases requiring active management, chronic

hypertension, preeclampsia/eclampsia, known hypersensitivity to oxytocin, or refusal to participate.

Data Collection

The study was approved by the Institutional Review Board (No. 1050/2025). All participants provided written informed consent prior to enrollment, and confidentiality of data was maintained throughout the study. Participants were recruited after obtaining written informed consent. Demographic and obstetric data were recorded, including age group (18–25, 26–30, 31–35, >35 years), weight group (underweight, normal, overweight, obese), parity (nulliparous, 1–2, 3–4, ≥5), and indication for cesarean section (fetal distress, cephalopelvic disproportion, previous CS, breech presentation, others). Preoperative parameters such as systolic and diastolic blood pressure (SBP, DBP), heart rate (HR), history of hypertension, cardiovascular or respiratory comorbidities, and medications administered in the previous 24 hours were documented. The dose of oxytocin administered (<10 IU, 10–20 IU, >20 IU) and route of administration (intravenous bolus, intramuscular injection, or infusion) were recorded, along with the time elapsed after delivery when oxytocin was given (≤5 min, 6–10 min, >10 min). Hemodynamic changes were monitored continuously for 10 minutes post-administration. Changes in SBP, DBP, and HR were categorized as increases or decreases, and the magnitude of change was quantified (<10 mmHg, 10–20 mmHg, >20 mmHg for BP; <10 bpm, 10–20 bpm, >20 bpm for HR). Hypotension was defined as a decrease in SBP >20% from baseline or SBP <90 mmHg, and bradycardia was defined as HR <50 bpm. The occurrence, duration, and management of hypotension or bradycardia were recorded. Side effects (nausea, vomiting, headache) and recovery delay were also noted. Finally, the relationship between oxytocin administration and BP/HR changes was analyzed to determine safety.

Statistical Analysis

Data were entered and analyzed using SPSS version 26. Descriptive statistics were presented as frequencies and percentages for categorical variables and means ± standard deviations for continuous variables. The Chi-square test was applied to assess associations between categorical variables, such as cesarean indication and hypotension. One-way ANOVA was used to compare mean SBP changes across different administration routes. Logistic regression analysis was performed to identify predictors of hypotension, reporting odds ratios (ORs) with 95% confidence intervals (CIs). A p-value <0.05 was considered statistically significant.

Results

Among the 60 participants, the majority were aged 26–30 years (33.3%), followed by 31–35 years (30%), 18–25 years (25%), and >35 years (11.7%). Most women had a normal weight (41.7%), while 33.3% were overweight, 16.7% obese, and 8.3% underweight. Half of the women (50%) had a parity of 1–2, 25% had 3–4 pregnancies, 16.7% were nulliparous, and 8.3% had ≥5 pregnancies. Regarding cesarean section indications, fetal distress was the most common (30%), followed by previous cesarean section (25%), cephalopelvic disproportion (20%), breech presentation (13.3%), and other causes (11.7%).

Table 1: Frequency and Percentage of Study Variables (n=60)

Variable	Category	Frequency (n)	Percentage (%)
Age Group	18–25	15	25
	26–30	20	33.3
	31–35	18	30
	>35	7	11.7
Weight Group	Underweight	5	8.3
	Normal	25	41.7
	Overweight	20	33.3
	Obese	10	16.7
Parity	0	10	16.7
	1–2	30	50
	3–4	15	25
	≥5	5	8.3
CS Indication	Fetal Distress	18	30
	Cephalopelvic Disproportion	12	20
	Previous CS	15	25
	Breech	8	13.3
	Others	7	11.7

In the study population, most participants had a preoperative systolic blood pressure (SBP) within the range of 110–130 mmHg (66.7%), while 13.3% had SBP <110 mmHg and 20% had SBP >130 mmHg. Similarly, the majority had a preoperative diastolic blood pressure (DBP) between 70–85 mmHg (63.3%), with 16.7% showing DBP <70 mmHg and 20% >85 mmHg. Preoperative heart rate (HR) was 70–100 bpm in 76.7% of cases, <70 bpm in 10%, and >100 bpm in 13.3%. A history of hypertension was reported in 25% of participants, and cardiovascular or respiratory disease was present in 13.3%. In the 24 hours before surgery, 33.3% of women received medications, whereas 66.7% did not. Regarding oxytocin dose, most received 10–20 IU (70%), while 8.3% received <10 IU and 21.7% received >20 IU.

Table 2: Frequency and Percentage of Preoperative and Intraoperative Variables (n=60)

Variable	Category	Frequency (n)	Percentage (%)
Preop SBP	<110 mmHg	8	13.3
	110–130 mmHg	40	66.7
	>130 mmHg	12	20
Preop DBP	<70 mmHg	10	16.7
	70–85 mmHg	38	63.3
	>85 mmHg	12	20
Preop HR	<70 bpm	6	10
	70–100 bpm	46	76.7
	>100 bpm	8	13.3
Hx of HTN	Yes	15	25
	No	45	75
CV/Resp Disease	Yes	8	13.3
	No	52	86.7
Medications 24h	Yes	20	33.3
	No	40	66.7
Oxytocin Dose	<10 IU	5	8.3
	10–20 IU	42	70
	>20 IU	13	21.7

In the study, the most common route of administration was IV bolus (41.7%), followed by intramuscular (IM) (33.3%) and infusion (25%). Half of the participants (50%) received the drug within 5 minutes after delivery, while 33.3% received it within 6–10 minutes and 16.7% after 10 minutes. A decrease in systolic blood pressure (SBP) was observed in 63.3% of cases, with 58.3% showing a 10–20 mmHg drop and 16.7% experiencing a >20 mmHg decrease. Similarly, diastolic blood pressure (DBP) decreased in 70% of participants, predominantly in the range of 5–10 mmHg (50%). Hypotension occurred in 41.7% of women, with most episodes lasting 1–3 minutes (20%). Heart rate (HR) increased in 53.3% of cases, with 46.7% showing a 10–20 bpm rise and 20% experiencing a rise of >20 bpm. Tachycardia was observed in 30% of participants, while bradycardia occurred in 16.7%, of whom 8.3% required atropine and 5% were treated with a fluid bolus.

Table 3: Frequency and Percentage of Hemodynamic Changes (n=60)

Variable	Category	Frequency (n)	Percentage (%)
Administration Route	IV Bolus	25	41.7
	IM	20	33.3
	Infusion	15	25
Time After Delivery	≤5 min	30	50
	6–10 min	20	33.3
	>10 min	10	16.7
SBP Change (↑/↓)	Increase (↑)	22	36.7
	Decrease (↓)	38	63.3
SBP Change (mmHg)	<10 mmHg	15	25
	10–20 mmHg	35	58.3
	>20 mmHg	10	16.7
DBP Change (↑/↓)	Increase (↑)	18	30
	Decrease (↓)	42	70
DBP Change (mmHg)	<5 mmHg	12	20
	5–10 mmHg	30	50
	>10 mmHg	18	30
Hypotension Observed	Yes	25	41.7
	No	35	58.3
Hypotension Duration	<1 min	8	13.3
	1–3 min	12	20
	>3 min	5	8.3
HR Change (↑/↓)	Increase (↑)	32	53.3
	Decrease (↓)	28	46.7
HR Change (bpm)	<10 bpm	20	33.3
	10–20 bpm	28	46.7
	>20 bpm	12	20
Tachycardia Observed	Yes	18	30
	No	42	70
Bradycardia Observed	Yes	10	16.7
	No	50	83.3
Bradycardia Treatment	Atropine	5	8.3
	Fluid Bolus	3	5
	None	52	86.7

Among the study participants, 33.3% experienced side effects, with nausea reported in 13.3%, headache in 11.7%, and vomiting in 8.3%, while 66.7% reported no side effects. Recovery delay was observed in 20% of cases, whereas 80% had no delay. A significant relationship between oxytocin administration and changes in blood pressure or heart rate was found in 30% of participants, while 70% showed no significant hemodynamic changes. Overall, oxytocin was considered safe in 83.3% of cases, with only 16.7% classified as unsafe.

Table 4: Frequency and Percentage of Postoperative Findings (n=60)

Variable	Category	Frequency (n)	Percentage (%)
Side Effects	Nausea	8	13.3
	Vomiting	5	8.3
	Headache	7	11.7
	None	40	66.7
Recovery Delay	Yes	12	20
	No	48	80
Oxytocin BP/HR Relationship	Significant	18	30
	Not Significant	42	70
Oxytocin Safe	Yes	50	83.3
	No	10	16.7

A significant association was observed between cesarean section (CS) indication and the occurrence of hypotension (p=0.045). Among women with fetal distress, 55.6% (10 out of 18) experienced hypotension. Hypotension was noted in 33.3% of those with cephalopelvic disproportion, 40% with a history of previous CS, 37.5% with breech presentation, and 28.6% in the 'others' category. Overall, 41.7% (25 out of 60) of participants developed hypotension, with its distribution varying significantly across different CS indications.

Table 5: Association between CS Indication and Hypotension (Chi-square Test)

CS Indication	Hypotension Observed	No Hypotension	Total	p-value
Fetal Distress	10	8	18	0.045
Cephalopelvic Disproportion	4	8	12	
Previous CS	6	9	15	
Breech	3	5	8	
Others	2	5	7	
Total	25	35	60	

Logistic regression analysis identified obesity and higher oxytocin doses as significant predictors of hypotension. Obese women had 2.5 times higher odds of developing hypotension (OR=2.5; 95% CI: 1.1–5.8; p=0.03), while those receiving oxytocin doses >20 IU had 3.2 times higher odds (OR=3.2; 95% CI: 1.4–7.5; p=0.005). Age >30 years (OR=1.8; p=0.08), previous cesarean section (OR=1.3; p=0.48), and preoperative systolic blood pressure >130 mmHg (OR=1.1; p=0.82) were not significant predictors.

Table 6: Logistic Regression Predicting Hypotension

Variable	Odds Ratio (OR)	95% CI	p-value
Age (>30 years)	1.8	0.9 – 3.6	0.08
Obese	2.5	1.1 – 5.8	0.03*
Previous CS	1.3	0.6 – 2.9	0.48
Oxytocin Dose (>20 IU)	3.2	1.4 – 7.5	0.005**
Preop SBP (>130 mmHg)	1.1	0.5 – 2.4	0.82

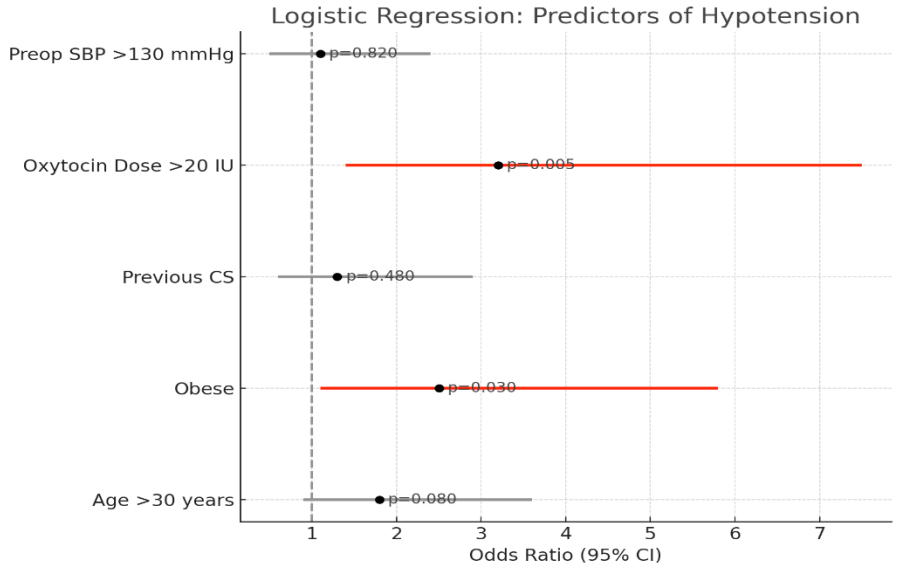

Figure 1. Regression analysis

Discussion

This study demonstrated comparable cardiovascular effects of carbetocin and oxytocin during the whole one-hour assessment period. Both medications induced global vasodilation, resulting in a reduction in vascular tone in both big and small arteries, accompanied by a minor decrease in blood pressure without any compensatory increase in heart rate. Unlike carbetocin, oxytocin exhibited an immediate yet transient mild negative chronotropic impact and a reduction in left ventricular ejection time (ETc) that persisted for up to 20 minutes, normalizing by 60 minutes. The circulatory effects of uterotonics in terms of timing and intensity are contingent upon their administration method: statim, slowly, or by infusion. Both carbetocin and oxytocin, when administered intravenously, result in a peak heart rate after thirty seconds, accompanied by a trough in blood pressure and peripheral vascular resistance (7, 9). When administered intravenously over 60 seconds, the peaks and troughs appear to manifest approximately one minute post-injection completion (19). This pattern has also been observed for methylergometrine administered intravenously over 30 seconds (6). The circulatory effects of oxytocin administered as a 5-minute infusion are significantly diminished (7). No difference in maximal heart rate occurs with carbetocin administration, whether given fast or over 10 minutes intravenously; however, the increase in heart rate is delayed with slow administration. In our investigation, the uterotonics were administered as prescribed for 60 seconds, followed by a 60-second interval before the DPA recording commenced at T1, which lasted for 70 seconds. Our investigation did not capture the transient hemodynamic alterations happening during the first 2 minutes following the initiation of injection. Nonetheless, except from a decrease in HR, we observed no significant disparities between our results and those reported in publications employing alternative approaches. It is noteworthy that a same trend of decreased heart rate was observed in our prior investigation of oxytocin administered at CS. In a study by Moertl et al. that evaluated the hemodynamic effects of carbetocin and oxytocin. the

medications were administered over 10 seconds, which may account for the marginally different cardiovascular responses observed in our investigation. The prompt administration of oxytocin or carbetocin is currently deemed inadvisable. Among the DPA variables indicative of cardiac function, the EEI demonstrated an enhancement in left ventricular ejection power and significant arterial vasodilation after 20 minutes in both groups, implying an increase in cardiac output. The ETc markedly diminished in the oxytocin group, however no change was observed in the carbetocin group. The differences were statistically significant from 1 to 20 minutes when assessed using changes from baseline, i.e., Δ-values. A reduction in ETc signifies a reduction in LV ejection time, indicating negative inotropy and/or reduced preload or hypovolemia. The relationship is not entirely linear, since it is contingent upon the patient's preload condition, whether high or low . The duration of left ventricular ejection can be reduced by both positive and negative inotropic drugs, although it is predominantly linked to negative inotropy (3, 5). The reduction of ETc in the oxytocin group contradicts our previous investigations on oxytocin, in which ETc either stayed stable or rose (23,). In a prior investigation conducted by our team, the ETc variable exhibited inadequate reliability, which we attribute to methodological challenges in pinpointing the conclusion of systole (22). The results indicating a reduction of ETc by oxytocin, along with a potential distinction from carbetocin, remain ambiguous, albeit leaning towards carbetocin. The results necessitate additional research to ascertain the clinical significance. One woman in the carbetocin group exhibited a ST index elevation of 2.3–2.9 mm after 1 minute, although reported no subjective symptoms. We examined her CRF and identified inadequately controlled hypotension. The significance of appropriate management of hypotension related to spinal anesthetic, pharmacological agents, and hypovolemia must be underscored. For all other women, the ST index stayed constant for the entire one-hour duration. This is significant as an increasing percentage of pregnant women have concurrent cardiac disease (6). Given that oxytocin can induce dose-dependent ST-segment depression, troponin release, QT interval lengthening, and arrhythmias, it is imperative to examine the myocardial effects of carbetocin as well (7). Consistent with prior research (10, 12, 5), there was no disparity in blood loss across the groups. These studies and meta-analyses (14, 38, 39) indicate a diminished requirement for further uterotonics when administering carbetocin versus oxytocin in both elective and non-elective cesarean sections; however, in our investigation, this difference did not achieve statistical significance. Repeated administration of oxytocin may elevate the risk of hypotension and cardiovascular adverse effects (3). Consistent with prior research (9, 19), we observed no variation in the incidence of chest pain and discomfort. Oxytocin receptors (OXTR) are located in the uterus, mammary glands, heart, brain, and blood arteries (9). The biology of OXTR is complex, characterized by diverse, context-dependent cellular processing, resemblances to vasopressin receptors, and extensive peripheral and central expression. OXTR is part of a substantial family of G protein-coupled cell surface receptors, triggered by several signaling pathways (4). Oxytocin and vasopressin differ by merely two amino acid sequences, elucidating why oxytocin also stimulates vasopressor receptors V1a (V1aR) and V1b (V1bR). Passoni et al. discovered that carbetocin activates the oxytocin receptor (OXTR) but does not activate the vasopressin receptors V1aR and V1bR, and that carbetocin can function as a competitive antagonist at vasopressin receptors. (1). Carbetocin exclusively stimulates the OXTR/Gq pathway, while oxytocin engages OXTR in conjunction with G-protein subtypes Gq, Gi, and Go. The Passoni study reveals significant distinctions in essential molecular pharmacological characteristics between carbetocin and oxytocin, with carbetocin demonstrating a "weaker" effect on OXTR. The distinctive functional selective coupling of OXTR/Gq by carbetocin may elucidate the minor yet significant variances in vascular activity seen between carbetocin and oxytocin in our investigation.

Conclusion

This study highlights that oxytocin administration during cesarean section is associated with notable hemodynamic changes, particularly hypotension and tachycardia. Obesity and higher oxytocin doses (>20 IU) were identified as significant predictors of hypotension. Although oxytocin was deemed safe in the majority of cases, approximately one-third of patients experienced side effects, and 41.7% developed transient hypotension. These findings underscore the importance of careful dose titration, close monitoring of vital signs, and individualized management strategies to minimize maternal complications during cesarean delivery.

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