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Evaluation of Capnography with Spontaneous Respiration under Regional Anaesthesia in LSCS Patients and its Clinical Application - A Prospective Observational Study

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Abstract: ***Background: Pregnant women may experience potentially fatal conditions before, during, and after giving birth. Capnography is the continuous monitoring of instantaneous CO2 concentration in expired gases during respiratory cycle. Routinely ETCO2 monitoring is done in intubated patients. Patients who undergo LSCS under regional anaesthesia carrying same obstetric risk do not get advantage of capnography monitoring as standard of care. This study aims to correlate the trends of capnography in LSCS patients under Regional anaesthesia. Methodology: It was a prospective observational cohort study done at tertiary care hospital. Total 241female patients undergoing LSCS surgery under regional anaesthesia were included in the study. After spinal anaesthesia ETCO2 monitoring was done at various steps of LSCS along with other vital parameters. Result: The average age of the parturient was 26.00 ± 3.94 years, ranging from 20-32 years. The mean end-tidal CO2 (ETCO2) level at the time of incision was 33.17 mmHg, with a range from 24 to 35 mmHg. Across all stages of LSCS, patients with a higher ASA grade (ASA III) exhibited lower mean ETCO2 levels compared to those with a lower ASA grade (ASA II). Mean ETCO2 was significantly lower in ASA III patients. Conclusion: The study successfully demonstrated that capnography can be used in non intubated obstetric patients under central neuraxial blockade. Significant fluctuation in ETCO2 levels were observed throughout the different steps of LSCS with significant fall in ETCO2 observed during Placental delivery.***

Keywords: capnography, LSCS, spontaneous respiration, regional anaesthesia

1. Introduction

Pregnant women may experience potentially fatal conditions before, during, and after giving birth. A fraction of these women become near misses (MNMs) after they narrowly avoid death, while some of them die. Capnography is the continuous monitoring of instantaneous CO2 concentration in expired gases during respiratory cycle. CO2 removal from the lungs (pulmonary processes) is directly shown by the measurement of CO2 in expelled gases. It suggests, in an indirect way, that CO2 is produced at the tissue level and delivered to the lungs.[1] Routinely ETCO2 monitoring is done in intubated patients. Patients who undergo LSCS under regional anaesthesia carrying same obstetric risk do not get advantage of capnography monitoring as standard of care. Capnography is useful as a means of respiratory monitoring in patients undergoing LSCS under regional anaesthesia as it is non-invasive, doesn't rely on patient compliance and doesn't necessitate the interruption of oxygen or nebulized drug treatments and provides continuous real time information in a simple graphic form.[2] It is commonly known that capnography can be used to confirm endotracheal intubation. Numerous research works have demonstrated the advantages of end-tidal carbon dioxide (EtCO2) monitoring for patients who are intubated. ETCO2 can now be accurately measured and monitored in patients who are not intubated due to recent technical advancements. The provider can promptly and reliably monitor ventilation parameters noninvasively using sidestream collection and analysis. With the use of ETCO2 monitoring, patients' progress can be monitored and can be acted upon quickly to address any aberrant ventilatory issues, such as asthma, chronic obstructive pulmonary disease (COPD), diabetic ketoacidosis, pulmonary embolism, airway blockage, seizures, etc. By continuously providing data on airway patency, ventilatory rate and quality, and circulatory sufficiency, this approach improves patient safety.[3] This study aims to correlate the trends of capnography in LSCS patients under Regional anaesthesia.

2. Methodology

This study was prospective, observational cohort study. This study was done at Tertiary Care Hospital i.e at Department of Anaesthesiology of Bharti Vidhypeeth Medical College, Pune.

Study population: All adult female patients undergoing LSCS operation under regional anaesthesia

Study duration: This study was completed over 2 years (2022-2024) at Bharati Hospital, Pune.

Sample size: A total of 241 patients undergone LSCS surgery under regional anaesthesia were included.

$$Sample\ Size\ (n) = \frac{(Z_{1-\frac{\alpha}{2}})^{2*}(p)(q)}{(d)^2}$$

N= Desired Sample Size

$Z_{1-\alpha}$= Critical Value and a standard value for the corresponding level of confidence (At 95% CI or 5% level of significance (type- I error) it is 1.96 and 99% CI it is 2.58
P= Expected prevalence or based on previous research
q= 1- p
d= Margin of error or precision

Study participants:

Inclusion criteria:
1) Age more than 21 years posted for LSCS under regional anaesthesia
2) ASA II and ASA III patients

Exclusion criteria: -
1) Individuals who were not willing to participate in the study
2) Patients with contraindication to regional anaesthesia
3) Patients with preexisting chronic respiratory illness.

Methodology:
After obtaining approval from institutional ethical committee (BVDUMC/IEC/84) and informed consent from all patients; total 241 patients undergoing LSCS surgery were included in the study. After detailed preoperative evaluation, Maternal severity score was calculated Baseline parameters of vitals (Pulse rate, Blood Pressure, ECG, SPO2, ETCO2) were measured on OT table. Post operative follow up continued for 3 days to monitor recovery course and if any significant presentation seen. Conventional sidestream capnometer was used in this study. The patient's nostril is fitted with two prongs. Oxygen was supplemented with face mask. The device did not interfere with capnography monitoring. The sidestream capnometer employed in this study has a measuring device that aspirates gases from the prongs through a sample tube, passes through an analyzer, and records the waveform in a monitor.

Regional anaesthesia (Subarachnoid Block) with Bupivacaine 0.5% was given under all aseptic precautions. Vital parameters along with capnogram were noted in every steps of LSCS which includes before incision, at baby delivery, placental delivery, after closure of incision. Variations in these parameters and capnogram and clinical findings in accordance to the step of LSCS were recorded in the proforma. Vital parameters monitoring was continued in post operative care unit till day 3. Intraoperative events like hypotension, nausea, bradycardia, desaturation was mentioned in respect to steps of LSCS. Changes in individual parameters, capnogram and steps of LSCS were analysed at the end of the study with clinical presentation of the patient.

Statistical Data Analysis

Plan of data analysis: All statistical analysis will be done by using SPSS software with version 25.0. Continuous variables results shown by descriptive statistics and categorial variable results will be shown by frequencies and percentages. Throughout results 5% level of significance will be used. All results shown with 95% of confidence. P value <0.05 considered as significant**.** Statistical analysis using linear regression analysis and ANOVA test was done.

3. Result

Age: It was observed in study that the average age of the participant was 26.00 ± 3.94 years. The age of the participants ranged from 21 to 32 years. Maximum participant i.e. 103 participants belongs to 20-24 year age group.

ASA Grading of the patients: Acc. to ASA grading maximum study participant belongs to ASA grade 2 i.e 219(90.9%). Only 9.1 % participants belongs to ASA grade 3.

Indications for LSCS
1) **Previous LSCS with current complications:** A significant number of patients had a history of LSCS i.e. 165 (68%) combined with other factors such as CPD (Cephalopelvic Disproportion) and PROM (Premature Rupture of Membranes).
2) **Preeclampsia:** it was observed that 22 (9%) had hypertensive disorder in pregnancy requiring early delivery.
3) **Fetal distress** Conditions such as fetal bradycardia and meconium-stained liquor were noted in 36(15%) .
4) **Others** Included conditions like PROM without labor, failed induction, hypothyroidism and multiple gestations with complications, placenta previa were noted (18, 8%).

Baseline Vital Parameters of Parturient: It was observed that the average pulse rate of the participants was 91.05 ±12.981 SD bpm, with a wide range from 76 to 150 bpm. The mean diastolic blood pressure was 75.89 mmHg, with a relatively narrow range from 70 to 82 mmHg. The low standard deviation of 4.67 mmHg indicates minimal variability among participants' diastolic blood pressure. The mean SPO2 level was 98.96%, with a range from 98% to 100%. This indicates that the participants generally maintained good oxygen saturation levels throughout the study, with minimal variation (standard deviation of 0.45%).

Baseline Parameters	Minimum	Maximum	Mean	Std.	Range
Pulse Rate (/min)	76	150	91	12.981	74
Blood Pressure (systolic) mm of Hg	110	150	121.64	10.3	40
Blood Pressure (diastolic) mm of Hg	70	82	75.89	4.67	12
SPO2(%)	98.00%	100.00%	98.96%	0.45%	2.00%

Time intervals for steps of LSCS from incision: The average time from the incision to the delivery of the baby was 8.17 minutes, with times ranging from 6 to 14 minutes. The mean time to placental delivery was 16.57 minutes, with a range from 12 to 20 minutes. The slight increase in variability is indicated by a standard deviation of 2.222 minutes. The mean time for closure of the incision was 27.68 minutes, with a broader range of 20 to 34 minutes.

Steps After Incision	Minimum (min)	Maximum (min)	Mean	Std. Deviation	Range
Baby Delivery Time	6	14	8.17	2.038	8
Placental delivery time	12	20	16.57	2.222	8
Closure time	20	34	27.68	3.654	14

Blood pressure during various Steps of LSCS: The average systolic blood pressure observed at the time of incision was 120.71 mm of Hg ranging from 90 to 152 mm of Hg and Diastolic blood pressure was 75.53 mm of Hg ranging from 54 to 82 mm of Hg. At the time of Baby delivery mean systolic blood pressure was 120.19 mm of Hg ranging from 100 to 144 mm of Hg. Average Diastolic blood pressure was 71.55 mm of Hg ranging from 60 to 82 mm of Hg.

Systolic Blood Pressure during Various Steps of LSCS	Minimum (mm Hg)	Maximum (mm Hg)	Mean (mm Hg)	Std.	P value*
Incision	90	152	120.71	12.634	<0.001
Baby delivery	100	144	120.19	10.966	<0.001
Placental delivery	98	134	121	9.534	<0.001
closure	110	142	121.5	9.921	<0.001

Diastolic Blood Pressure during various Steps of LSCS	Minimum (mm Hg)	Maximum (mm Hg)	Mean (mm Hg)	Std. Deviation	P value*
Incision	54	82	75.53	6.587	<0.001
Baby delivery	60	82	71.55	7.291	<0.001
Placental delivery	62	82	73.14	5.626	<0.001
closure	60	82	73.34	6.007	<0.001

Pulse rate during various Steps of LSCS: At the time of incision, the average pulse rate was 92.96 bpm, with a range from 72 to 138 bpm. The range suggests that while most patients maintained a normal pulse rate, there were instances of both bradycardia and tachycardia. During the delivery of the baby, the mean pulse rate slightly increased to 95.39 bpm, with a minimum of 86 bpm and a maximum of 140 bpm. At the time of placental delivery, the mean pulse rate was 94.66 bpm, with the highest recorded rate being 150 bpm. During the closure phase, the mean pulse rate slightly decreased to 94.36 bpm, with a range from 82 to 138 bpm.

Steps of LSCS	Minimum Pulse Rate per min	Maximum Pulse Rate per min	Mean	Std. Deviation	P value*
Incision	72	138	92.96	10.414	<0.001
Baby delivery	86	140	95.39	10.414	<0.001
Placental delivery	82	150	94.66	10.509	<0.001
closure	82	138	94.36	9.69	<0.001

Respiratory rate during various Steps of LSCS: At placental delivery, the mean respiratory rate slightly decreased to 16.1 breaths per minute, with the range from 14 to 31 breaths per minute. The increased standard deviation of 2.691 suggests greater variability among patients. The wider range indicates that some patients experienced more significant deviations from the average, During the closure phase, the mean respiratory rate remained stable at 16.12 breaths per minute, with a range from 14 to 30 breaths per minute.

Respiratory rate during various Steps of LSCS	Minimum	Maximum	Mean	Std. Deviation	Range
Incision	14	28	16.37	2.275	14
Baby delivery	15	30	16.78	2.333	15
Placental delivery	14	31	16.1	2.691	17
closure	14	30	16.12	2.592	16

SPO2 during various Steps of LSCS: The average oxygen saturation (SPO2) at the time of incision was 98.67%, with a narrow range between 97% and 100 %. During the delivery of the baby, the mean SPO2 was 98.65%, with values ranging from 98% to 100%. The mean SPO2 level at placental delivery was slightly lower at 98.31%, with a minimum of 97% and a maximum of 99%. During the closure phase, the mean SPO2 was 98.56%, with a wider range from 96% to 100%.

Steps of LSCS	Minimum	Maximum	Mean	Std. Deviation	Range
Incision	97	100	98.67	0.609	0.038
Baby delivery	98	100	98.65	0.504	<0.001
Placental delivery	97	99	98.31	0.756	<0.001
Closure	96	100	98.56	0.809	<0.001

ETCO2 during various Steps of LSCS:
The mean end-tidal CO2 (ETCO2) level at the time of incision was 33.17 mmHg, with a range from 24 to 35 mmHg. During baby delivery, the mean ETCO2 level decreased slightly to 32.49 mmHg, with values ranging from 23 to 36 mmHg. At placental delivery, the mean ETCO2 further decreased to 31.05 mmHg, with a range from 20 to 33 mmHg. During the closure phase, the mean ETCO2 was 30.85 mmHg, with a range from 20 to 34 mm of Hg. The analysis of ETCO2 levels across the different stages of LSCS (Lower Segment Caesarean Section) shows a consistent trend of decreasing mean ETCO2 levels from incision to closure.

Steps of LSCS	Minimum ETCO2 (mmHg)	Maximum ETCO2 (mmHg)	Mean	Std. Deviation	Range
Incision	24	35	33.17	1.709	11
Baby delivery	23	36	32.49	1.996	13
Placental delivery	23	33	31.05	2.035	14
Closure	20	34	30.85	2.086	14

Correlation of ASA Grading and ETCO2 levels: Across all stages of LSCS, patients with ASA III exhibited lower mean ETCO2 levels compared to those with ASA II. Mean ETCO2 was significantly lower in ASA III patients with larger standard deviation 4.309. It reduced further with baby and placenta delivery significantly. (P value <0.001). The Independent Samples Test reveals significant differences in ETCO2 levels between ASA II and ASA III patients, particularly noticeable during placental delivery and closure. The significant t-values and low p-values (Sig. 2-tailed < 0.05) suggest that the differences observed are statistically significant and not due to chance.

Steps of LSCS	ASA	Mean	Std. Deviation	P Value
Incision	II	33.41	0.89	**<0.001**
	III	30.77	4.309	
Baby delivery	II	32.8	1.262	**<0.001**
	III	29.36	4.215	
Placental delivery	II	31.47	0.853	**<0.001**
	III	26.86	4.422	
Closure	II	31.25	1.069	**<0.001**
	III	26.86	4.422	

Regression Analysis of changes in vital parameters with changes in ETCO2 at the time of Incision: The table presents the results of a multiple linear regression analysis with ETCO2 (end-tidal CO2) at incision as the dependent variable and several physiological parameters as independent variables.

Physiological parameters	Unstandardized Coefficients		Standardized Coefficients	P value	95.0% Confidence Interval for B	
	B	Std. Error	Beta		Lower Bound	Upper Bound
BP - Systolic (mmHg)	0.052	0.007	-0.383	**<0.001**	-0.066	-0.038
BP - Diastolic (mmHg)	0.084	0.013	0.322	**<0.001**	0.059	0.108
Pulse rate (min)	-0.069	0.013	-0.42	**<0.001**	-0.095	-0.043
SPO2 (%)	-0.536	0.142	-0.191	**<0.001**	-0.815	-0.257
RR (min)	-0.217	0.058	-0.288	**<0.001**	-0.331	-0.102

BP - Incision Systolic (mmHg)
A negative unstandardized coefficient (B = -0.052) suggests that for every 1 mmHg increase in systolic BP at incision, ETCO2 showed decrease by 0.052 units, holding other factors constant. There is a fall in ETCO2 seen in spite of good systolic Blood Pressure.

BP Incision Diastolic (mmHg)
A positive coefficient (B = 0.084) indicates that for every 1 mmHg increase in diastolic BP at incision, ETCO2 increased by 0.084 units**.** The significant p-value suggests this relationship is statistically significant.

Pulse Rate - Incision (/min)
A negative coefficient indicates that **an increase in pulse rate is associated with a decrease in ETCO2.** This result is significant, with each beat per minute increase in pulse rate resulting in a 0.069 unit decrease in ETCO2.

SPO2 - Incision (%)
A negative coefficient suggests that SPO2 levels remained normal with lower ETCO2 values. The significant p-value indicates a statistically significant observation.

RR - Incision (/min)
The negative coefficient indicates that an increase in respiratory rate at incision is associated with a decrease in ETCO2. Notably, systolic BP and pulse rate negatively correlate with ETCO2, while diastolic BP positively correlates. SPO2 and respiratory rate also negatively correlate with ETCO2, indicating that higher values in these parameters are associated with lower ETCO2 levels.

Variance in ETCO2 levels at the incision step : The ANOVA results confirm that the regression model is statistically significant in explaining the variation in ETCO2 levels at the incision stage. The significant p-value (<0.0001) indicates that the set of predictors—RR, BP (systolic and diastolic), SPO2, and pulse rate correlate with ETCO2. The high F-value further underscores the model's ability to explain a significant portion of the variance in ETCO2, highlighting the possibility of good sensitivity.

	Sum of Squares	df	Square Mean	F	P value
Regression	384.897	5	76.979	57.164	<0.0001
Residual	316.464	235	1.347		
Total	701.361	240			

a. Dependent Variable: ETCO2- incision

b Predictors: (Constant), RR- Incision(/min), BP Incision Diastolic(mmHg), SPO2-incision (%), BP - Incision Systolic(mmHg), Pulse Rate- Incision(/min)

Multiple Regression Analysis of changes in vital parameters with changes in ETCO2 at the time of baby delivery: Multiple linear regression analysis with ETCO2 at the baby delivery stage as the dependent variable and various physiological parameters as independent variables. Key metrics include the unstandardized coefficients (B), standardized coefficients (Beta), significance (Sig.), and the 95% confidence intervals for the coefficients. Both SPO2 and RR showed strong negative correlation with ETCO2 with P value (<0.001) and weak positive correlation shown with pulse rate and diastolic blood pressure.

Physiological parameters	Unstandardized Coefficients		Standardized Coefficients	P value	95.0% Confidence Interval for B	
	B	Std. Error	Beta		Lower Bound	Upper Bound
BP - Systolic (mmHg)	0.015	0.017	-0.081	0.38	-0.048	0.018
BP - Diastolic (mmHg)	0.006	0.024	0.023	0.789	-0.041	0.054
Pulse rate (min)	0.005	0.017	0.025	0.763	-0.028	0.038
SPO2 (%)	-0.999	0.244	-0.252	**<0.001**	-1.479	-0.519
RR (min)	0.569	0.071	-0.665	**<0.001**	-0.709	-0.43

SPO2 - Baby Delivery (%)
A significant negative coefficient indicates that SPO2 levels remain normal with lower ETCO2 levels. The significant p-value (<0.0001) suggests this effect is statistically significant, with each percentage increase in SPO2 associated with a decrease in ETCO2 by approximately 1 unit.

RR - Baby Delivery (/min)
A significant negative coefficient suggests that an increase in respiratory rate (RR) is strongly associated with a decrease in ETCO2 levels. The significant p-value (.0001) indicates this relationship is statistically significant, reflecting a decrease in ETCO2 by approximately 0.569 units for each breath per minute increase in RR.

Variance in ETCO2 levels during the baby delivery step : The ANOVA table shows that the regression model is statistically significant in explaining the variance in ETCO2 levels during the baby delivery stage. The significant p-value (<.0001) confirms that the set of predictors—RR, BP (systolic and diastolic), SPO2, and pulse rate - correlate with ETCO2. The high F-value further supports the model's explanatory power, indicating highlighting the possibility of good sensitivity.

	Sum of Squares	df	Square Mean	F	P value
Regression	440.701 5	5	88.14	40.18	**<0.0001**
Residual	515.498	235	2.194		
Total	956.199	240			

a Dependent Variable: ETCO2- baby delivery
Predictors: (Constant), RR - baby delivery(/min), BP-Baby delivery Systolic(mmHg), SPO2- Baby delivery(%), Pulse Rate- Baby Delivery(/min), BP, Baby Delivery Diastolic (mmHg)incision (%), BP - Incision Systolic(mmHg), Pulse Rate- Incision(/min)

Multiple Regression Analysis of changes in vital parameters with changes in ETCO2 at the time of placental delivery: multiple linear regression analysis with ETCO2 at the placental delivery stage as the dependent variable. The independent variables include various physiological measures.

Physiological parameters	Unstandardized Coefficients		Standardized Coefficients	P value	95.0% Confidence Interval for B	
	B	Std. Error	Beta		Lower Bound	Upper Bound
BP - Systolic (mmHg)	0.038	0.018	0.177	**0.035**	0.003	0.073
BP - Diastolic (mmHg)	-0.153	0.03	-0.422	**<0.001**	-0.212	-0.093
Pulse rate (min)	-0.01	-0.02	0.052	-0.618	0.049	0.029
SPO2 (%)	-0.494	0.145	-0.184	**0.001**	-0.779	-0.21
RR (min)	-0.645	0.087	-0.853	**<0.001**	-0.816	-0.474

BP - Placental Delivery Diastolic (mmHg)
A negative coefficient (B = -0.153) indicates that an increase in diastolic blood pressure is associated with a decrease in ETCO2 levels. The significant p-value (<0.001) confirms that this relationship is statistically significant, suggesting that fall in ETCO2 may not be accompanied by fall in diastolic BP it can remain in normal limit.

Pulse Rate - Placental Delivery (/min)
The coefficient for pulse rate is not significant (p = .618), indicating no statistically significant relationship observed between pulse rate and ETCO2 levels during placental delivery and changes in pulse rate in relation to ETCO2 may not help in decision making.

SPO2 - Placental Delivery (%)
A negative coefficient indicates that higher SPO2 levels are associated with lower ETCO2 levels, with the relationship being statistically significant (p = .001). SPO2 level may not show significant changes in presence of abnormal ETCO2 levels.

RR - Placental Delivery (/min)
The significant negative coefficient (B = -0.645) indicates a strong inverse relationship between respiratory rate and ETCO2 levels. This significant result (p = .000) suggests that increased respiratory rates are associated with decreased ETCO2 levels, likely due to increased ventilation reducing CO2 concentration in the blood. The results indicate that systolic and diastolic blood pressure, SPO2, and respiratory rate significantly influence ETCO2 levels during placental

delivery. Specifically, higher systolic BP correlates with higher ETCO2, while higher diastolic BP and SPO2nlevels are associated with lower ETCO2.

Variance in ETCO2 levels during the placental delivery step: The ANOVA table demonstrates that the regression model is statistically significant in explaining the variance in ETCO2 levels during the placental delivery stage.

	Sum of Squares	df	Square Mean	F	P value
Regression	632.115	5	126.423	82.029	**<0.0001**
Residual	362.183	235	1.541		
Total	994.299	240			
a Dependent Variable: ETCO2- placental delivery					
b Predictors: (Constant), RR - placental delivery(/min), BP- Placental Delivery Systolic (mmHg), Spo2-Placental Delivery (%), BP Placental Delivery Diastolic (mmHg), Pulse Rate- Placental Delivery(/min)					

Multiple Regression Analysis of changes in vital parameters with changes in ETCO2 at the time of closure:

Physiological parameters	Unstandardized Coefficients		Standardized Coefficients	P value	95.0% Confidence Interval for B	
	B	Std. Error	Beta		Lower Bound	Upper Bound
BP – Systolic (mmHg)	0.106	0.013	-0.503	**<0.001**	-0.132	-0.079
BP - Diastolic (mmHg)	0.092	0.02	0.265	**<0.001**	0.053	0.131
Pulse rate (min)	0.125	0.015	-0.581	**<0.001**	-0.154	-0.096
SPO2 (%)	-0.611	0.129	-0.237	**<0.001**	-0.865	-0.358
RR (min)	-0.078	0.056	-0.097	**<0.001**	-0.189	0.033

BP - Closure Systolic (mmHg)
The negative coefficient (B = -0.106) suggests that even if systolic BP is normal, fall in ETCO2 did not reach to normal level.

BP - Closure Diastolic (mmHg)
The positive coefficient (B = 0.092) indicates that an increase in diastolic blood pressure is associated with an increase in ETCO2 levels. This result is statistically significant (p = .000), suggesting that ETCO2 fall witnessed in presence of normal diastolic BP.

Pulse Rate - Closure (/min)
The significant negative coefficient (B = -0.125) indicates that an increase in pulse rate is associated with a decrease in ETCO2. The strong negative relationship (Beta = - 0.581) suggests that tachycardia was consistent finding with fall in ETCO2 at closure and need more attention at closure.

SPO2 - Closure (%)
The significant negative coefficient (B = -0.611) indicates that higher SPO2 levels are observed with lower ETCO2 levels. This finding is statistically significant (p = .000), suggesting that the usefulness of ETCO2 value in presence of normal SPO2 which is one of the limitation of pulse oximetry.

RR - Closure (/min)
The coefficient for respiratory rate (RR) is weak negative correlation (0.078). Even though it showed weak negative correlation the difference was statistically significant and baseline ETCO2 values were not reached

The regression model reveals significant relationships between ETCO2 at closure and several physiological parameters. Specifically, increases in systolic BP, pulse rate, and SPO2 are associated with decrease in ETCO2 levels, while increases in diastolic BP correlate with increased ETCO2 levels.

Variance in ETCO2 levels at the closure step: The ANOVA table indicates that the regression model significantly explains the variance in ETCO2 levels at the closure stage. The low p-value (.000) confirms the model's statistical significance

	Sum of Squares	df	Square Mean	F	P value
Regression	561.912 5	5	112.382	54.712	**<0.0001**
Residual	482.71	235	1.541		
Total	1044.622	240			
a Dependent Variable: ETCO2- closure step					
b Predictors: (Constant), RR -closure(/min), BP- Closure Systolic(mmHg), SP02-Closure (%), BP-Closure Diastolic (mmHg), Pulse Rate-Closure(/min)					

ETCO2 in various stages of LSCS Paired Samples Test

Pairs	Differences in ETCO2	Mean diff.	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		P Value
					Lower	Upper	
Pair 1	ETCO2- incision - ETCO2-baby delivery	0.68	1.096	0.071	0.541	0.82	<0.001
Pair 2	ETCO2- incision - ETCO2-placental delivery	2.112	0.949	0.061	1.992	2.232	**<0.001**
Pair 3	ETCO2- incision - ETCO2-closure	2.315	0.966	0.062	2.193	2.438	**<0.001**
Pair 4	ETCO2-baby delivery ETCO2- placental delivery	1.432	1.331	0.086	1.263	1.6	**<0.001**
Pair 5	ETCO2- baby delivery	1.635	1.525	0.098	1.441	1.828	**<0.001**

	ETCO2-closure						
Pair 6	ETCO2-placental delivery	0.203	0.994	0.064	0.077	0.329	0.002
	ETCO2-closure						

Pair 1: ETCO2 - Incision vs. ETCO2 - Baby Delivery
The mean ETCO2 level at incision is significantly different from the level at baby delivery, with a mean difference of 0.680 mmHg. The significant p-value (.000) indicates this difference is statistically significant.

Pair 2: ETCO2 - Incision vs. ETCO2 - Placental Delivery
There is a significant difference in ETCO2 levels between incision and placental delivery stages, with a mean difference of 2.112 mmHg. The significant p-value indicates this difference is not due to chance.

Pair 3: ETCO2 - Incision vs. ETCO2 - Closure
The mean ETCO2 levels at incision and closure are significantly different, with a mean difference of 2.315 mmHg, indicating changes in ETCO2 throughout the procedure.

Pair 4: ETCO2 - Baby Delivery vs. ETCO2 - Placental Delivery
The difference in ETCO2 levels between baby delivery and placental delivery stages is significant, with a mean difference of 1.432 mmHg.

Pair 5: ETCO2 - Baby Delivery vs. ETCO2 - Closure
The mean difference of 1.635 mmHg between ETCO2 levels at baby delivery and closure is statistically significant.

Pair 6: ETCO2 - Placental Delivery vs. ETCO2 – Closure
The smallest mean difference (0.203 mmHg) is observed between the placental delivery and closure stages. This difference is still statistically significant, although smaller compared to other pairs. The paired samples t-tests show significant differences in ETCO2 levels between various steps of the LSCS procedure.

Association of Age and change in ETCO2 value: Fall in ETCO2 was seen across all ages.

Significantly less number of patients showed higher fall of ETCO2 more than 3mm Hg.

Age group	Change in ETCO2 value (mmHg)		Total	P value
	< or equal to 3	more than 3		
20-24	85 (82.50%)	18 (17.50%)	103 (100%)	<0.0001
25-29	79 (100%)	0 (0%)	79 (100%)	
30 and above	44 (74.60%)	15 (25.40%)	59 (100%)	
Total	208 (86.30%)	33 (13.70%)	241 (100%)	

Association of parity and change in ETCO2 value: Primigravida showed higher incidence of ETCO2 fall more than 3mm Hg (21.8%) as against multipara women. (6.9%).

Parity	Change in ETCO2 value (mmHg)		Total	P value
	< or equal to 3	more than 3		
Multipara	122	9	131	<0.0001
	93.10%	6.90%	100.00%	
Primipara	86	24	110	
	78.20%	21.80%	100.00%	
Total	208	33	241	
	86.30%	13.70%	100.00%	

Association of ASA grading and change in ETCO2 value: Significantly more ASA grade 3 patients showed ETCO2 fall of more than 3mmHg($p<0.0001$). Association of diagnosis and change in ETCO2 value A Chi-square test of independence was applied to examine the relationship between different diagnoses and the categorized change in ETCO2 values (≤3 and >3). The diagnoses included conditions such as PROM, CPD, CPD with thoracic scoliosis. The results are summarized in the table below.

ASA Grading	Change in ETCO2 value (mmHg)		Total	P value
2	204	15	219	<0.0001
	93.20%	6.80%	100.00%	
3	4	18	22	
	18.20%	81.80%	100.00%	
Total	208	33	241	
	86.30%	13.70%	100.00%	

Association of diagnosis and change in ETCO2 value: CPD with Thoracic scoliosis, cardiac disease, pre-eclampsia cases showed higher fall of ETCO2 more than 3 mm Hg. Meconium-stained Liquor showed almost equal incidence of cases showing fall less than or equal to 3 and more than 3. Oligohydramnios was one more condition were equal number of patients showed higher fall of ETCO2. Difference between these conditions and other conditions not showing higher fall was statistically significant. ($p<0.001$).

S No	Diagnosis	ETCO 2<3	ETCO 2 >3	p-value
1	PROM	13	0	<0.001
2	CPD	21	2	
3	CPD with thoracic scoliosis	0	2	
4	Oligohydramnios	11	7	
5	Fetal Bradycardia	11	1	
6	Scar tenderness	33	0	
7	IUGR	32	0	
8	Meconium-stained Liquor	13	11	
9	Cardiac Disease	0	2	
10	Preeclampsia	3	7	
11	Previous LSCS	69	0	

Note: Chi-square test was applied and p value <0.05 was considered significant. **Sensitivity and specificity of change in ETCO2 levels at the incision stage to closure**

stage in relation to the maternal severity score : The table presented assesses the sensitivity and specificity of changes in ETCO2 levels from the incision to closure stages

in relation to the maternal severity score (MSS). The key findings from the table are summarized as follows:

- **True Positives (TP):** 18
- **False Negatives (FN):** 4
- **True Negatives (TN):** 204
- **False Positives (FP):** 15

Cases of (MSS = 0) showing a change in ETCO2 > 3 mmHg.

Sensitivity:

$$Sensitivity = \frac{18}{18+4} = \frac{18}{22} \approx 0.818 \; or \; 81.8\%$$

Specificity:

$$Specificity = \frac{204}{204+15} = \frac{204}{219} \approx 0.931 \; or \; 93.1\%$$

		Change in ETCO2 value (mmHg)		Total
		< or equal to 3	more than 3	
Maternal Severity	0	204	15	219
Score	1	4	18	22
Total		208	33	241

4. Discussion

The present study investigates the trends and challenges in management during Lower Segment Cesarean Section (LSCS) under Spinal Anaesthesia with a particular focus on use of capnography in non-intubated patients and ETCO2 levels for early diagnosis and improve monitoring. The scope of the study encompasses a comprehensive analysis of demographic data, vital parameters, intraoperative events, and the diagnostic accuracy

of capnography and feasibility of capnography in predicting cause effect interrelation with other vital parameters being monitored. By analysing ETCO2 trends during different stages of LSCS, the study aims to identify patterns that may inform clinical decision-making and improve maternal and fetal outcomes.

The average age of the parturient was 26.00 ± 3.94 years in present study with ranging from 20-32 years. In **Cleary-Goldman J et al. (2005)** [4] and **Joseph KS et al. (2017)** [5] found younger maternal age is often associated with a lower risk of complications, while advanced maternal age increases the risk of conditions such as hypertension, gestational diabetes, and preeclampsia [27,28]. This study's findings are consistent with previous research indicating a higher prevalence of LSCS in older mothers due to these associated risks **Liu S et al. (2007)[6], Knight M et al. (2018)** [7]

This study included 219 parturient with ASA II grade and 22 parturient with ASA III Grade. **Mayhew et al (2019)** [8] found the correlation between higher ASA grades and increased perioperative risk is well-documented, underscoring the importance of this grading in preoperative planning.

This study identified a range of indications for LSCS, with a notable number due to previous LSCS, fetal distress, and maternal medical conditions like preeclampsia and gestational diabetes. **Landon MB et al. (2004)[9]** and **Silver RM et al. (2006)** [10] found the recurrence of LSCS in patients with a history of the procedure aligns with existing literature, which highlights concerns over uterine rupture and complications associated. The analysis of pulse rate and blood pressure during different stages of the Lower Segment Cesarean Section (LSCS) procedure revealed significant variations, underscoring the physiological challenges associated with the procedure. During the LSCS procedure, pulse rate fluctuations were observed across various stages. The average pulse rate of the participants was 91.05 ±12.981 SD bpm, with a wide range from 76 to 150 bpm with p value of <0.001.

Bijker JB et al. (2007)[11] and **Reves JG et al. (1985)[12]** observed this trend can be attributed to the sympathetic nervous system's response to surgical steps, which often leads to tachycardia because of increased catecholamine release.According to **Ivascu R**

et al. (2024)[13] the rise in pulse rate during incision is likely due to the initial surgical stimulus, while the peak during baby delivery could be associated with both the physiological stress of delivery and the administration of uterotonic agents, which can further stimulate the heart rate.

A study by **Luthra A et al. (2017)** [14] reported similar patterns of increased heart rate and blood pressure during cesarean sections under spinal anesthesia, particularly during delivery and uterine manipulation. **Birnbach DJ et al. (2010)** [15] found these hemodynamic changes are not only a response to surgical stress but are also influenced by factors such as anesthesia type, patient positioning, and the use of medications like oxytocin and anaesthetics. We witnessed that the average oxygen saturation(SPO2) at the time of incision was 98.67%, with a narrow range between 97% and 100%.

Pedersen T et al. (2014)[16] found the maintenance of optimal oxygenation is particularly important in patients with pre-existing respiratory conditions or those at risk of developing intraoperative complications, such as atelectasis or bronchospasm.

Oxygen Saturation takes more time to show fall, capnography changes are instantaneous as SPO2 is an estimate of SaO2 of circulating haemoglobin and it does not provide information of tissue oxygenation.

End-tidal CO2 (ETCO2) levels demonstrated notable fluctuations throughout the LSCS procedure, with a general trend of decrease from the incision stage to the closure stage. According to **Bhavani-Shankar K et al.** (1992)[17] ETCO2 levels, which provide an indirect measure of arterial CO2, are influenced by factors such as ventilation, perfusion, and metabolic activity. The analysis of ETCO2 levels across the different stages of LSCS (Lower Segment Cesarean Section) shows a consistent trend of decreasing mean ETCO2 levels from incision to closure.

Mushambi MC et al. (2015) [18] found that the predictable rise in ETCO2 and blood pressure during incision and baby delivery stages can alert clinicians to the need for increased monitoring and potential intervention to manage hypercapnia or hypertension. **Conclusion:** Significant fluctuations were observed in different steps of LSCS under regional anaesthesia. Significant fall in ETCO2 was observed during placental delivery (p value<0.001). Continued ETCO2 monitoring in case of significant ETCO2 fall accompanied by hemodynamic instability and vital parameter changes can help to identify the complications earlier. This ETCO2 fall can be clinically correlated with help of advanced investigations like 2D Echo, D Dimer, Troponin, Brain Natriuretic Peptide.

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