A Heuristic Approach For Perfusion Index Analysis Using Pulse Oximeter Technology And Effect Of Thermoregulation Among Parturient Undergoing Lumbar Epidural Anesthesia For LSCS Surgery

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Abstract: Hypothermia was expected in lumbar epidural anesthesia and due to slow redistribution of internal heat during lumbar epidural anesthesia among parturient undergoing lower segment caesarean section LSCS surgery. Or specific aim was to explore perfusion index analysis using pulse oximeter technology and effect of thermoregulation among parturient undergoing lumbar epidural anesthesia for LSCS Surgery. This was a descriptive, cross sectional mono centric study at the Obstetric Theatre and statistic used including Chi square, Independent T –Test, ANOVA and Bivariate analysis with SPSS version 24.0. Mean finger perfusion index FPI indicated as clinical sign for non conversion and conversion of lumbar epidural anesthesia to general anesthesia GA. Perfusion index PI was higher value (n = 154), 4.7 ± 0.1 in non conversion group of lumbar epidural anesthesia as compared to the conversion group (n = 6), 4.0 ± 0.4, , t(5) = -12.3, p = 0.00. The mean parturient's temperature at 36.5^{0}C as thresholds for vasoconstriction mapping to finger perfusion index 4.6. At the level of 36.5^{0}C (mild hypothermic) with initial pulse rate at 85/min, the cardiac output produced at the level of 5091.75 ml (5.1 L). An increased of perfusion index would not induced the bleeding for parturient mothers undergoing LSCS surgery as displayed Spearman's correlation r = 0.02, p = 0.79 by bivariate analysis. Our study demonstrated that ambient temperature as stimulus for skin temperature changes not proven. Finger Perfusion Index FPI having a role as indicator for efficacy of lumbar epidural anesthesia in caesarean section surgery and biothermal models

Keywords: pulse oximeter technology, perfusion index, hypothermia, lumbar epidural anesthesia and caesarean section,

Introduction:

In the physiological context of anesthesia science, perfusion is known as the process of delivering blood to a capillary bed by human body within biological tissue. Perfusion Index reading is reflected as numerical value with creating the amplitude of the plethysmographic pulse wave that is displayed on pulse oximetry screen. To certain extend Perfusion Index PI is the reading value of the amplitude of the plethysmographic (a graphic presentation of the perfusion index) pulsatile blood flow to the non-pulsatile static blood flow in a parturient peripheral capillary and tissue especially in a fingertip and toe. As a common practice, a pulse oximeter assembled with the latest infrared technology to monitor the SpO_2 levels. It is is used to determine the oxygen saturation of the hemoglobin in the blood with a normal range reading between SpO_2 95.0% - 100.0%. The fingertip pulse oximeter is a small and innovative medical device, for non-invasive and continuous measuring of arterial SpO_2 and pulse rate detection. Ginosar et al (2009) very convincing that perfusion index PI can be used as indicator of sympathectomy for lumbar epidural anesthesia compare to skin temperature. Hypothermia was expected to occur during lumbar epidural anesthesia as a result from a heat loss exceeding metabolic heat production. Beside that could be due to slow redistribution of internal heat during lumbar epidural anesthesia among parturient undergoing lower segment caesarean section LSCS surgery.

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On the other hand, the normal body temperature is benchmarked at 37 degrees Celsius. In our understanding when blood supply through capillaries to the skin decreases, the temperature of the skin also decreases. This can be related to vasoconstriction of the skin and thus reduces body heat loss. Mullington et al (2018) put an analogy that emergency caesarean section can affect cutaneous vasomotor tone as well as mean body temperature. Certain studies indicated that regional anesthesia (spinal/epidural) impaired thermoregulation and predisposed parturient to hypothermia in the typically cold operating room ambient. In reality the distribution of body heat normally occurred due systemic vasodilatation and thus resulting an increased mean skin temperature. Skin blood flow could be altered during the perioperative period. Alteration of body temperature during the perioperative period might contribute to altered body and skin temperature among parturient. Frank et al (1992) highlighted the occurrence of during epidural and general anesthesia, especially when the block level is relatively high T4-6 for lumbar epidural anesthesia. The most accurate reading of body temperature is thought through a rectal thermometer reading but our practice of taking temperature. Frank et al (1997) carried out another study and found evidence of hypothermia incidence as similarity in patients receiving regional anesthesia as in those receiving general anesthesia. Certain researchers argued the belief that the perfusion index PI has some form of influences by parturient body temperature. The perception is more towards perfusion index can be used as indicator for sympathetic blockade in lumbar epidural anesthesia. As mentioned by Kuroki et al (2013) perfusion index PI correlated with peripheral blood flow. For the purpose of understanding perfusion index, it is claimed as an early warning of anesthetic failure. An increase in perfusion index reading is an early indicator that epidural anesthesia has initiated peripheral blood vessel dilation, which occurs on

the onset of lumbar epidural anesthesia. Based on pathophysiology narration skin provides important information about certain degree of clinical disorders. It is about mechanism reduction of blood flow due to vasoconstriction mediated by sympathetic neuroactivation. At this particular point, Zifeng Xu et al (2013) strongly said that perfusion index PI provided an indicator of the onset of epidural anesthesia. For overall perspective, we believed perfusion index and skin temperature can be used as an effective indicator of sympathectomy in lumbar epidural anesthesia among parturient undergoing lower segment caesarean section LSCS surgery.

MATERIAL AND METHOD

Research Design: This was a descriptive, cross sectional mono centric study at the Obstetric Theatre. It included anesthetic forms of the Anesthesiology Service referring to charts for parturient of various pre gestational body mass indexes BMI who underwent cesarean section. Variables evaluated included age, weight, height, BMI, physical status (ASA), difficulty in epidural puncture, hemodynamic and anesthetic complications. This study was approved by the Ethics Committee for ethical issues of research. This study was self financed by investigators I. SAMPLING AND METHODS::Parturient mothers planned for elective and emergency LSCS and undergoing epidural anesthesia chosen as samples of this study. The sampling power was based on Yamane formula n = N / (1 + Ne2) Where n = corrected sample size, N = population size, and e = Margin of error (MoE), e = 0.05 based on the research condition. The total population of parturient undergoing lower segment caesarean section LSCS during the study period was 272 parturient. Hence sample chosen was all together 160 calculated using Yamane formula. Lower Segment Caesarean Section LSCS Surgery would not be begun until loss of sensation to pin prick, ethyl chloride spray and fine cotton wool touch achieved bilaterally to maximum level T7. However, quite a number of cases whereby pinprick, ethyl chloride spray and fine cotton wool touch were not applied. If the block did not reach the level T7 within 30 min or with an additional study drug injected and 45 min after the 3rd dose, the patient would be accepted for this the study as epidural failure. Simultaneously motor block been assessed bilaterally using the modified Bromage scale: 1 = no paralysis (full flexion of hip, knee and foot), 2 = unable to flex hip (able to flex knee and ankle), 3 = unable to flex knee (able to flex foot only), 4 = unable to flex hip, knee or ankle joint. Sampling of the study was done through wide range of age group of all parturient mothers undergoing epidural anesthesia. We used combination of clinical observational and interventional methods for parturient mothers undergoing for LSCS and examined achievable of satisfactory level of epidural anesthesia after epidural puncture plus insertion of Tuohy epidural needle and catheter including the injection of drugs used. The Universal Convenience Sampling was used because to have a valid representing of the total populations within the time frame of collecting data.

TOOL USED FOR COLLECTING DATA

A check list for LSCS Epidural Anesthesia was used to collect the data in exploring factors contribute to the satisfactory level of epidural analgesia for parturient mothers planned for elective and emergency LSCS. As clinical practice, a pulse oximeter also been used as continuous monitoring plus as predictor to measure values of SpO2 for epidural anesthesia effectiveness. The perfusion index PI was monitored and recorded at five minutes interval for 20 minutes before and after epidural anesthesia commenced. A thermometer was used for left axillary temperature monitoring at the same site of probe assembled for pulse oximeter. This skin-surface temperature monitoring well tolerated during lumbar epidural anesthesia.

DATA ANALYSIS

Statistical analyses were performed using SPSS® version 24.0. Frequency or arithmetic mean and standard deviation were calculated for all data. Comparison of categorical variables was made using the chi-square test, Bivariate correlation, Indepenedent T Test and ANOVA were used to evaluate the influence of some variables on successful or failure of epidural anesthesia with $p < 0.05$ was considered statistically significant.

RESULTS

Demographic & characteristics of the study among parturient mothers A total of hundred and sixty (n = 160) parturient involved in this study. This was from N = 272 of the total population of parturient undergone epidural anesthesia during the period of data collection 21st January till 10 of July 2017. The mean age of parturient participated in this study was 28.03 with a standard deviation of ± 5.48. The minimum and maximum ages were 16 and 45 years respectively. Parturient with successful epidural anesthesia reported to have mean age of 27.96 ± 5.47 where as those with epidural failure that needed conversion to general anesthesia was 29.83 ± 6.11. For this perspective the age groups were not well distributed as proven in the tested for normality with Shapiro-Wilk $p = 0.00$ $p < 0.05$. Mean pre gestational weight was found 71.29 ± 14.07 kg with minimum of 32 and 104 kg among parturient. For this element, successful epidural group of parturient was 71.03 ± 14.46 and for epidural conversion group was found to be 77.83 ± 9.04 kg. Looking at pre gestational mean height, it was found 1.55 ± 0.08 with minimum of 1.29 and 1.83 meters (m). The mean pre gestational height for successful epidural group was 1.55 ± 0.08 and for the epidural conversion group was 1.56 ± 0.07. The mean pre gestational body mass index BMI among parturient was 29.85 ± 6.09 kg/m2. With this it was found that the minimum and maximum BMI were 14.81 and 51.68 kg/m2 respectively. The mean pre gestational BMI for successful epidural group was 29.76 ± 6.11 kg/m2 and for conversion epidural group 32.30 ± 5.44 kg/m^2. Based on table 1, it was clearly displayed that duration of labour and perfusion index PI have positive association with the conversion of lumbar epidural anesthesia to general anesthesia. This study found higher duration of labour (n = 6), 885.0 ± 97.1 among conversion group of lumbar epidural anesthesia to general anesthesia as compared to non conversion group (n = 154), 688.9 ± 256.3, $t(8) = 4.40$, $p = 0.00$. Perfusion index PI was higher value (n = 154), 4.7 ± 0.1 in non conversion group of lumbar epidural anesthesia as compared to the conversion group (n = 6), 4.0 ± 0.4, , $t(5) = -12.3$, $p = 0.00$.

Table 1: Parturient Characteristic – Independent sample test (T –Test)

	Conversion to general anesthesia Mean ± SD	Non conversion to general anesthesia Mean ± SD	Overall Mean ± SD	P value
Age	(n = 6), 29.8 ± 6.1	(n = 154), 28.0 ± 5.5	(n = 160), 28.0 ± 5.5	0.41
Height (m)	(n = 6), 1.6 ± 0.1	(n = 154), 1.5 ± 0.1	(n = 160), 1.5 ± 0.1	0.71
Pre gestational weight (kg)	(n = 6), 77.8 ± 9.0	(n = 154), 71.0 ± 14.2	(n = 160), 71.3 ± 14.1	0.25
Body mass index BMI	(n = 6), 32.3 ± 5.4	(n = 154), 29.8 ± 6.1	(n = 160), 29.9 ± 6.1	0.32
Initial systolic blood pressure	(n = 6), 134.2 ± 10.5	(n = 154), 131.5 ± 16,6	(n = 160), 131.6 ± 16.4	0.70
Initial diastolic blood pressure	(n = 6), 84.8 ± 7.9	(n = 154), 80.3 ± 10.0	(n = 160), 80.4 ± 9.9	0.27
Initial pulse rate	(n = 6), 87.3 ± 11.4	(n = 154), 84.8 ± 10.5	(n = 160), 84.9 ± 10.5	0.56
Duration of labour	(n = 6), 885.0 ± 97.1	(n = 154), 688.9 ± 256.3	(n = 160), 696.2 ± 254.8	0.01
Mean perfusion index	(n = 6), 4.0 ± 0.4	(n = 154), 4.7 ± 0.1	(n = 160), 4.6 ± 0.2	0.00
Blood Lost	(n = 6), 500.0 ± 53.2	(n = 154), 520.1 ± 55.5	(n = 160), 519.3 ± 55.3	0.39

From table 2, we observed that Visual Analogue Scale VAS 3 (n = 4, 2.6%) had a role in conversion of lumbar epidural anesthesia to general anesthesia GA when tested with Chi square-test. As indicated the value of the chi square statistic was 106.2 with the p-value appeared “Asymptotic Significance (2-sided)” 0.00.

Table 2: Parturient Characteristic – Chi square test

	Conversion to general anesthesia	Non conversion to general anesthesia	P value
Type of LSCS	Emergency (n = 4, 2.5%) Elective (n = 2, 1.3%) (n = 6, 3.8%)	Emergency (n = 41, 25.6%) Elective (n = 3, 63.1%) (n = 154, 96.2%)	0.11
ASA	ASA 1 (n = 4, 2.5%) ASA 2 (n = 2, 1.3%) ASA 3 (n = 0, 0.0%) (n = 6, 3.8%)	ASA 1 (n = 106, 66.2%) ASA 2 (n = 46, 28.8%) ASA 3 (n = 2, 1.2%) (n = 154, 96.2%)	0.95
History of mode delivery	Normal vaginal delivery (n = 1, 0.6%) Instrumental (n = 0. 0.0%) Previous LSCS (n = 2, 1.3%) First time LSCS (n = 3, 1.9%) (n = 6, 3.8%)	Normal vaginal delivery (n = 1, 0.6%) Instrumental (n = 3. 1.9%) Previous LSCS (n = 20, 12.5%) First time LSCS (n = 90, 56.2%) (n = 154, 96.2%)	0.54
Lumbar space attended	L2 L3 (n = 1, 0.6%) L3 L4 (n = 1, 0.6%) L4 L5 (n = 4, 2.6%) (n = 6, 3.8%)	L2 L3 (n = 17, 10.6%) L3 L4 (n = 86, 53.8%) L4 L5 (n = 51, 31.9%) (n = 154, 96.2)	0.16
Visual Analogue Scale VAS	VAS 1 (n = 1, 0.6%) VAS 2 (n = 2, 0.6%) VAS 3 (n = 4, 2.6%) (n = 6, 3.8%)	VAS 1 (n = 136, 85.0%) VAS 2 (n = 18, 11.7%) VAS 3 (n = 0, 0.0%) (n = 154, 96.2%)	0.00

From table 3, two technical elements with dichotomous variables were tested McNemar test. It was found that bony obstruction and bloody tap did not influence the conversion of lumbar epidural anesthesia to general anesthesia. From our own experience, we had problem that during introduction of epidural needle ended with inability to thread the catheter. Lumbar epidural anesthesia might be technically difficult to perform because of the significant anatomical abnormalities with the phenomenon of bony obstruction. Bloody tap could occur due to injury of epidural vein with the needle. In parturient mothers who have normal blood clotting, it is extremely rare for bloody to arise. However, in a parturient who has a coagulopathy might be at risk of epidural hematoma due to bloody tap. At this junction it was found no correlation of bloody to conversion of lumbar epidural anesthesia to general anesthesia as through McNemar test.

Table 3: Dichotonous variables – technical component for lumbar epidural anesthesia

	Conversion to general anesthesia	Non conversion to general anesthesia	McNemar test
Bony obstruction	Yes (n = 0, 0.0%) No (n = 6, 3.8%) (n = 6, 3.8%)	Yes (n = 3, 1.9%) No (n = 151, 94..3%) (n = 154, 96.2%)	0.51
Bloody tap	Yes (n = 0, 0.0%) No (n = 6, 3.8%) (n = 6, 3.8%)	Yes (n = 8, 5.0%) No (n = 146, 91.2%) (n = 154, 96.2%)	0.79

We analyzed Changes in finger perfusion index PI for the possibility corresponded to changes in the blood volume (refer Figure 1). Based on bivariate analysis we found that finger perfusion index PI did not correspond changes in blood volume as r = - 0.07, p = 0.35. We were in opinion that most probably the mean blood loss of 519.3 ± 55.3 ml considered minimal which not ended with vasoconstriction among parturient mothers undergoing LSCS surgery. We considered this parameter well controlled due to good volumetric flow rate of blood within the tissue the finger blood perfusion index. It was interesting to see that the mean percentage increased of finger perfusion index PI among conversion group n = 6, 38.9 ± 16.7 while the mean percentage increased of finger perfusion index PI among non conversion group n = 154, 53.9 ± 3.6. Nevertheless, there was no significant diffrenece in term of percenatge increased of finger perfusion index as t(5) = -2.2, p = 0.08 for both groups.

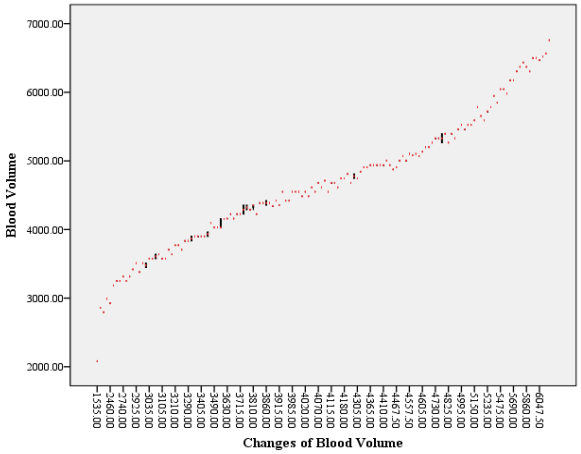
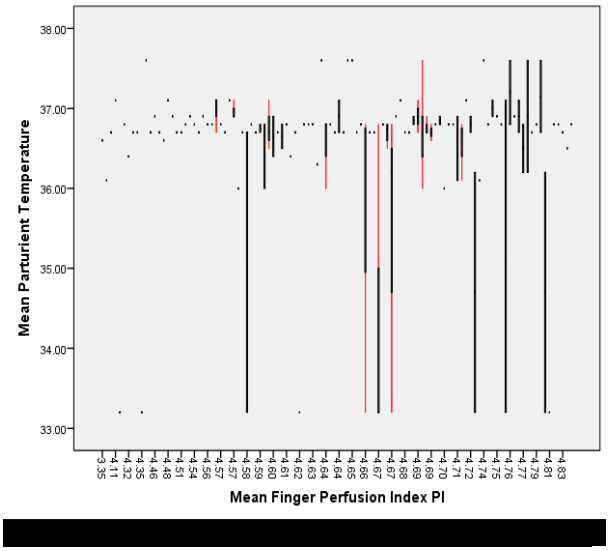


Figure 1: *The Linear Trend Blood Volume and Changes of Blood Volume among Parturient Undergoing Epidural Anesthesia for LSCS Surgery*

Several studies suggested the effects of low peripheral perfusion index could be due to hypothermia. Our cognitive view on the aspect of hypothermia during epidural anesthesia developed as a result of redistribution of heat throughout bodies of parturient mothers. Mercier & Benhamou (1997) discussed well regarding reduced heat loss during lumbar epidural analgesia and labor-induced heat production in relation to temperature regulation. With this analogy we assumed finger perfusion index PI is an early indicator for epidural anesthesia effectiveness as initiated by peripheral blood vessel dilation. So we considered finger perfusion index PI was an accurate index of peripheral blood flow among parturient mothers undergoing LSCS surgery. From our meta analysis by bivariate statistic as displayed in Figure 2, We could not prove that mean temperature 36.5^{0}C among parturient influenced the rate of perfusion index with correlation r = 0.02 and p = 0.84. We took the phenomenon 32.0^{0}C – 35.9^{0}C as moderate hypothermia and temperature of 36.5^{0}C as mild hypothermia. The thresholds for vasoconstriction could be at 36.5°C as cited by Bindu et al (2017) and quite coincidence with our mean parturient temperature 36.5^{0}C. At that basis, we felt wonder at mean parturient temperature 36.5^{0}C thresholds for vasoconstriction mapping to finger perfusion index 4.6 (refer Figure 2).



	n	Minimum	Maximum	Mean
Mean PI	160	3.4	4.9	4.6
Mean Parturient Temperature ^{0}C	160	33.2	37.6	36.5

Figure 2: *The Graphic Presentation for Mean Parturient Temperature in Relation to Mean Finger Perfusion Index*

The perfusion index varied depending on physiological conditions and monitoring sites but also could be due to the volume of blood lost. Mercier & Benhamou (1997) also claimed that hypothermia influenced by duration of labor preceding epidural analgesia and ambient temperature. In our case as mean parturient temperature among parturient at 36.5^{0}C as mild hypothermia, we did not observed duration of labor influenced the incidence of hypothermia with r = - 0.13, p = 0.11 as displayed in Table 4.

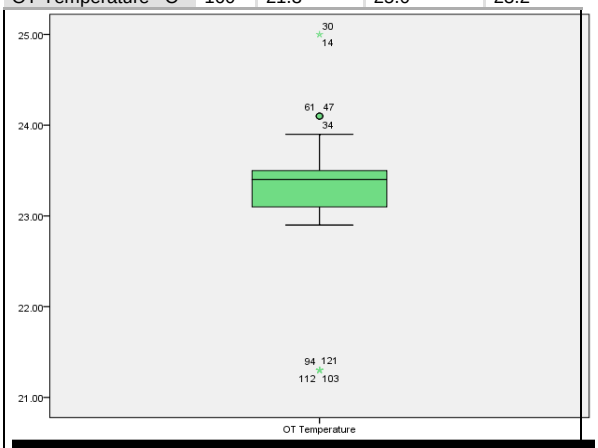
Table 4: Correlations between Duration of Labor and Hypothermia by Bivariate Analysis

			Mean Parturient Temperature
Spearman's rho	Duration of Labour in Minutes	Correlation Coefficient	-.13
		Sig. (2-tailed)	.11

On the basis of the measurement principle, finger perfusion index PI from pulse oximeter technology could also be altered by ambient temperature. In operating theatre setting we should maintained ambient temperature at 25°C–26°C. However in this study, our descriptive analysis revealed a wide range of ambient temperature minimum at 21.3^{0}C and maximum at 25.0^{0}C which was a wide gap and proven with the test of normality Kolmogorov-Smirnova (refer Figure 3). For mean ambient temperature of 23.2^{0}C was mapped to the finger perfusion index of 4.6. Bindu et al (2017) really believed that hypothermia occurred during general anesthesia. In our finding it really matched with what Bindu et al (2017) believed as non conversion group of lumbar epidural anesthesia having mean temperature of 36.5^{0}C (mild hypothermic). The conversion group (lumbar epidural anesthesia converted to general anesthesia GA having much lower mean (n=6) temperature 36.1^{0}C. We would like to suggest here that the theory perfusion index depending on parturient mothers including physiological issues, physical structure of anatomy and monitoring sites where finger probes applied. At the same time natural ability of parturient mothers establish their own homeostasis for adapting to normal perfusion index values especially at different ambient temperatures in operating theatre.

Descriptive Statistics

	n	Minimum	Maximum	Mean
Mean P I	160	3.4	4.9	4.6
OT Temperature ^{0}C	160	21.3	25.0	23.2



Tests of Normality Kolmogorov-Smirnov[a]			
OT Temperature	(t) 0.28	n = 160	p = 0.00

Figure 3: *The distribution of ambient Temperature in Operating Theatre*

Issues of temperature gradients did not correlate with cardiac output had been addressed by (Hariri et al, 2019). We also analyzed and did bivariate testing for any correlation between temperature and cardiac output. We

found similar trend whereby temperature gradients did not correlate with cardiac output as r = - 0.03, p = 0.72 (refer Figure 4). Looking at the pattern of scatter plot for both cardiac output and the mean parturient temperature, it was noted that at level of 36.5^{0}C (mild hypothermic) with initial pulse at 85/min the cardiac output at the level of 5091.75 ml (5.1 L). Hall et al (2011) highlighted the occurrence of cardiovascular changes during pregnancy including element of increasing cardiac output among parturient mothers. We were delighted to say that during pregnancy some form of body changes occur especially increasing body mass index resulting certain degree of exertion to cardiovascular system. When we compared with previous studies there had been certain description on changes in heart rate and cardiac output. In our study we noticed mean initial pulse rate per minute slightly higher in non conversion group (n = 6, 87.3 ± 11.4) of lumbar epidural anesthesia as compared to the conversion group (n = 154, 84.8 ± 10.5).

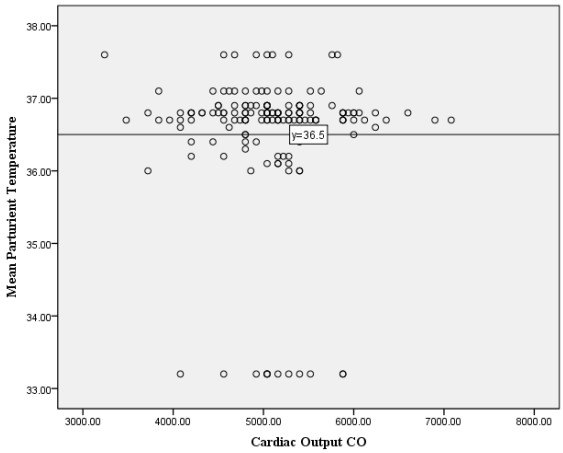


Figure 4: *The Scatter Plot between Cardiac Output and Mean Parturient Temperature*

At the moment we could say that not enough evident to relate between blood loss with clinical signs such as pulse rate and body temperature. Except a small portion of statement by Razvi et al (1996) on massive bleeding noticed if blood pressure and pulse affected and for us still vague. Obstetric blood loss as described by Ashraf et al (2006) through obstetrician's estimation of mean 539 ml. In our case at mean body temperature of 36.5^{0}C induced 519.3 ± 55.5 ml of blood lost with mean finger perfusion index PI of 4.6 ± 0.2 (refer Figure 5). We could not claim that increased of perfusion index would induced the bleeding for parturient mothers undergoing LSCS surgery.

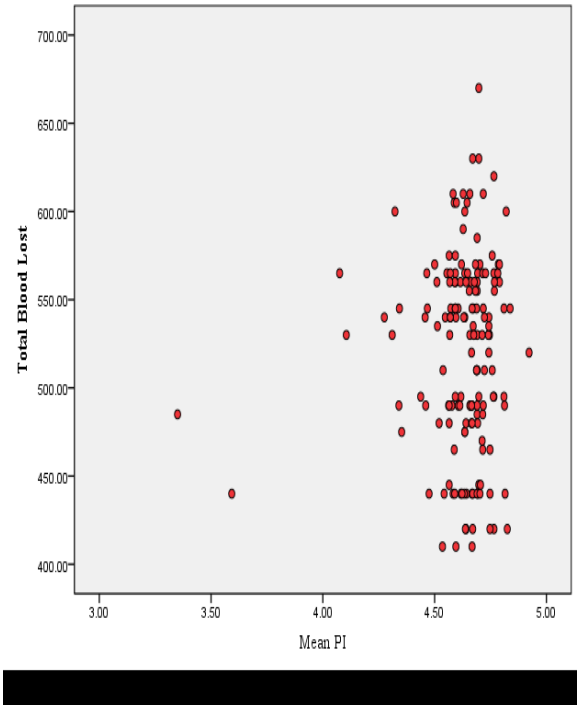


Figure 5: *The observed Value of Blood Lost in Relation to Finger Perfusion Index (Spearman's correlation r = 0.02, p = 0.79 by bivariate analysis)*

On the other hand we observed that mean ambient (operating temperature) at the level of 23.2 ± 0 .6^{0}C correspond to the mean parturient at the level of 36.5 ± 1 .0^{0}C. Nevertheless, ambient (operating theatre temperature) did not influenced the parturient's body temperature (refer Figure 6). As illustrated by Hakim Mumim et al (2018) the operating theatre temperature should be maintained at 23°C to prevent hypothermia and suggesting maintaining normal temperature for a quality clinical practice. Based on Figure 6, there was no linear relationship between parturient and operating theatre (ambient) temperature. In other word, we could not proof that ambient temperature as stimulus for skin temperature changes in this study.

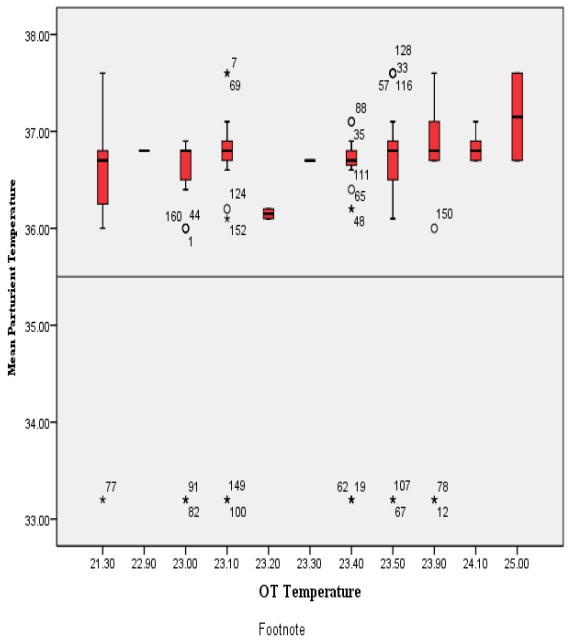


Figure 6: *The correlation of Operating Theatre Temperature with Parturient Mother's Temperature (Spearman's correlation r = 0.09, p = 0.26)*

CONCLUSION

Intra operative mild hypothermic situation in this study was inevitable among parturient mothers undergoing caesarean section surgery. Finger Perfusion Index FPI played a role as indicator for efficacy of lumbar epidural anesthesia in caesarean section surgery.

LIMITATION OF THE STUDY

A combined approach in term of measuring finger perfusion index FPI and the site device for temperature monitoring left the accessibility to the anesthesiologists' discretion.

RECOMMENDATION

Skin temperature measurement among parturient mothers required an accurate reading for clinical excellence practice. A new Pulse Oximeter Technology should have the capacity not only Pulse Scanning & Recording Technology but also could be used to measure skin temperature instead of measuring temperature conventionally through axilla. Inadvertent intra operative mild hypothermia during lumbar epidural and general anesthesia should be minimized the exposure to cold ambient (environment) in obstetric operating theatre. Thermal profiles and operating room temperature should be developed as comparative temperatures analysis for biothermal models in relation to finger perfusion index FPI in lumbar epidural anesthesia practice.

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CONFLICTS OF INTEREST

We declare that there are no conflicts of interest in this study.

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