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Pulse Oximeter Perfusion Index as an Early Indicator of Onset of Sympathectomy After Epidural Anaesthesia

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Author`s Contribution

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ABSTRACT

Objective: To establish a reliable indicator of epidural effectiveness, we compared the frequency of subjects achieving sympathectomy onset in patients undergoing lower limb surgeries under lumbar epidural anaesthesia in terms of changes in perfusion index (PI), mean arterial pressures (MAP), and toe temperature.

Methodology: This descriptive case series study was conducted at the Department of Anesthesiology, Holy Family Hospital, Rawalpindi from July 2018 - January 2019. A total of 96 patients were included, all of them received lumbar epidural catheters for lower limb surgeries and were given 10 ml of epidural bupivacaine 0.5% through the epidural catheter. Baseline values were recorded for PI in toe, MAP and temperature of toe. At 5, 10 and 20 minutes after epidural anaesthesia, these values were re-recorded. Data collection was completed before the start of surgery. Criteria for clinically evident sympathectomy was defined beforehand. The frequency of subjects reaching these predefined targets were analyzed at said time intervals using Mc-Nemar test at each time interval.

Results: For PI 66/96, 88/96 and 96/96 of subjects in the study fulfilled the criteria of achieving sympathectomy at 5, 10 and 20 minutes , respectively, compared to 7/96 , 15/96 and 59/96 for MAP changes and 0/96, 29/96 and 45/96 for changes in temperature of toe.

Conclusion: As per this study, PI seemed to be a faster, clearer and a more objective indicator of the onset of sympathectomy after epidural anaesthesia than toe temperature or MAP.

Keywords: Pulse oximeter, Perfusion index, Epidural anaesthesia, Sympathectomy.

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Introduction

Successful lumbar neuraxial blocks cause segmental sympathectomy due to the interruption of efferent sympathetic fibres producing differential vasodilatation in lower limbs. Clinical signs induced by sympathectomy can thus be used as a means of confirmation of right block placement[1]. Bedside evaluation tests of the sympathectomy onset after regional anesthesia encompasses changes in skin temperature, leg–toe temperature difference and blood pressure changes. However, these clinical signs and bedside evaluations do not offer a rapid indication to be used as an endpoint for making clinical decisions, particularly when wanting to establish epidural catheter function before general anesthesia induction [2]. Other refined assessments of vasodilatation are also available e.g Laser Doppler flowmetry however it requires fancy tools, which are not usually accessible outside an academic research setting.

The use of regional anesthesia in the developing countries, where facilities of a peripheral nerve stimulator, ultrasound and other imaging modalities is scarce, a limiting factor remains the doubt regarding the success of the block [3]. Therefore, the determination of a

reliable indicator of block success could serve to be a major step forward in the use of regional anaesthesia in the developing countries; decreasing the number of unnecessary general anaesthesia administration and associated complications and reducing the overall cost and ultimately increasing patient satisfaction.

With its almost universal presence in the OTs, a pulse oximeter`s potential to provide clinical measurements other than oxygen saturation is being explored [4]. One such application is that of perfusion index (PI). It is the ratio of pulsatile to non-pulsatile component of pulse oximetry plethysmograph and it gives a simple and true indication of changes in digital blood flow [5]. PI changes competently mirror alterations of peripheral perfusion via their clinical signs and therefore can be employed to determine the effect of therapeutic mediation on peripheral perfusion. [6,7, 8 , 10]

The utility of pulse oximeter PI to detect vasodilation due to sympathectomy has been previously studied and acknowledged and is believed to give a rapid and unequivocal manifestation of sympathectomy after epidural anaesthesia as compared to skin temperature and mean arterial pressure(MAP) [9]. *Ginosar et al,* in their study concluded that by 20 min after the administration of bupivacaine in the epidural catheter, the target increase in PI had occurred in all subjects. By comparison, only 62% and 48% of subjects had reached the aimed changes of MAP and temperature of toe, respectively.[10]

In this study, data obtained from the analysis of photoplethysmogram waveform, skin temperature and MAP recordings, were compared at certain time intervals after giving bupivacaine through the lumbar epidural to establish the fastest and the most reliable bedside assessment of sympathectomy onset, so that for the busy operation theatres earlier decision could be taken after neuraxial anaesthesia and precious operation theatre time could be saved.

Methodology

After obtaining permission from the hospital ethical board, this descriptive case series was started in the Department of Anesthesiology, Holy Family Hospital, Rawalpindi for 6 months i.e. from July 2018 to January 2019. A sample size of 96 was calculated using the WHO sample size calculator, with a confidence level of 95% , anticipated population proportion of 48.2% and absolute precision of 10%. Consecutive sampling was done. The patients included were aged 20-45 years, and belonged to ASA class 1 and 2 and were scheduled for lower limb surgeries under epidural anaesthesia alone whereas pregnant patients, patients with peripheral arterial disease, any focal neurological deficits, diabetes mellitus or any condition precluding the use of neuraxial anesthesia were excluded.

Written informed consent was taken from all the patients. Preoperative assessment was done one day before surgery, of all patients. Patients were kept nil per oral according to ASA guidelines. We conducted the study in the pre-operative area of the surgical operation theatres. Data collection was completed before the start of surgery. The total study time was 45 minutes. Room temperature was maintained at 25 C. Before the placement of epidural, all patients were given 1 L of Ringer Lactate intravenously. Epidural was placed at the L2-L3 or the L3-L4 interspace, in the lateral decubitus position with an 18-Gauge Tuohy needle (Braun Medical Inc.) by a midline approach with loss of resistance technique using air. A 20-Gauge multiorifice epidural catheter was then placed about 4cms in the epidural space. The subjects were made to rest for 20 mins after placing the epidural and before giving any dose in the catheter, after which baseline (BL) data was recorded.

All 96 subjects were given 10 ml of 0.5% bupivacaine via the catheter tubing at 2 ml/min (10mls were given over 5 min) after careful negative aspiration for blood and CSF for 30seconds. Data was recorded for a duration of 20 minutes, and the study was concluded.

We recorded PI, data from cutaneous temperature and MAP at BL and at 5, 10 and 20 min after giving bupivacaine through the epidural. The criteria for sympathectomy onset was set as a !00% relative increase in PI from baseline (rPI=100%), a 15% relative decrease in MAP from baseline (rMAP =15%) and an increase in toe temperature of 1º C (dT = 1) from baseline values. The number of subjects who fulfilled or were unable to fulfill the predefined standard for the individual tests of sympathectomy (rPI, rMAP and dT), at the set time intervals were recorded on a structured proforma.

Statistical analysis was performed using SPSS version 25 (SPSS Inc., Chicago, IL). The quantitative variables were age, sex and perfusion index, MAP and toe temperature at the BL and at 5, 10 and 20 minutes and were analysed as mean and standard deviation. The qualitative variables were the frequency of subjects reaching the pre-defined rPI, rMAP and dT at 5, 10 and 20 minutes after epidural

bupivacaine administration. Separate 2x2 contingency tables were constructed to compare rPI with rMAP and rPI with dT. A separate contingency table was drawn for each time point and we analysed them by Mc-Nemar test applied on baseline values and after achievement of sympathectomy. Statistical significance was defined as a P value less than or equal to 0.05.

Results

A total of 96 patients were enrolled in this study. This study had a population with a mean age of 30.11 ± 7.34 years. 56.67 % (53 out of 96) were males whereas 43.33% (43 out of 96) were females. Mean values of PI, MAP and toe temperature at the baseline and at 5mins, 10mins, and 20 minutes after epidural bupivacaine administration are shown in Table I. The right placement of epidural catheters was verified in all patients by giving additional amounts of local anesthetic to achieve an adequate sensory block on both sides, which permitted the scheduled surgery to be carried out without any discomfort. No adverse accidents related to the epidural catheter were reported.

The absolute changes in PI from BL (dPI), in MAP from BL (dMAP) and the skin temperature variations of toe (dT) are depicted in Table II. By 20 mins from drug administration, MAP had reduced by 17.2 ± 4.3 mm Hg (representing 16.4 ± 3.8 % reduction from BL), PI had incremented by 6.9 ± 2.2 (showing a 224.9 ± 122% rise from BL) and the toe temperature had increased by 1.1 ± 0.3°C. With the administration of epidural local anesthetic, pre-defined clinically proven target variations in PI were evident in our patients well before than rest of the two bedside parameters of sympathectomy (Table II).

Table III: Clinical indices for epidural-induced sympathectomy: numbers of patients achieving pre-defined goal indicative of sympathectomy overtime.

Pre-defined goals for onset of sympathectomy	Duration following the epidural dose (min)	Number achieving pre-defined rPI, rMAP and dT	Percentage achieving pre-defined rPI, rMAP and dT
r PI toe (100% change from the baseline)	5 mins	66/96	68.75 %
	10 mins	88/96	91.67 %
	20 mins	96/96	100 %
r MAP (15% change from baseline)	5 mins	7/96	7.29 %
	10 mins	15/96	15.62 %
	20 mins	59/96	61.46 %
d T(toe) (1°C change from baseline)	5 mins	0/96	0 %
	10 mins	29/96	30.20 %
	20 mins	45/96	46.87 %

After 20 min from epidural drug administration, the objective rise in PI of a minimum of a 100% rise from BL had happened in 96 subjects unanimously. Whereas, only 61.4 % and 46.8% of patients had reached target changes in MAP and toe temperature, respectively. Likewise, at 5min from drug administration, 68.7% had reached the target rise in PI, whereas only 7.3% and 0% had reached the target changes in MAP and toe temperature, respectively. These end-points as relative change in PI ($rPI = dPI/PI_{BL} X 100$) , relative change in MAP ($rMAP = dMAP/MAP_{BL} x 100$) and absolute change in toe temperature ($dT = T_{EPIDURAL} – T_{BL}$) at 5, 10 and 20 mins after epidural drug administration were calculated and are presented as numbers and percentages of subjects achieving the pre-defined rPI, rMAP and dT for onset of sympathectomy in Table III.

The McNemar test (which is grounded on 2x2 possibility

Table I: Bedside indices for epidural-induced sympathectomy: mean values at the baseline and at 5 , 10 and 20 mins following epidural bupivacaine administration.

	Quantitative variables	Baseline	5 mins	10 mins	20 mins
Mean ± SD	PI	3.71 ± 1.79	7.07 ± 3.41	8.45 ± 3.54	10.68 ± 3.50
	MAP	104.86 ± 9.86	98.43 ± 10.07	92.80 ± 9.34	87.65 ± 9.07
	Toe temp	27.60 ± 2.06	27.95 ± 2.07	28.33 ± 2.13	28.68 ± 2.15

Table II: Clinical parameters for epidural-induced sympathectomy: variations over time after administration of bupivacaine in epidural.

	Absolute change from baseline	Time following the epidural drug		
		5 mins	10 mins	20 mins
Mean ± SD	d PI toe	3.35 ± 1.84	4.73 ± 1.93	6.96 ± 2.23
	d MAP (mmHg)	-6.44 ± 3.61	-12.06 ± 3.97	-17.21 ± 4.33
	d T (toe) (°C)	0.35 ± 0.17	0.73 ± 0.29	1.08 ± 0.36

Descriptives expressed as absolute change from baseline. Values given as mean ± SD.
dPI = PI EPIDURAL- PI BL, dMAP= MAPEPIDURAL-MAPBL, dT= dEPIDURAL-dBL

tables) could not be used at some data points due to unanimity in data, but at all other statistics points the McNemar test was applied, and the p-values were consistently found to be significant, as shown in Table IV.

Table IV : Comparison of Clinical indices for epidural-induced sympathectomy : numbers of patients achieving pre-defined goals indicative of sympathectomy overtime, with P values.

Time following the epidural dose (min)	Comaprison of Pre-defined goal of onset of sympathectomy	Comparison of Number of subjects achieving pre-defined rPI, rMAP and dT	Percentage achieving pre-defined rPI, rMAP and dT	P value ($p < 0.05$ = LOS)
5 mins	r PI vs r MAP	66/96	68.75 %	**< 0.0001**
		7/96	7.29 %	
	d T	0/96	0 %	
10 mins	r PI vs r MAP	88/96	91.67 %	**< 0.0001**
		15/96	15.62%	
	r MAP vs d T	15/96	15.62 %	**p =0.0165**
		29/96	30.20%	
	d T vs r PI	29/96	30.20 %	**< 0.0001**
		88/96	91.67%	
20 mins	r PI vs r MAP	96/96	100 %	**< 0.0001**
		59/96	61.46%	
	r MAP vs d T	59/96	61.46 %	**p =0.0430**
		45/96	46.87%	
	d T vs r PI	45/96	46.87 %	**< 0.0001**
		96/96	100%	

Discussion

In this study, we used Photoplethysmography (PPG) derived PI as an indication of vasodilation due to sympathectomy in the toe after epidural anesthesia. PPG has formerly been used to identify volume variations in the microvasculature of tissues [11–13] and has been used to accurately guide fluctuations in sympathetic activity.[14] This study displays the efficacy of quantitative PPG exploration in detecting the commencement of sympathectomy.

After epidural anesthesia, the incremental change and as well as the relative change in PI were more pronounced and were statistically significant earlier than for variations in MAP or cutaneous temperature. The skin temperature of the great toe has been noted to rise by about 1.5 °C and 6 °C, respectively, by 10 and 20 min following epidural anesthesia;[15] we designated a 1 °C temperature variation in the big toe as a clinically noticeable mark point within this range. Published criteria of intraoperative hypotension are enormously variable; those depending on the MAP generally define a decline from BL of 20% or more.[16] Since we determined normal sympathectomy induced decline in arterial blood pressure instead of actual arterial hypotension, we used extra comprehensive criterion of 15% drop from BL as our criterion. We intentionally appointed a new stringent criterion for PI, as this was the key diagnostic test under scrutiny, and defined a 100% change from BL. In spite of this, PI provided an affirmative proof of sympathectomy due to epidural anaesthesia, prior, objectively and more persistently than any of the MAP or the cutaneous temperature.

Artifacts in the PPG waveform has been recorded in 45% of ICU patients,[17] while 77% of saturation probe alarms in the post-anesthesia care unit are due to a signal artifact.[18] Online, real- time quantitative PPG waveform exploration with computed PI, has become available lately, in latest generation pulse oximeters, and the feature of a real-time waveform could surely help minimize the effect of artifacts. A likely restraint in the study is the likelihood of a right–left disparity in the advent of sympathetic changes in the PPG trace, which has been documented after epidural anesthesia.[19] In current study, since all the data was measured unilaterally, the relative right- or left-sided preponderance of the sympathectomy would apply to both approaches equally.

The skin temperature change was found to be a late indicator of sympathectomy, despite formerly published studies delineating its usefulness.[20] .We also found PPG

to be a rapid and more sensitive pointer of sympathectomy than variations in MAP. There is a possibility that preloading all patients with 1 L of Ringer lactate and use of a somewhat lower dose of epidural bupivacaine may have led to reduced sensitivity of MAP as a tool for detecting sympathectomy, further quality research on the topic can be done to rule out the effect of these potential confounders.

Conclusion

Our data suggests that the pulse oximeter PI, is a suitable point of care diagnostic tool for the confirmation of epidural induced sympathectomy; it gives a rapid and a more objective indication of sympathetic blockade than the other clinical diagnostic parameters tested.

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