

# EPIDURAL ANALGESIA FOR LABOUR: COMPARING THE EFFECTS OF CONTINUOUS EPIDURAL INFUSION (CEI) AND PROGRAMMED INTERMITTENT EPIDURAL BOLUS (PIEB) ON OBSTETRIC OUTCOMES

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## Abstract

**Objective:** In the last few years there is a trend of transiting from the continuous epidural infusion (CEI) method for epidural analgesia to a new method – programmed intermittent epidural analgesia (PIEB). This change improves the quality of epidural analgesia, thanks to an increased spread of the anaesthetic in the epidural space and higher maternal satisfaction. Nevertheless, we must make sure that such change of method does not lead to worse obstetric and neonatal outcomes.

**Materials and Methods:** This is a retrospective observational case control study. We compared several obstetrical outcomes between the CEI and PIEB groups, such as the rates of instrumental delivery, rates of caesarean section, duration of first and second stages of labour well as APGAR scores. We further segmented the subjects and examined them in groups of nulliparous and multiparous parturients.

**Results:** 2696 parturients were included in this study: 1387 (51.4%) parturients in the CEI group and 1309 (48.6%) parturients in the PIEB group. No significant difference was found in instrumental or caesarean section delivery rates between groups. This result held even when the groups were differentiated between nulliparous and multiparous. No differences were revealed regarding first and second stage duration or APGAR scores.

**Conclusion:** Our study demonstrates transition from the CEI to the PIEB method does not lead to any statistically significant effects on either obstetric or neonatal outcomes.

## Keywords

Epidural anaesthesia • labour analgesia • continuous epidural infusion • programmed intermittent epidural bolus analgesia

## Introduction

Labour is an ongoing process during which the mother experiences very significant pain. The intensity of this pain is affected by many factors, and it is known that the ability to control and moderate it has positive psychological and physiological impacts on the mother, both immediately and in the long run [1-3]. Epidural analgesia is the most common option for pain relief during delivery, with a rate of 60% in Israel [4] and 71% in the United States [5].

Nevertheless, epidural analgesia has been found to be associated with an increase in the rates of side effects such as decreased blood pressure, increased maternal

fever, urinary retention, prolonged labour duration, higher incidence of motor block, need for oxytocin administration and increased rates of instrumental labours [6,7,8]. The frequencies of instrumental labours and caesarean sections are higher among nulliparous parturients compared to multiparous ones. In both groups, it has been shown that the use of epidural analgesia is correlated to higher rates of instrumental labours and caesarean sections, and to the prolongation of the second stage of labour [9-12].

During labour, there is a need for continuous analgesia, which may be achieved by: a) a slow ongoing infusion

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of an anaesthetic into the epidural space – continuous epidural infusion (CEI); b) bolus infusion of an anaesthetic at regular intervals in accordance with a predefined program – programmed intermittent epidural bolus (PIEB). These methods provide the parturient with a stable basic level of local analgesia throughout the labour. In addition, the parturient is given the option of raising the dose of anaesthetics in a controlled manner using a pressure control device – patient-controlled epidural analgesia (PCEA) [6,13].

For many years, the CEI method was considered the treatment of choice, while recent technological advancements have made the PIEB method more available and accessible. Studies comparing these two methods note advantages of the PIEB method compared to the CEI method: lower intensity of pain, higher satisfaction levels, decreased rates of motor blocks and pain breakthroughs, lower dosages of anaesthetics and better obstetric outcomes (lower rates of instrumental deliveries and shorter labour duration) [13-17]. The proposed explanation for this is that the quick infusion of a bolus dose as given in the PIEB method enables a better and more even distribution of the anaesthetic in the epidural space, compared to the CEI method in which the infusion is performed at a slow and constant rate [18]. In a study comparing the two methods in nulliparous parturients, a lower incidence of motor block and instrumental labours was found in the PIEB group, compared to the CEI group. No difference was found in the duration of the first and second stages of labour [15].

In conformity to global trends, a change has been applied to the epidural analgesia method in our institution from the CEI method to PIEB method. Shaare Zedek Medical Center of Jerusalem, tertiary hospital, has the largest number of labours, averaging at 16,000 annual labours, of which a notable percentage (76%) are recurrent labours.

In these times when new methods come into practice, we believe there is great clinical importance to a study that helps deepen the understanding of the manners in which the different epidural analgesia methods may affect the general obstetric outcomes, and instrumental labours specifically. Moreover, due to the differences in obstetric patterns in recurrent labours compared to first-time labours, we believe that the result should be examined for each of these groups individually.

Therefore, we performed a comparative retrospective study in which our aim was to examine whether the method of epidural analgesia administration (PIEB versus CEI) has an effect on the obstetric outcomes – the frequency of instrumental labours in nullipara parturients and multipara parturients, the rate of caesarean sections, the duration of the first and second stages of labour, and the Apgar 1 and Apgar 5 scores of the neonate.

## Materials and Methods

### Study Design

During August and September 2018, there has been a change applied to the epidural analgesia administration method at our institution, switching from the CEI method (with continuous infusion of 0.1% bupivacaine + fentanyl 2 mcg/ml solution - 10 mL/h and patient-controlled boluses of 5 mL each and a lockout interval of 15 minutes) to the PIEB method (with mandatory programmed intermittent epidural 5mL boluses of 0.2% ropivacaine + fentanyl 2 mcg/ml solution with an additional option for patient-controlled 7mL boluses with a lockout interval of 20 minutes). We examined the relationship between the method of epidural analgesia administration and the obstetric outcomes.

A retrospective cohort database study was conducted at Shaare Zedek Medical Center (SZMC) between March and May 2019. All women receiving epidural analgesia by CEI in January-February 2018 or by PIEB in January-February 2019 were included. We excluded women with multifetal pregnancies, background diseases, and ASA score III-IV.

SZMC's medical record database on all labours and deliveries is updated in real time during labour and delivery by attending healthcare professionals and audited periodically by trained technical personnel to ensure validity of the data. Over 95% of Israeli citizens' medical care is covered by the Israeli National Health Plan, hence continuity of care is granted for long periods of time for most of the patients. Maternal and neonatal records were reviewed and retrieved for relevant data, information was coded and identifiable, and personal information for each parturient was protected by anonymization prior to analysis.

The following data were collected regarding each parturient:

- a) **general background:** age, background diseases;
- b) **obstetric history:** number of pregnancies / labours, previous caesarean sections;
- c) **current pregnancy:** number of fetuses, gestational age at the time of labour;
- d) **epidural analgesia administration method:** PIEB / CEI;
- e) **obstetric outcomes:** labour onset type (spontaneous / augmentation), duration of the first and second stages of labour, type of labour (vaginal- NVD / instrumental-vacuum / caesarean section- CS), neonatal characteristics (birth weight, Apgar score at 1 and 5 minutes).

A comparison was made between the obstetric outcomes of all parturients in the control group (CEI) and those of the study group (PIEB). Primary outcome was the rates of instrumental delivery. Secondary outcome was: rates of caesarean section, duration of first and second stages

of labour, and APGAR scores at 1 and 5 minutes. An additional comparison was made following a segmentation of the subjects in each group to nulliparous and multiparous parturients.

### Statistical Analysis

An initial univariate analysis was carried out, categorical variables were presented as a percentage and compared using chi square and Fisher's exact test, as appropriate. Continuous variables presentation was according to each variable distribution, while normal distributed variables were presented as a mean and standard deviation; those displaying non-normal distribution were presented as median with interquartile range. A comparison was made using Student's t-test and Mann Whitney test, accordingly. All analyses were two-sided and a p value < 0.05 was considered statistically significant. A sub-group analysis comparing nulliparity to multiparity was conducted.

Data analysis was carried out using SPSS software (version 23 statistical package; IBM, Armonk, NY). The study was approved by the local institutional ethics committee in accordance with the principles of the Declaration of Helsinki (approval number 0214-19-SZMC).

## Results

The study reviewed a total of 2984 medical records of parturients at our institution during the study period. After filtering these records according to the exclusion criteria, a total of 2696 women were included in the study, of which 1387 (51.4%) parturients received epidural analgesia by the CEI method and 1309 (48.6%) parturients received epidural analgesia by the PIEB method.

There was no statistically significant difference in demographic data between groups (Table 1).

Mean, median, and standard deviation were calculated for the continuous variables: maternal age, number of pregnancies (gravity), and labours (parity), gestational age at the time of labour, duration of the first and second stages of labour and the weight of the newborn (Table 2). In addition, an analysis was performed for the above continuous variables using t-test. No significant difference was found in these characteristics between the subjects in the CEI group and the PIEB (Table 3). 789 (29.3%) parturients were nulliparous and 1907 (70.7%) parturients were multiparous.

Regarding the mode of delivery – 88% of the parturients gave birth by normal vaginal delivery (NVD), 8% by instrumental

Table 1: Categorical Variables – Descriptive Statistics and  $\chi^2$  Test

		CEI	PIEB	Total	P Value- Chi Square test
<b>N (%)</b>		1387 (51.4%)	1309 (48.6%)	2696 (100%)	
<b>Number of Births</b>	Nulliparous	406 (29.3%)	383 (29.3%)	789 (29.3%)	0.994
	Multiparous	981 (70.7%)	926 (70.7%)	1907 (70.7%)	
<b>Type of Delivery</b>	NVD	1211 (87.3%)	1162 (88.8%)	2373 (88.0%)	0.44
	Vacuum	116 (8.4%)	101 (7.7%)	217 (8.0%)	
	CS	60 (4.3%)	46 (3.5%)	106 (3.9%)	
<b>Initiation of Delivery</b>	Spontaneous	1171 (84.4%)	1115 (85.2%)	2286 (84.8%)	0.586
	Augmentation	216 (15.6%)	194 (14.8%)	410 (15.2%)	
<b>Birth Weight</b>	BW<4 kg	1299 (93.7%)	1224 (93.5%)	2523 (93.6%)	0.875
	BW>=4 kg	88 (6.3%)	85 (6.5%)	173 (6.4%)	
<b>Any past CS</b>	No	1278 (92.1%)	1193 (91.1%)	2471 (91.7%)	0.347
	Yes	109 (7.9%)	116 (8.9%)	225 (8.3%)	
<b>APGAR 1</b>	Apgar<=7	52 (3.7%)	35 (2.7%)	87 (3.2)	0.114
	Apgar>8	1335 (96.3%)	1274 (97.3%)	2609 (96.8%)	
<b>APGAR 5</b>	Apgar<=7	15 (1.1%)	8 (0.6%)	23 (0.9%)	0.184
	Apgar>8	1372 (98.9%)	1301 (99.4%)	2673 (99.1%)	

Table 2: Descriptive Statistics of Maternal, Labour and Newborn Characteristics

	Age	Gravity	Parity	Gestational age (weeks)	Birth Weight	1 <sup>st</sup> Stage of labor (hours)	2 <sup>nd</sup> Stage of labor (hours)
<b>Mean</b>	29.02	3.65	3.22	39.36	3322	8.6	0.75
<b>Median</b>	28	3	2	40	3330	7.4	0.3
<b>Std. Deviation</b>	5.66	2.8	2.4	1.59	464.64	5.99	0.95

delivery (vacuum), and 3.9% by caesarean section (Table 1). There was no significant difference between the methods of administering epidural analgesia (CEI / PIEB) and the frequency of instrumental labours and / or caesarean sections (Table 1,  $p > 0.05$ ).

Frequency of instrumental labours and caesarean sections is lower among multiparous parturients (4.1% and 2.3% respectively) compared to nulliparous parturients (17.6% and 8%).

In nulliparous parturients percentages of instrumental deliveries (ID) and caesarean deliveries (CD) in the CEI

group were found to be 20% and 8.1% respectively, while the PIEB group presented lower frequencies of 15.1% and 7.8%, respectively. This difference was not statistically significant (Table 4,  $p = 0.192$ ). This trend was not observed in multiparous parturients, where the frequencies of ID and CD were similar in both groups.

No significant difference was found between the two groups (CEI / PIEB) in terms of duration of the first and second stages of labour. Also, in the analysis according to nulliparous and multiparous parturients, no difference was found between groups.

Table 3: Descriptive Statistics of Maternal, Labour and Newborn Characteristics by Groups (CEI / PIEB)

	Study Group	Mean	Std. Deviation	Std. Error Mean	Sig. (2-tailed)
Age	CEI	29.0	5.61	0.15	0.97
	PIEB	29.0	5.73	0.16	
Gravity	CEI	3.7	2.82	0.08	0.79
	PIEB	3.6	2.79	0.08	
Parity	CEI	3.2	2.45	0.07	0.59
	PIEB	3.2	2.36	0.07	
Gestational age	CEI	39.4	1.46	0.04	0.06
	PIEB	39.3	1.71	0.05	
Birth Weight	CEI	3326.7	452.2	12.14	0.62
	PIEB	3317.8	477.6	13.21	
1 <sup>st</sup> Stage of labour (hours)	CEI	8.8	6.33	0.18	0.13
	PIEB	8.4	5.61	0.17	
2 <sup>nd</sup> Stage of labour (hours)	CEI	0.8	0.96	0.03	0.91
	PIEB	0.7	0.93	0.03	

Table 4: Mode of Delivery Depending on the Method of Epidural Analgesia Administration, Segmented to Nulliparous and Multiparous Parturients

		NVD	Vacuum	CS	Total	P Value- Chi Square test
Nulliparous	CEI	292 (71.9%)	81 (20%)	33 (8.1%)	406	0.192
	PIEB	295 (77%)	58 (15.1%)	30 (7.8%)	383	
Multiparous	CEI	919 (93.7%)	35 (3.6%)	27 (2.8%)	981	0.168
	PIEB	867 (93.6%)	43 (4.6%)	16 (1.7%)	926	

Table 5: Duration of the First and Second Stages of Labour Depending on the Method of Epidural Analgesia Administration, Segmented to Nulliparous and Multiparous Parturients

		N	Mean (hours)	Std. Deviation	p-value (t-test)	
Nulliparous	1 <sup>st</sup> stage of labour	CEI	334	10.84	6.03	0.64
		PIEB	323	10.62	6.04	
	2 <sup>nd</sup> stage of labour	CEI	376	1.75	1.09	0.24
		PIEB	360	1.66	1.06	
Multiparous	1 <sup>st</sup> Stage of labour	CEI	853	7.98	6.26	0.12
		PIEB	826	7.54	5.18	
	2 <sup>nd</sup> Stage of labour	CEI	944	0.35	0.52	0.22
		PIEB	903	0.38	0.55	

No significant difference was seen between epidural analgesia administration methods (CEI / PIEB) regarding Apgar scores at 1 minute and 5 minutes after birth (Table 1).

## Discussion

During the year 2018, a change has been applied to the epidural analgesia administration method at our institution, with a transition from the CEI method to the PIEB method. As is well known, any change to the practice must be based on studies showing the method's advantages and proving that such a change does not involve an increase in the frequency of clinical complications. Numerous studies have shown that administering an epidural analgesia using the PIEB method is effective and safe for both the mother and the fetus [13-17]. These studies supported the transition from the traditional CEI method to the PIEB method and as a result a change has been made in clinical practice around the world. Our study was conducted with the aim of examining whether the positive trends seen in the world are consistent with our results and that the transition to epidural delivery using the PIEB method is indeed effective and safe in our institution as well.

The findings of this study show that changing the method of epidural analgesia administration from CEI to PIEB does not involve an increase in the rate of instrumental or operative deliveries. The two methods were found to be similar in terms of the incidence of instrumental labours, frequency of caesarean sections, duration of the first and second stages of labour, and Apgar 1 and Apgar 5 scores of the newborn. Moreover, no significant differences were found between the CEI group and the PIEB group after the segmentation of the subjects in each group to nulliparous and multiparous parturients. The results presented in this study differ from most of the existing data in the scientific literature, which notes a clear preference for the PIEB method [14-17].

We suggest that these differences may be due, among other things, to the unique characteristics of the maternity population in Israel in our institution. According to OECD data for 2017, the average number of children a woman gives birth to during her lifetime is 1.7. When comparing these countries, it can be seen that in the United States and Europe the average is very close to that of all OECD countries (1.8 and 1.6 respectively), while Israel is at the top of the table, with an average of 3.1 children per woman [19].

We believe that in research dealing with obstetric outcomes there is great importance in segmenting the subjects according to nulliparous and multiparous parturients. In similar studies conducted around the world, it can be seen that after segmenting the subjects in such a manner, most of the parturients examined were nulliparous [10,20]. In contrast,

in our study 70.7% of the subjects were multiparous, with an average of 3.2 labours.

Among nulliparous parturients, the current study showed a prominent, but not statistically significant, decrease in the rate of instrumental labours and caesarean sections with the transition from the CEI method to the PIEB method. This trend has not been observed in multiparous subjects. Therefore, it is suggested that, for multiparous parturients, there may not be a clear advantage to one method over the other, while for nulliparous parturients, there is an advantage to the PIEB method, similarly to what is described in the literature. Unlike other studies conducted around the world, the current sample mostly consisted of multiparous subjects, and this may be the reason why no significant advantage was found for this method. Nevertheless, we propose to conduct further studies, with a larger sample of nulliparous subjects to determine how changing the method of epidural analgesia administration affects this group.

Although no significant advantages to the PIEB were found, the fact that there has been no increase in the frequency of instrumental or operative deliveries following the transition from the CEI method is of great clinical importance. Considering its high fertility rate, even a slight increase in Israel's percentage of instrumental labours and caesarean sections may result in a substantial increase in the rate of repeat caesarean sections. Such an increase is followed by clinical and institutional consequences, ranging from obstetric complications to excess workload on the medical staff and the healthcare system.

Many works have established the link between providing epidural analgesia and prolonging the first and second stages of labour [11]. Subsequent studies have shown that this effect can be mitigated by using lower concentrations of the local anaesthetic [12]. Examining the relationship between the method of epidural analgesia administration and the obstetric outcomes, we asked, among other things, to trace the manners in which the duration of the first and second stages of labour are affected. A review of the literature revealed that administering an epidural using the PIEB method is associated with a shorter duration of labour stages compared with the CEI method [13,21]. Moreover, a meta-analysis found that using the PIEB method decreased the frequency of interventions for the administration of additional doses of anaesthetics and resulted in a higher level of reported maternal satisfaction [21]. It is possible that the shortening of the duration of the labour stages is related, among other things, to the fact that the PIEB method reduces the need for additional interventions related to anaesthesia, and thus in fact, smaller doses of anaesthetics are administered throughout the labour. In this study, no significant difference was found regarding the duration of labour stages between the control group (CEI) and the study group (PIEB), even after the segmentation of the subjects to



nulliparous and multiparous parturients. Therefore, based on this data, we cannot say that there is a correlation between the method of administering the epidural analgesia and the duration of labour stages.

Finally, we examined whether, and in what manner, the change of the epidural administration method affected the newborn's condition. Previous works showed that the use of epidural analgesia is not related to an increase in fetal stress expressed, *inter alia*, by a low Apgar 1 and/or Apgar 5 score [8]. In addition, a review consisting of 17 studies revealed that Apgar scores were not affected by the method of epidural analgesia administration and were similar in the CEI group and the PIEB group [14]. Similarly, our study found no significant difference between the two groups. These results support the existing information from the literature and indicate that the transition to the PIEB method does not involve an increase in the incidence of instrumental or operative deliveries.

The strengths of this study are the large number of subjects ( $n = 2696$ ) and the maternity population, which mainly includes multiparous parturients. Unlike previous studies, the sample in this work faithfully represents the unique obstetric characteristics of Israel. This makes this study different and unique compared to studies conducted so far in the field, in which the samples were composed mainly of nulliparous parturients. As for the limitations of the study, it was conducted as a retrospective study and was based on past data documented in the digital medical record. Unfortunately, at the time of data collection, some important information was not documented in the files, including maternal satisfaction and Bromage score for assessment of the prevalence of motor blocks.

Another notable limitation is that apart from the change made in the method of administering the epidural, a change was also applied to the type of local anaesthetic used. The CEI group was given 0.1% bupivacaine in combination with a 2 mcg / ml fentanyl solution, while the PIEB group was given 0.2% ropivacaine in combination with a 2 mcg / ml fentanyl solution. Although the two substances differ from each other in terms of toxicity and pharmacokinetic properties, many studies comparing the substances found no differences in maternal satisfaction, effect on the fetus, course of birth, or other obstetric characteristics [22]. Moreover, according to literature, there is no significant difference in terms of potency of the substance, comparing a 0.2% ropivacaine dose and a 0.1% bupivacaine dose [23,24]. Since in the dosages we used the two substances have a very similar effect, the assumption is that the change in the substance should not affect the results of the study.

Our results show that the PIEB method does not involve more complications for the mother and fetus than the CEI method; however, every precaution should be taken to

avoid accidental dural puncture. A test dose should then be performed as usual to rule out catheter entry into the spinal cavity. Make sure the catheter is not in the blood vessels through aspiration [25].

To conclude, the results of this study showed that there is no significant difference between CEI and PIEB methods in the frequency of instrumental labours and caesarean sections, in the duration of the first and second stages of labour, and in the neonatal Apgar 1 and Apgar 5 scores. There does not appear to be a significant difference even after segmentation of subjects to nulliparous and multiparous parturients. The main significance of these data is that there has been no increase in the rate of instrumental or operative deliveries following the transition from the traditional CEI method to the PIEB method. These results support the findings presented in the literature. Given these findings, it can be said that providing an epidural using the PIEB method is at least as safe as using the traditional CEI method and therefore, PIEB may be used as the standard of care.

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**Informed consent:** Informed consent was not sought for the present study because it is a retrospective study.

**Ethical approval:** Ethical approval for this study was obtained from SZMC ethics committee in accordance with the principles of the Declaration of Helsinki approval number 0214-19-SZMC.

**Trial registration:** This clinical trial was not registered because it is a retrospective study.

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