# PREDICTIVE MODEL FOR THE INADEQUATE LABOR EPIDURAL ANALGESIA: AN OUTCOME OF THE PROSPECTIVE OBSERVATIONAL STUDY AT UNIVERSITY WOMEN'S HOSPITAL*

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## Abstract

*Background:* Continuous epidural analgesic infusions provide superior analgesia as compared to other forms of labor analgesia. However, inadequate analgesia after labor epidurals is not uncommon and has been found to be as high as 24% in some studies. The mechanism of these failures include inappropriate epidural catheter location, tissue compartmentalization within epidural space, delayed migration, kinking, occlusion or disconnection of correctly placed epidural catheter.

*Aims:* The aim of our study was to examine the effect of various factors on the incidence of inadequate pain relief with labor epidurals.

*Methods:* Eighteen independent potential risk factors for failed epidurals were collected from each parturient: patient characteristics (body mass index, history of failed epidural, opioid tolerance, illicit drug use and back abnormalities), labor details (parity, singleton versus multiples pregnancies, induced versus spontaneous labor, augmentation with oxytocin, malpresentation and cervical dilatation greater than 7 cm), epidural technique (experience of the operator-resident/specialist, method of loss of resistance-air/saline, paresthesia during epidural insertion, difficult insertion, ultrasound used, and number of attempts) and other factors (time of epidural insertion).

*Results:* Data collected from 502 parturients showed that difficulty in placement of epidural catheter was reported in 43 (8.6%) patients. Inadequate pain relief was seen in 104 (21%) parturients. Cervical dilatation >7 cm, previous failed epidural analgesia, paresthesia during epidural insertion, and loss of resistance using air were found to be the best predictors of inadequate epidural analgesia A constructed classification table showed that the predictive model correctly classified 96.7% of successful epidurals of producing adequate pain relief. However, the predictive model correctly classified only eighteen failed/inadequate epidurals (16.8%) as failures. Overall, 79.7% of the epidurals placed were successfully classified by the predictive model.

*Conclusion:* In parturients identified as being at high risk for failed epidural, ultrasound guidance, saline-based loss of resistance technique, and appropriate intra-epidural-space length of catheter are the methods that should be utilized to lower the incidence of failure.

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## Introduction

Labor epidurals provide superior analgesia as compared to other forms of pain control during labor[1]. Major improvements in safe delivery and efficacy of labor epidural analgesia have ensured satisfactory birth and delivery experience in parturients; however, the variable percentage of failed or inadequate analgesia ranging from 0.9% to 24% still remains a major barrier to attaining a perfect score in the maternal satisfaction scale[2-3]. The various reasons for these failures can be inappropriate epidural catheter location, tissue compartmentalization within epidural space, and delayed migration, kinking, occlusion or disconnection of correctly placed epidural catheter. Lang et al reported a case of epidural lipomatosis contributing to failed epidural analgesia[4]. Agaram et al additionally documented cervical dilatation greater than 7 cm, opioid tolerance, a history of failed epidurals, and epidural insertion by residents as contributors for failed epidurals[1]. Le Coq et al reported radicular pain during the epidural placement, ineffectiveness of initial dose of local anesthetics in regards to pain-relief, fetal presentation (posterior), and prolonged as well as short labor (greater than 6 hours or shorter than 1 hour) as additional risk factors for failed epidurals[2]. Moreover, inappropriate intra-epidural-space catheter length (less than 3 cm, or more than 6 cm) also contribute to failed epidurals[4-8]. An additional drawback of failed labor epidural is the inability to further provide surgical anesthesia via epidural route for urgent cesarean sections.

The aim of our study was to examine the effect of several factors on the incidence of inadequate pain relief with labor epidurals.

## Methods

After institutional review board approval with waiver for written informed consent, prospective data was collected from 502 parturients. In all cases, epidural catheter was inserted in a sitting position, using loss of resistance technique with air or saline, at lumbar interspace levels L2-L3 or L3-L4 with a 17 gauge Tuohy needle. 19-gauge closed tip spring wound multi-orifice catheters were inserted 4 to 6 cm into the epidural space. A standard epidural bolus of 10mcg/ml fentanyl in 10 ml of 0.125% bupivacaine was injected and was followed by the epidural infusion of 2.5mcg/ml fentanyl in 0.125% bupivacaine at a rate of 8-10 ml/hr. Prior to epidural placement baseline noninvasive monitors were applied which included maternal blood pressure, heart rate, pulse oximetry and fetal heart rate monitors. Difficult epidural insertion was defined as more than 2 attempts before successful placement and/or substantial difficulties identifying landmarks. The term "opioid tolerance" was used if the parturient was a regular opioid user for more than 3 months. Pain was assessed 30 minutes after epidural insertion using a verbal pain scale (VPS) of 0 to 100 (0 = no pain, 100 = worst imaginable pain). A score of 10 or more was considered as an inadequate analgesia. Evaluation was based on abdominal or back pain resulting from uterine contractions. Additionally, inadequate labor analgesia was considered if an additional dose of local anesthetics was administered within 30 minutes of epidural insertion. The following 18 independent variables were collected from each parturient: patient characteristics (body mass index, history of failed epidural, opioid tolerance, illicit drug use and back abnormalities), labor details (parity, singleton versus multiples pregnancies, induced versus spontaneous labor, augmentation with oxytocin, malpresentation and cervical dilatation greater than 7 cm), epidural technique (experience of the operator-resident/specialist, method of loss of resistance-air/saline, paresthesia during epidural insertion, difficult insertion, ultrasound used, and number of attempts and time of epidural insertion. Parturients whose pain relief was not being assessed at 30 min (rapid progress to the second stage or delivery) and parturients whose epidurals were clearly not in the epidural space as evidenced by a wet tap or intravascular placement of the epidural catheter were excluded from the study.

Pearson's $\chi 2$ test calculated the P values for eliciting association between the risk-factor and incidence of inadequate epidural analgesia. Yates' continuity correction had to be used to attenuate the effect of the small contingency tables that had fewer than five values. The P-value of $<0.05$ was considered

significant. After entry of all the factors in to a forward stepwise logistic regression model, low-to-no impact factors for outcome were discarded to extract the final model containing greatest impact factors. The greatest factors constructed a classification table to elicit the power of prediction of inadequate labor epidural analgesia. Minimum sample size as calculated was 180 parturients based on a rule of thumb for logistic regression with dichotomous dependant variables (minimum 10 subjects for each variable risk factor studied).

## Results

Out of the 502 parturients included into the study, 171 patients (34.1%) were multiparous and 331 patients (65.9%) were primiparous. In 147 patients (29.3%), labor was induced, most commonly with prostaglandins, and in 176 patients (35.1%) labor was augmented with oxytocin. At the time of epidural insertion 436 patients (86.9%) had a cervical dilatation of less than 7 cm. The majority of operators (in 465 patients: 92.6% cases) used air for loss of resistance (LOR) technique. Epidurals were reported as difficult to insert in 43 patients (8.6%) (Tables 1-2). Based on the strict cut-off of VPS of 10/100, 104 parturients (21%) had inadequate pain relief; though with more acceptable cut-off of VPS 40/100, the inadequate epidural analgesia in our study patient population was 3.4% (17 patients). Univariate analysis using $\chi 2$ test showed that previous history of failure of epidural analgesia, multiparity, oxytocin use, induction of labor, LOR with air, cervical dilatation >7 cm at insertion, and paresthesia during epidural insertion had statistically significant associations with inadequate analgesia (Table 1). Subsequently, forward stepwise logistic regression model determined that cervical dilatation >7 cm, previous history of failed epidural analgesia, paresthesia during epidural insertion, and loss of resistance using air were found to be the best predictors of inadequate epidural analgesia (Table 3). A classification table based on the final model of logistic regression is showed in Table 4 and this model correctly classified 96.7% of epidurals producing adequate pain relief; however, it classified only eighteen inadequate epidurals (16.8%) correctly. Overall, 79.7% of the epidurals were successfully classified by the model.

*Table 1*
*Factors Associated with Inadequate Epidural Analgesia– Univariate Analysis*

| Variable | P value (Pearson's) |
|---|---|
| Obesity | 0.369 |
| **History of failed epidural** | **0.001** |
| **Multiparity versus primiparity** | **0.021** |
| **Air versus saline for loss of resistance** | **0.020** |
| **Cervical dilation greater than7 cm** | **0.001** |
| **Oxytocin usage** | **0.012** |
| **Induction of labor** | **0.023** |
| **Paresthesia during epidural insertion** | **0.001** |
| Singleton versus multiples pregnancies | 0.062 |
| Malpresentation | 0.126 |
| Opioid tolerance | 0.451 |
| Illicit drug use | 0.451 |
| Difficult insertion | 0.846 |
| Back abnormality | 0.351 |
| Resident versus Anesthesiologist | 0.096 |
| Number of epidural attempts | 0.196 |
| Time of the day for epidural insertion | 0.407 |
| Ultrasound used | 0.163 |

*Table 2*
*Other Data*

| Anesthesiology personnel | | |
|---|---|---|
| Resident | CRNA | Attending |
| 177 (35.3%) | 309 (61.6%) | 16 (3.2%) |
| Time of the day when epidural was placed | | |
| 0700H to 1500H | 1500H to 2300H | 2300H to 0700H |
| 225 (44.8%) | 146 (29.1%) | 131 (26.1%) |
| Pain score grading (VPS) | | |
| 0 to 9 | 10 to 39 | 40-100 |
| 398 (79.3%) | 87 (17.3%) | 17 (3.4%) |
| Number of attempts | | |
| | 1 | >1 |
| Ultrasound used | 50 (98%) | 1 (1.9%) |
| Ultrasound not used | 320 (70.9%) | 131 (29.1%) |
| P value <0.001 | | |

*Table 3*
*Logistic regression: Factors and Odds Ratios*

| Variable | Odds Ratio | 95%Confidence Interval | P |
|---|---|---|---|
| History of failed epidural | 2.5 | 1.308-4.790 | 0.001 |
| Cervical dilation greater than 7 cm | 2.129 | 1.158-3.913 | 0.001 |
| Paresthesia during epidural insertion | 3.188 | 1.426-7.127 | 0.001 |
| Loss of resistance technique | 0.411 | 0.193-0.879 | 0.02 |

*Table 4*
*Classification Table*

| Observed | | Predicted | | |
|---|---|---|---|---|
| | | Inadequate pain relief | | Percentage Correct |
| | | NO | YES | |
| Inadequate pain relief | NO | 382 | 13 | 96.7 |
| | YES | 89 | 18 | 16.8 |
| Overall percentage | | | | 79.7 |

## Discussion

As compared to sixteen factors investigated and converted to predictive model by Agaram et al[1], our study investigated eighteen factors to elicit a predictive model for labor epidural failure based on our experience at a university women's hospital. The striking finding of our study was that failed epidurals were immune to the experience of the operator's hands. As compared to the reported failure of labor epidurals ranging from 0.9% to 24%[1,4], the incidence of epidural failure in our study was 21% (on a higher side of the range) because of the higher prevalence of obesity in our patient population as well as primary attempts at labor epidurals by the supervised trainees. In addition, this high rate of inadequate labor epidural analgesia in our study may have been indirectly related to the fact that we have used 10 and above out of the 100 points on VPS as a cut-off indicator for the failed labor epidurals as opposed to 40 out of 100 points on VPS. Similar to Agaram et al[1], there was no association between difficulty in insertion and the experience of the anesthesiologist ($P$ = 0.147) (Tables 1-2); the absence of statistical difference for labor epidural failure based on the experience of anesthesiologist may be secondary to the fact that the vast majority of epidurals were placed by the trainees as compared to the supervising anesthesiologist.. However, the number of insertion attempts at labor epidural placement and occurrences of paresthesia during epidural insertion were higher with the trainees' attempts at epidural insertion. The epidural insertion was more difficult in obese parturients [cross tab tests for association between independent factors showed that difficulty in epidural insertion had a significant association with obesity ($P$ = 0.004)]; however, the inadequacy of analgesia was not different between obese and non-obese parturients because the co-existence of opposing confounding factors with obesity may have contributed for obesity being the insignificant predictor of outcome in logistic regression. Use of ultrasound for appreciation of appropriate lumbar interspace as well as the localization of appropriate depth of the epidural space was helpful in reducing the number of attempts in labor epidural placement. Time of the day for the epidural insertion was not a risk factor for inadequate pain relief with labor epidurals (Table 2). Subsequently, it was decided that logistic regression may provide information for developing a risk score to predict outcome. Even though the parity of the patient (P = 0.021), oxytocin usage (P = 0.012) and induction of labor (P = 0.023) were also significant contributors to inadequate epidural analgesia, the predictive model recognized that history of failed epidural (P = 0.001), cervical dilatation greater than 7 cm (P = 0.001), paresthesia during epidural insertion (P = 0.001), and loss of resistance using air (P = 0.020) as the best predictors of the inadequate labor epidural analgesia. Hereafter, the overall predictive rate with our predictive model was 80%. As compared to a different set of sixteen variates investigated by Agaram et al[1] that concluded with a predictive model based on cervical dilatation greater than 7 cm, opioid tolerance, previous failed epidural analgesia and insertion by trainee, our predictive model did not find significant dependence on opioid tolerance and insertion by trainee as risk factors for failed epidurals; rather our predictive model elicited two other significant factors for failed epidurals, namely paresthesia during epidural insertion and loss of resistance using air.

Even though the predictive model was primarily based on our significant data in four best predictors observed in our patient population, all factors studied

by us can be collected prior to epidural insertion for quantifying the risk of failed labor epidural analgesia. However, the enormity of the eighteen factors with undefined effect on the final evolution of the failed epidural in any particular patient population may call for further studies to refine our predictive model to more accurately predict the failure of labor epidural analgesia in every patient. Last but not the least, the factors statistically insignificant per our data may have been confounded by other non-studied and non-observed variates like newly introduced application of ultrasound guidance for epidural placement may have been insignificant per our data secondary to the operators' limited experience with ultrasound use.

## Conclusion

In parturients identified as being at high risk for failed epidural based on the studied factors and evolved predictive model, use of ultrasound guidance for epidural needle placement, adoption of saline-based loss of resistance technique; and maintenance of appropriate intra-epidural-space length of catheter may help in lowering the incidence of failed epidurals.

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