Obese parturients have lower epidural local anaesthetic requirements for analgesia in labour†

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Background. There are no studies comparing local anaesthetic requirements for obese and normal parturients. Obesity has been associated with a higher incidence of Caesarean section and higher levels of epidural block have also been found in obese obstetric patients, suggesting they may require less local anaesthetic. The aim of our study was to estimate the minimum local analgesic concentration (MLAC) of bupivacaine for obese and non-obese parturients.

Methods. Otherwise healthy parturients (n = 32) requesting epidural analgesia were enrolled in this up–down sequential allocation study. Women were in active labour (3–6 cm cervical dilatation) with visual analogue pain scores (VAPS) >40/100 mm. Subjects with BMI >30 kg m⁻² were allocated to the obese group and BMI <30 kg m⁻² were allocated to the normal group. The initial epidural dose for both groups was 20 ml 0.1% w/v bupivacaine (20 mg), with a dosing increment of 0.01% w/v VAPS <10/100 mm defined effective analgesia. The MLAC was estimated using up–down reversals and probit regression with P<0.05 as significant.

Results. Groups were similar except for BMI and weight (P<0.001). Local anaesthetic requirements were significantly reduced by a factor of 1.68 (95% CI 1.32–2.29) in the obese group, with significantly higher initial level of block (P<0.001).

Conclusion. We found obese parturients to have significantly decreased epidural bupivacaine analgesic requirements. A contributing factor to obese patients having more difficult labours may be that relatively larger doses of local anaesthetic are administered than actually required. It may be worth considering lowering the concentrations and doses with which we initiate analgesia in obese parturients.

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There are few studies comparing the anaesthetic requirements for morbidly obese parturients to those that are not obese, and none for labour analgesia. It has been shown that obese parturients have more complicated pregnancies (hypertension and diabetes), with larger babies,1 Hood and Dewan2 compared the anaesthetic and obstetric outcomes in morbidly obese parturients with matched control parturients, and found that 62% of morbidly obese women underwent Caesarean section, compared with only 24% of control patients. Further analysis showed that 48% of labouring morbidly obese patients required emergency Caesarean section compared with only 9% of control patients. Hodgkinson and Husain3 showed that higher levels of epidural block could be anticipated in obese obstetric patients in proportion to their obesity, suggesting a possibility that they require less local anaesthetic to achieve an adequate level of labour analgesia. It is feasible that obese parturients may have lower requirements for labour analgesia and that standard local anaesthetic doses may be unnecessarily large in this population.

Obesity has been linked to increased musculoskeletal pain and difficulty in performing daily tasks,4 however there are no studies that show obese parturients to have greater pain or local anaesthetic requirements in labour. To evaluate the pharmacodynamics of various epidural analgesics, the minimum local analgesic concentration (MLAC) model was

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developed to determine the relative potencies of local anaesthetics in the first stage of labour.\textsuperscript{5} MLAC has also been used to estimate the local anaesthetic sparing effect of epidural opioids.\textsuperscript{6–8} the effect of i.v. vs epidural opioids,\textsuperscript{9} and the effect of cervical dilatation on local anaesthetic requirements.\textsuperscript{10} In a recent paper we reported that the MLAC of bupivacaine in dystocia was increased for epidural labour analgesia as a result of the more intense pain related to dysfunctional labour.\textsuperscript{11} In the study we present here, we wanted to investigate whether there were differences in the local anaesthetic requirements for epidural analgesia in labour in obese and non-obese parturients using the MLAC methodology.

The patient population at the labour and delivery unit of Duke University Medical Centre contains a large number of obese parturients. One study by Bell and colleagues\textsuperscript{12} showed that the average BMI at our institution was 29.2 kg m\textsuperscript{-2} in obstetric patients. Along with national trends in increasing obesity,\textsuperscript{13} our patient population is also increasing in body habitus. In this study we investigated the median local anaesthetic requirements (MLAC) of obese (BMI>30) and non-obese patients (BMI\<30) using an up–down sequential allocation technique.\textsuperscript{5}

**Methods**

**Subjects**

This research was conducted on the Labour and Delivery Floor of Duke University Medical Centre. After obtaining approval from the Institutional Review Board, women who requested epidural analgesia for labour were asked to participate and, if agreeable, gave written informed consent.

All patients met the following entry criteria; multigravida patients with singleton pregnancies of >36 and <41 weeks gestation, cephalic presentation, and cervical dilatation between 3 and 6 cm at the time of epidural request. Exclusion criteria were receipt of opioid or sedative medication before epidural placement, a history of substance abuse, pre-eclampsia, macrosomia, non-reassuring fetal heart rate tracing, abnormal biophysical profile or oxytocin stress test. In addition, if epidural analgesia was requested before labour as defined on clinical grounds by the obstetric practitioner, or if the initial visual analogue pain score (VAPS) before epidural placement was <40/100 mm, the patient was not included in the study. Thirty-two patients were enrolled in the study and the starting concentration of bupivacaine used in each group was 0.1% w/v.

**Epidural catheterization technique**

After i.v. prehydration with 500–1000 ml lactated Ringer’s solution, patients were placed in the flexed sitting position. After raising a midline skin wheal with 1.5% w/v lidocaine, the epidural space was identified using loss of resistance to saline at the L2–3, L3–L4 or L4–5 level, and a multi-hole epidural catheter was placed 5 cm into the epidural space.

No test dose was used other than the study solution. Each patient received 20 ml of bupivacaine in two 10 ml boluses over 5–10 min. Each study solution was freshly prepared by the attending anaesthesiologist using preservative-free saline as the diluent to achieve the desired concentration at room temperature (20°C). After the epidural catheter was inserted, patients were placed in the supine position with left uterine displacement and 30° elevation of the head of the bed. Patients were monitored using a non-invasive arterial pressure monitor, pulse oximeter, and tococardiograph. Efficacy of the study drug was assessed by the clinician placing the epidural, unaware of the concentration of study solution, using 100 mm VAPS, where 0 represented ‘no pain’ and 100 was ‘worst possible pain’. This was done at time zero which was just after epidural placement, and two 15 min intervals after epidural dosing for the first 30 min after bolus injection. A VAPS of 10/100 mm or less achieved during the 30 min study period was defined as effective. At this point block height was measured with ice and recorded.

**MLAC determination**

The patients were divided into two groups according to their BMI at the time of epidural placement. Each group was analysed separately to estimate the MLAC for each body habitus (BMI) group. The concentration of local anaesthetic received by a particular patient in each group was determined by the response of the previous patient in the same group to a higher or lower concentration, using an up–down sequential allocation technique. The testing interval (the increment or decrement between subsequent patients) was 0.01% w/v. The first patient in each group received bupivacaine 0.1% w/v based on our previous estimates of bupivacaine MLAC.\textsuperscript{11}

As in the standard MLAC methodology\textsuperscript{5–11 14 15} three outcomes were considered:

(i) **Effective:** A VAPS of 10/100 mm or less during contractions was achieved within 30 min of epidural local anaesthetic injection. A result defined as effective resulted in a 0.01% w/v decrement for the next patient assigned to that group.

(ii) **Ineffective:** A VAPS <10/100 mm was not achieved within 30 min of epidural local anaesthetic injection, but the patient’s pain responded with a VAPS <10/100 mm to rescue with up to 20 ml bolus of bupivacaine 0.1% w/v with fentanyl 2 μg ml\textsuperscript{-1}. A result defined as ineffective resulted in a 0.01% w/v increment for the next patient assigned to that group.

(iii) **Reject:** A VAPS >10/100 mm because of pain that was not responsive within 20 min to additional bupivacaine 0.1% w/v with fentanyl 2 μg ml\textsuperscript{-1} rescue. A result defined as a reject resulted in the same concentration being repeated for the next patient assigned to that group.
Statistical analysis

Patient characteristics and obstetric data were collected and are presented as mean (SD), median [interquartile range] and count as appropriate. Means (SD) were analysed using unpaired Student’s t- or Welch’s t-tests for differing variances, medians [interquartile ranges] by Mann–Whitney U-test and counts or proportions by Fisher’s exact test. Additional analyses included analysis of covariance (ANCOVA) and logistic regression. The median effective concentrations were estimated from the up–down reversals and probit regression, which enabled the MLAC with 95% confidence intervals (95% CIs) to be derived. Analyses were carried out using the following software; Excel 2000 (Microsoft Corp., Redmond, VA), Number Crunching Statistical System (NCSS) 2004 (NCSS Inc., Kaysville, UT), Minitab 14 (Minitab Inc., State College, PA) and GraphPad Prism 4.01 (GraphPad Software Inc., San Diego, CA). Statistical significance was defined for \( P < 0.05 \) (two-sided).

Results

Groups were similar except for BMI and weight \((P < 0.001)\). Results are shown in Table 1. There were no significant differences in heights of the two patient groups so the differences in BMI were as a result of heavier patients in the obese groups. This was further assessed using ANCOVA, which returned \( r^2 \) values of 0.97 and 0.10 for weight and height respectively in contributing to the variability of BMI. Pain scores of uterine contractions at the time of epidural placement were also not significantly different in the two groups. There were no failed epidural catheter placements amongst the 32 patients included in this study.

The up–down sequences are depicted in Figure 1. Local anaesthetic requirements were significantly \((P < 0.001)\) reduced by a factor of 1.68 (95% CI 1.32–2.29) in the obese group. The MLAC estimates shown in Table 2 show a significant difference of 0.046 (95% CI 0.026–0.065) in the groups. In addition the upper extent of sensory block (to ice) was found to be significantly \((P=0.0016)\) higher in the obese subjects (Table 1). Logistic regression confirmed the independently significant effects of concentration \((P=0.002)\), sensory level \((P<0.0001)\) and group \((P=0.001)\) with initial pain score \((P=0.42)\) and height \((P=0.80)\) as not significant on analgesic outcome.

Discussion

Our results show a decreased requirement of bupivacaine for labour analgesia in obese parturients as compared with

| Table 1 Demographic, obstetric and sensory block data for the 32 patients that were included in the study. Data are presented as mean (SD) and median [interquartile range] |
|---------------------|---------------------|---------------------|---------------------|
| BMI<30              | BMI<30              | \( P\)-value        |
| BMI (kg m\(^{-2}\)) | 39.5 (7.0)          | 26.3 (3.7)          | <0.001              |
| Height (m)          | 1.62 (0.05)         | 1.66 (0.09)         | >0.20               |
| Weight (kg)         | 104.2 (20.4)        | 72.4 (12.1)         | <0.001              |
| Age (yr)            | 28.1 (6.0)          | 24.8 (6.1)          | >0.20               |
| Cervical dilatation (cm) | 3.8 (1.0)  | 4.2 (1.4)          | >0.20               |
| Pain scores (mm)    | 79 [68, 88]         | 75 [48, 87]         | >0.20               |
| Block height        | T8 [T6, T10]        | T10 [T10, T12]      | 0.0016              |

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<th>Table 2 MLAC (% w/v) and ratio estimates with 95% CI of the two groups of parturients—obese and normal (n=32)</th>
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<td>Up–down reversals</td>
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Fig 1 Shows the up–down sequences of the two groups of parturients—obese and normal with 95% CI shown. Note that the first data point has both obese and normal parturient superimposed at the same starting concentration as is standard for MLAC methodology.
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normal sized parturients. This is the first time the analgesic requirements of obese parturients have been investigated. With the ever-increasing body habitus of the population in the USA, obesity is becoming more common with more than 30% of Americans having a BMI >30 kg m\(^{-2}\). More obese patients are becoming pregnant and their management is commonly undertaken by both obstetricians and anaesthesiologists. With increasing financial and medical difficulties in managing obese patients, anything that can improve our treatment of obese parturients would be advantageous.

It is apparent from Figure 1 that the up–down sequence for the obese group may not have stabilized and is apparently still declining. This is reflected in the lower estimate for the MLAC for this group by probit analysis and a higher order requirements of obese parturients have been investigated. With increasing financial and medical difficulties in managing obese patients, anything that can improve our treatment of obese parturients would be advantageous.

The MLAC for this group by probit analysis and a higher order analysis was found to be significant (P=0.022) group by concentration interaction with logistic regression. This suggests that the data as presented, if anything, are likely to underestimate the true difference in the groups, with even more significant reductions in local anaesthetic requirement in obese parturients.

The mechanism underlying the reduced anaesthetic requirement in obese parturients is likely to be multifactorial. Our data suggest that obese patients in our study did not have any significant difference in their pain scores at the time of epidural request or placement and that this did not independently influence analgesic outcome using logistic regression. This would suggest that less pain is an unlikely explanation of the difference in local anaesthetic requirements that is, obese parturients do not need less local anaesthetic for analgesia because they are in less pain.

The data also show, as expected, significant differences in both BMI and weight in the obese and normal groups, but not in height. Height was also not found to be an independently significant variable using logistic regression. This by inference suggests that the length of the epidural space was not a confounder for the subjects in this study, as this would be similar in both groups of patients. However, it is still possible that volumes or consistencies of the epidural spaces may be different in these two groups of patients. A factor influencing epidural analgesic requirements, may be that obese patients have a reduced volume in their epidural space related to increased intra-abdominal pressures when compared with normal patients. Changes in epidural pressure have been shown to correlate with the amount of spread of local anaesthetic injected into the epidural space. It may be that the reduced volume of the epidural space in obese parturients may be one factor allowing the local anaesthetic injected in the epidural space to reach a higher level. Smaller amounts of local anaesthetic would then be needed to provide sufficient analgesia. This can be confirmed by obese parturients in our study having a significantly higher block level after epidural dosing, by as much as two dermatome levels, despite having received less local anaesthetic drug. A difference in block height at 30 min is to be expected, as at that time 8/15 non-obese women and only 5/15 obese women had ineffective analgesia. However, in addition, logistic regression demonstrated sensory block height to be the more significant factor and to have the larger effect size when modelled with concentration in predicting outcome. Interestingly, similar effects have been found with epidural fentanyl resulting simultaneously in significantly higher sensory levels and local anaesthetic sparing.

Obese patients have more adipose tissue in general which accounts for their body habitus. If their epidural space contained more fat, could that also account for a difference in pharmacodynamics? Arguments against this are suggested by a recent magnetic resonance imaging (MRI) study by Wu and colleagues, who performed MRIs in 101 random patients (lumbar spine) L3–4, L4–5, and L5–S1 levels and found BMI had no correlation with either posterior or anterior epidural fat content. Weight as opposed to body habitus (BMI) did correlate with more posterior epidural fat and subcutaneous fat. This increased posterior epidural fat could potentially make an impact, as the posterior compartment is where epidural catheters are placed. It is not clear however that epidural catheters placed for labour always lie in the posterior epidural space. Hogan in a small study showed that most epidural catheters lay in the lateral epidural space, a compartment that was not different in fat content in Wu’s MRI study in obese and normal patients.

Whatever the actual mechanism for their lower anaesthetic requirements, a contributing factor to obese patients having more difficult labours may be that relatively larger doses of local anaesthetic are administered than they require. While very low dose spinals (5 mg) have been used to successfully complete Caesarean section in obese parturients, it may also be worth extending this to decrease the concentrations and doses with which we initiate analgesia in obese patients.

While there has been some variability in MLAC estimates with different populations investigated, our study has demonstrated significantly reduced epidural analgesic requirements for obese parturients (BMI>30) in labour by a factor of 1.64 whilst simultaneously achieving significantly higher sensory block. This may have implications for epidural dosing for this challenging group.

Acknowledgement
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