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ORIGINAL ARTICLE

Increasing body mass index and abdominal subcutaneous fat thickness are associated with increased skin-to-epidural space distance in pregnant women

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ABSTRACT

Background: Body mass index does not indicate the distribution of adipose tissue. Central adiposity may be measured using ultrasound measurement of subcutaneous fat thickness. This study determined if the abdominal subcutaneous fat thickness measured correlated with skin-to-epidural space distance at delivery, and compared this with the booking body mass index.

Methods: We analysed a sub-set of participants from a single-centre, prospective cohort study that assessed the relationship between subcutaneous fat thickness and maternity outcomes. Abdominal subcutaneous fat thickness measurements were obtained during the routine fetal anomaly scan. The skin-to-epidural space distance was obtained in those having epidural or combined spinal-epidural analgesia. Linear regression was used to test for strength of association and adjusted R^2 values calculated to determine if subcutaneous fat thickness or body mass index was more strongly associated with skin-to-epidural space distance.

Results: The 463 women had a median (IQR) booking body mass index of 25.0 kg/m^2 (21.8–29.3) and subcutaneous fat thickness of 16.2 mm (13.0–21.0). The median (IQR) skin-to-epidural space distance was 5.0 cm (4.5–6.0). Both parameters significantly correlated with skin-to-epidural space distance (r=0.53 and 0.68 respectively, P <0.001). Adjusted linear regression coefficient (95% CI) for subcutaneous fat thickness was 0.09 (0.08 to 0.11), R^2=0.30 and for body mass index 0.12 (0.11 to 0.13), R^2=0.47.

Conclusions: Booking body mass index had a stronger relationship with skin-to- epidural space distance at delivery than subcutaneous fat thickness, explaining 47% of the variation in the skin-to-epidural distance.

Keywords: Body mass index; Subcutaneous fat thickness; Cesarean section; Epidural; Obesity

Introduction

Lumbar epidural techniques are commonly used for labour analgesia and to provide anaesthesia for caesarean section (CS), and comprise a large proportion of obstetric anaesthesia practice in Western countries.[1,2] Effective epidural function requires accurate location of the epidural space. In pregnant women, the skin-to-epidural space distance has been shown to increase in association with increasing weight[3] and body mass index,[4–6] to be higher in certain ethnic groups,[5] to be higher when inserted in the lateral position,[7] and to show variation according to the lumbar interspace of insertion.[8] The skin-to-intrathecal space distance (during spinal anaesthesia) has been shown to be higher in women with preeclampsia.[9]

The reported median skin-to-epidural space distance in pregnant women has increased over time, from

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4.7 cm in 1985,[8] to 5.0 cm in 2007[4] and 5.4 cm in 2011.[5] It is possible that this increase is related to increasing maternal obesity that has been demonstrated in low-, middle- and high-income countries.[10] Obesity is known to affect 20% of Australian pregnant women[11] and 31% of women of childbearing age in the United States of America (USA).[12] In maternity care, obesity is commonly classified according to body mass index (BMI).[13] Calculated from a woman's height and weight, increasing maternal BMI is known to be associated with adverse pregnancy outcomes[14–16] and increasing skin-to-epidural-space distance.[4–6]

There is an increasing understanding of the role of body fat distribution in metabolic health.[17] Ultrasound measurement of subcutaneous fat has been found to reliably assess abdominal obesity.[18,19] Recently, abdominal subcutaneous fat thickness (SCFT) measured by ultrasound in pregnancy has been identified as an independent predictor of adverse pregnancy outcomes.[20,21] Only one study has previously attempted to assess the influence of abdominal obesity on epidural insertion in pregnant women.[22] Faitot et al. failed to demonstrate an association between abdominal obesity (indicated by a waist circumference at delivery >105 cm) and difficulty of epidural insertion.[22] Two studies have demonstrated that the inability to palpate landmarks, rather than increasing BMI, predicts difficulty of epidural insertion in pregnant women,[22,23] suggesting that distribution of adipose tissue may influence epidural insertion more than BMI.

In this study we aimed to determine if abdominal SCFT, measured at the routine fetal anomaly ultrasound scan, was associated with skin-to-epidural space distance during labour epidural or CS techniques; and to compare this with the relationship between booking BMI and the skin-to-epidural space distance.

Methods

This prospective cohort study was approved by the Human Research Ethics Committee of the Royal Brisbane and Women's Hospital (3/12/2013; HREC/14/QRBW/492). An opt-out consent approach was approved and utilised. The participants were a subset of a larger population that was analysed to determine the relationship between abdominal SCFT and pregnancy outcomes.[24] The study was undertaken at the Royal Brisbane and Women's Hospital, a tertiary institution with over 4000 deliveries per year.

The primary outcome was the skin-to-epidural space distance, measured to the nearest 0.5 cm on the Tuohy needle and documented in the anaesthesia or labour analgesia record. The abdominal SCFT was obtained from the fetal anomaly ultrasound scan. This scan is routinely performed between 18 and 22 weeks' gestation. Due to late referrals of women from regional centres, cases were included if they had ultrasound images obtained at 18.0–23.9 weeks' gestation and the ultrasound imaging was undertaken for a routine fetal anomaly scan. All images were obtained using a GE Voluson E8 machine (GE Healthcare, http://www3.gehealthcare.com.au/en-AU) and a curvi-linear ultrasound probe (C1-5, C4-8 RAB). The abdominal SCFT measurements were taken at the cervix-placenta view (Fig. 1). This view was obtained by placing a standard convex array ultrasound transducer, mid-sagittal and superior to the symphysis pubis, measuring in the midline through the linea alba. Landmarks demonstrated on the ultrasound image were the bladder, cervix and uterus. The image contained the skin line and the subcutaneous tissue layer in the near field. These landmarks ensured that the image and subcutaneous fat measurements were reproducible. The first measurement was made in the midline and two measurements were taken on either side 5 mm apart. The measurements were made perpendicular to the anterior border. The calipers were placed from the skin line to the peritoneal fascia. Sonographers were encouraged to obtain the best view for their clinical purpose – in very obese women, that would usually involve lifting the pannus, however this was not dictated. The ultrasound examinations were performed by sonographers trained in obstetric ultrasound scanning; subsequently one trained operator reviewed the three measurements, which were averaged to give the SCFT for each participant. On some images the calipers measured in pixels rather than mm, in which case the measurement was adjusted to mm using a conversion factor.

Demographic and pregnancy outcome information was obtained from the institutional obstetric database or electronic patient record. Age, ethnicity, parity, height in metres and weight in kilograms were obtained from the booking appointment. The booking gestation varied because of different referral pathways to this tertiary institution and this gestation was documented. Cases were included if the first height and weight were measured at a gestational age between 12.0 and 23.9 weeks. The presence of gestational hypertension and/or preeclampsia was recorded and defined according to the Society of Obstetric Medicine of Australia and New Zealand.[25] Pre-term delivery was defined as delivery at <37 weeks' gestation. In our institution, epidural techniques are used for neuraxial analgesia in labour and combined spinal-epidural (CSE) techniques are used for anaesthesia for CS. Caesarean section categorization (elective or emergency) was made according to definitions of the Royal Australian and New Zealand College of Obstetricians and Gynaecologists.[26] The patient posture during epidural or CSE insertion (sitting or lateral) and the lumbar spinal interspace of insertion was obtained from the electronic patient record.

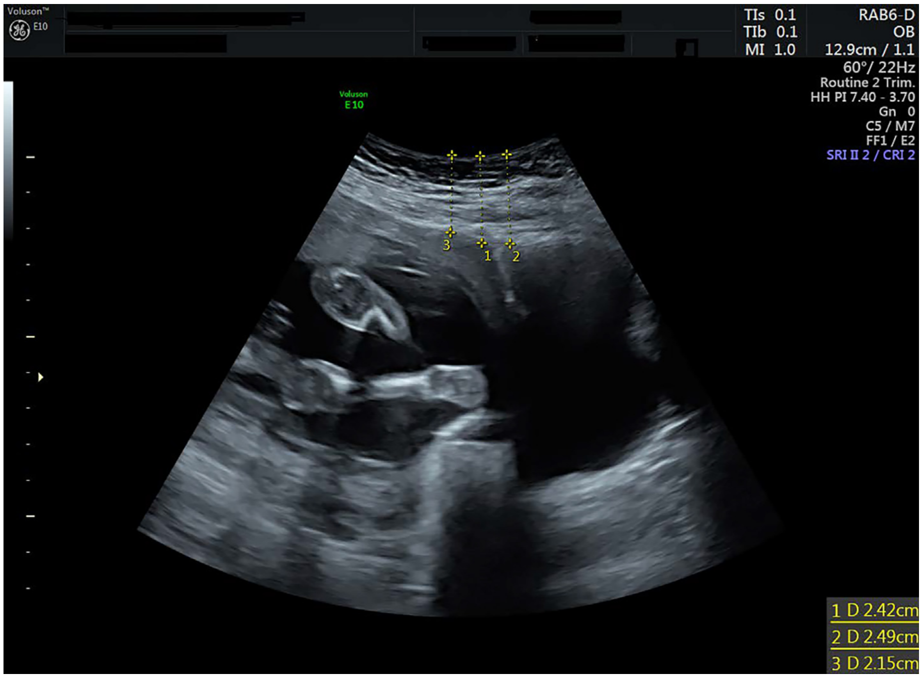

Fig. 1 Standard cervix/placenta view showing the three measurements, taken from the skin line to the peritoneal fascia

This was a sample of convenience, determined by the total number of women recruited for the maternal outcomes study and the fraction of those requiring epidural catheter insertion, either for labour analgesia or anaesthesia for CS. Pearson's correlation coefficient was calculated to assess the relationship between abdominal SCFT and booking BMI; between abdominal SCFT and skin-to-epidural-space distance; and between booking BMI and skin-to-epidural space distance. Univariate and multivariable linear regression analysis was used to calculate adjusted R^2 values to determine which of BMI or SCFT was a better predictor of skin-to-epidural-space distance. Variables considered for adjustment were identified by clinical reasoning and from the literature. Statistical analyses were considered significant at the 5% significance level and analyses were performed in SPSS Version 22 (SPSS Inc., Chicago, IL, USA).

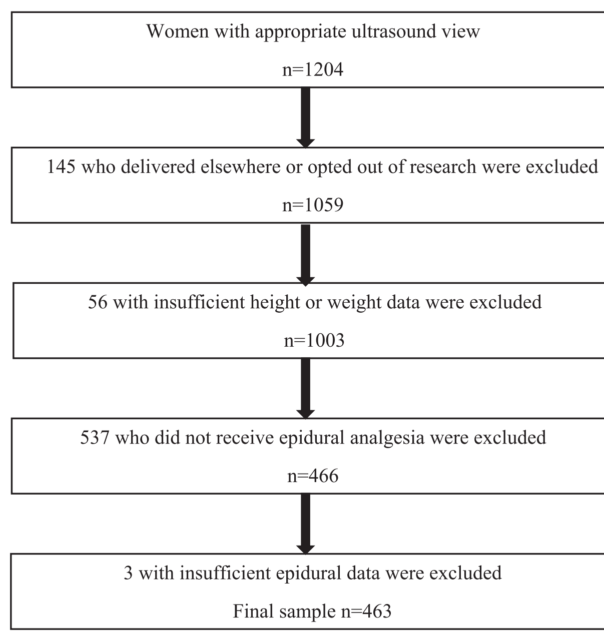

Fig. 2 Recruitment flowchart

Results

Data were collected between February 2015 and June 2016. Fig. 2 shows the recruitment flowchart. The final sample included 463 women. Table 1 shows the maternal demographic, delivery and anaesthesia details. The women had a mean (SD) age of 30.4 (5.3) years, 229 (49.5%) were nulliparous and 328 (70.8%) were Caucasian. Three-hundred-and-eighteen women (68.7%) received labour epidural analgesia and 145 (31.3%) received CSE anaesthesia for CS. The median (IQR, range) booking weight was 67.5 kg (60.0–80.0, 44.0–158.0) measured at a median (IQR) gestation of 17 weeks (15–17). The SCFT (Table 1) was measured at a median (IQR) gestation of 19 weeks (19–20) and the total range was 7.0–73.4 mm. The median (IQR) difference in time between measurement of the booking weight and the ultrasound measurement of SCFT was three weeks (2.0–4.0).

There was a strong correlation between SCFT and BMI (r=0.74, P <0.001). There was a moderate correlation between SCFT and skin-to-epidural space distance

Table 1 Demographic, delivery and epidural information for 463 women

Demographic and delivery information	n (%)
Gestation ≥37 weeks	432 (93.3%)
Gestational hypertension/preeclampsia (n=462)	53 (11.5%)
Mode of delivery	
Vaginal delivery	230 (49.7%)
Elective caesarean section	110 (23.8%)
Emergency caesarean section	123 (26.6%)
Booking BMI kg/m^2 (median, IQR)	25.0 (21.8–29.3)
(range)	17.3–56.7
Booking in BMI category[a]	n (%)
Underweight <18.5	7 (1.5)
Normal weight 18.5–24.9	223 (48.2)
Pre-obese 25.0–29.9	131 (28.3)
Obese Class I 30.0–34.9	48 (10.4)
Obese Class II 35.0–39.9	30 (6.5)
Obese Class III >40.0	24 (5.2)
Abdominal SCFT mm (median, IQR)	16.2 (13.0–21.0)
Epidural information	
Posture n (%) (n=460)	
Sitting	427 (92.8%)
Lateral	33 (7.2%)
Skin-to-epidural-space distance cm (median, IQR)	5.0 (4.5–6.0)
Lumbar interspace n (%) (n=458)	
L1-2	2 (0.4%)
L2-3	70 (15.3%)
L3-4	328 (71.6%)
L4-5	58 (12.7%)

BMI: body mass index (measured between 12 and 23.9 weeks' gestation.) SCFT: subcutaneous fat thickness. Measured between 18 and 23.9 weeks gestation.
[a]World Health Organization definitions.[13]

(r=0.53, P <0.001) and also between BMI and skin-to-epidural space distance (r=0.68, P <0.001). Scatterplots of the relationship between SCFT and skin-to-epidural space distance and between BMI and skin-to-epidural space distance are shown in Fig. 3. The adjusted and unadjusted linear regression results are shown in Table 2. The variables for adjustment included mode of delivery, delivery at <37 weeks, parity, ethnicity, presence of gestational hypertension/preeclampsia, position during epidural insertion and the lumbar interspace of insertion. The BMI had the higher R^2, suggesting that approximately 47% of the variability observed in the skin-to-epidural space distance can be explained by the booking BMI. As seen in Table 2, the R^2 is marginally larger in the adjusted models compared with the unadjusted models. Furthermore, the coefficients and adjusted R^2 are consistent between the unadjusted and adjusted models, suggesting that the adjustment terms do not attenuate the associations of SCFT or BMI with depth-to-epidural space.

Discussion

We have demonstrated a correlation between SCFT and BMI, and skin-to-epidural space distance in pregnant women receiving epidural analgesia for labour or CSE anaesthesia for CS. The BMI was identified as a better predictor of skin-to-epidural space distance than the abdominal SCFT, explaining 47% of the variability in skin-to-epidural space distance. For each unit increase in BMI, the skin-to-epidural space distance increased by 0.12 cm.

This is the second study to examine a measure of central adiposity and its relationship with skin-to-epidural space distance. Abdominal SCFT measured at the routine fetal anomaly ultrasound examination would be a cheap, low-risk assessment if included in a routine

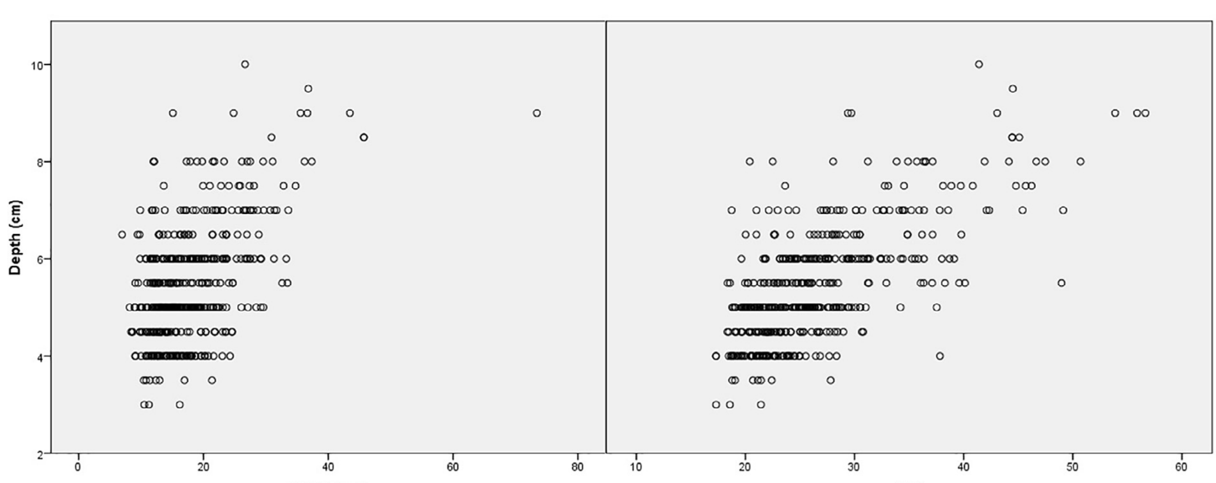

Fig. 3 Scatterplots showing the relationship between abdominal subcutaneous fat thickness (SCFT) in mm, and body mass index (BMI) in kg/m^2, with skin-to-epidural space distance in cm (n=463)

Table 2 Unadjusted and adjusted linear regression results describing the relationship between subcutaneous fat thickness and body mass index, and skin-to-epidural space thickness (n=463)

Explanatory variable	Unadjusted model		Adjusted model[a]	
	Coefficient (95%CI)	R^2	Coefficient (95%CI)	Adjusted R^2
SCFT	0.096 (0.082 to 0.110)	0.284	0.092 (0.077 to 0.106)	0.297
BMI	0.122 (0.110 to 0.134)	0.468	0.122 (0.109 to 0.134)	0.469

[a]Adjusted for ethnicity (Caucasian, not Caucasian), parity (0, 1+), premature delivery (<37 weeks, 37 + weeks), age (<25, <30, <35, <35+), lumbar interspace (L1-2 and L2-3, L3-4 and L4-5), position (sitting, lateral) and hypertension/preeclampsia (yes, no). SCFT: subcutaneous fat thickness; BMI: body mass index.

evaluation that is already accepted in antenatal care. However, our results indicate that it is not superior to BMI in predicting skin-to-epidural space distance. Although skin-to-epidural space distance has been shown to be increasing over time, our median depth of 5 cm is more consistent with the depth documented in 2007[4] (5.0 cm) compared to 2011[5] (5.4 cm). While this increasing trajectory was demonstrated in pregnant women,[4,5,8] the three studies were undertaken in different ethnic populations, which may have influenced the results.

The skin-to-epidural space distance and its associated morphological features are a much-studied topic. Body mass index,[4] weight,[2] ethnicity,[5] ponderal index (the ratio of height to weight) and ultrasound-measured depth[27] have all shown a positive correlation with skin-to-epidural space distance in pregnancy, with one study showing an inverse relationship between maternal age and skin-to-epidural space distance.[4] Body surface area, weight, height[28] and computed tomography (CT) measurements have been demonstrated to be associated with skin-to-epidural space distance in non-obstetric populations. Predictive equations for skin-to-epidural space distance have been published, incorporating BMI[29] and weight.[2] Other methods for determining skin-to-epidural space distance include ultrasound,[27,30] CT[31,32] and magnetic resonance imaging.[33] Of these, ultrasound is the most feasible method to incorporate into clinical obstetric and anaesthesiology practice and the most likely to be acceptable to pregnant women.

While of significant interest to researchers and clinicians, skin-to-epidural space distance is not necessarily a measure of difficulty of insertion of an epidural catheter. However, as the skin-to-epidural space distance increases, the error introduced by small deviations of the needle-tip from the midline becomes increasingly important. The ability to accurately predict the skin-to-epidural space distance has clinical utility. For example, by predicting an epidural depth distance greater than 8 cm, the appropriate longer Tuohy needle can be selected. Prediction may also permit prior planning for the length of epidural catheter to be left in the epidural space. Insertion of extra catheter length is recommended by expert opinion,[34,35] to prevent dislodgement of the catheter in obese women during labour. We demonstrated in a two-centre study that this practice is undertaken locally, with epidural catheters inserted to a greater mean depth in women with Class III obesity.[6] By preventing an inappropriately deep epidural needle insertion, knowledge of the epidural depth may reduce unintentional dural puncture. By preventing an inappropriately shallow insertion, ineffective anaesthesia and analgesia may be avoided. Ultrasound measurement at the time of epidural insertion may provide the most accurate estimate of epidural depth and has shown benefit even in women with easily identifiable landmarks.[36] However predictors of depth, such as SCFT or BMI may have a role in allocating resources when ultrasound machines or expertise are not readily available, by identifying those in whom a pre-procedural or pre-delivery neuraxial ultrasound should be performed.

Ellinas et al. demonstrated that difficulty palpating landmarks was a better predictor of insertion difficulty than BMI in obese pregnant women.[23] Insertion difficulty may be defined by the number of needle insertions, number of needle re-directions or epidural placement time.[23,36] Unpublished pilot results from our institution suggest that abdominal SCFT was correlated with difficulty palpating bony landmarks. Further work is required to investigate if a measure of central adiposity, such as abdominal SCFT, is a reliable method for identifying women whose landmarks may be difficult to palpate, thus predicting those at risk of difficult neuraxial insertion.

Our study has some limitations. The gestation at which the booking BMI was measured was usually earlier than the gestation at which the abdominal SCFT was measured. Both of these indices are likely to change over the course of a pregnancy and may not reflect the status at delivery, when the skin-to-epidural space distance was measured.[37] The booking BMI was used as it was documented most consistently and the gestation at which the SCFT was measured was dictated by the timing of the routine fetal anomaly scan, which is usually scheduled for 18–22 weeks. As this ultrasound examination is already incorporated into routine care, this measurement was obtained with no additional cost or inconvenience to the women. Our participants received two different neuraxial techniques, with the majority of participants receiving epidural analgesia in labour. However, the mode of delivery was included as an adjustment factor in the logistic regression models.

The impact of difference in technique between an epidural inserted in labour and a CSE inserted for anaesthesia is likely to have been minimal on the skin-to-epidural space distance. A strength of our study was the ability to adjust for the presence of gestational hypertension/preeclampsia, which may also affect the skin-to-epidural space distance due to increased tissue oedema.[9]

The ultrasound measurement was taken by trained obstetric ultrasonographers who were advised to obtain the best view for clinical purposes and followed a prescribed protocol. The management of a significant pannus was not dictated, however most sonographers would lift the pannus to obtain the best view. This may have increased inter-observer variation. The degree of tissue compression would also introduce some variability into the results, particularly in obese women, when increased transducer pressure is used to optimise images. Efforts to standardise tissue compression in future studies would reduce this variability. It was a strength of this study that one trained operator was able to obtain all the SCFT measurements. Some SCFT measurements were obtained from previously placed calipers – when these were not available the measurement was obtained by converting pixels to millimetres. This is also a potential source of error that should be minimised in future studies. The women in our study had a wide range of weight and BMI, however the majority were not obese, providing less technical difficulty for anaesthesiologists.

Anaesthesiologists are caring for more obese patients than previously and identifying a good predictor of epidural insertion difficulty would be clinically useful. Higher BMI does not necessarily increase insertion difficulty, but our results demonstrate that is it better than abdominal SCFT in predicting skin-to-epidural space distance. Further work is required to evaluate if abdominal SCFT can be used to predict difficulty of epidural insertion, using a structured, objective measure of epidural insertion difficulty.

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Declarations of interest

None.

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