ABDOMINAL PALPATION TO DETERMINE FETAL POSITION AT THE ONSET OF LABOUR: AN ACCURACY STUDY

by

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ABSTRACT

Since the late 19th Century, abdominal palpation of the gravid uterus has been routine, worldwide obstetric practice to determine fetal position. A systematic review showed a dearth of research on the accuracy of this ubiquitous test.

A test accuracy study was carried out prospectively to assess accuracy of abdominal palpation (index test) to identify the Left-Occipito-Anterior (LOA) fetal position at the onset of labour, in nulliparous women over 37 weeks' gestation, with ultrasound as the reference standard. Trained observers blind to the index test results performed the ultrasound independently. Midwives palpation data on the position of 629 women were obtained and 61 (9%) fetuses were verified as LOA by ultrasound. The sensitivity, specificity and likelihood ratio of abdominal palpation to detect LOA position were 34% (23-46), 71% (67-74) and 1.2 (0.83-1.74) respectively. Higher accuracy was achieved by midwives with experience > 5 years (OR 4.02; 1.2-12.9) and those who worked in the community (OR 0.15; 0.03-0.9).

Accuracy of abdominal palpation to determine LOA fetal position at the onset of labour is poor. If future research demonstrates that the optimal fetal position of LOA exists, midwives will need to confirm fetal position at the onset of labour by ultrasound to prognosticate.

DEDICATION

To Jeremy and my boys, for making my life wonderful.

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List of abbreviations

Abbreviation	
AP	Anterior-Posterior
BMI	Body Mass Index
CI	Confidence Interval
DOA	Direct Occipito Anterior
DspA	Direct Spine Anterior
DOP	Direct Occipito Posterior
DspP	Direct Spine Posterior
LOA	Left Occipito Anterior
LspA	Left Spine Anterior
LOL	Left Occipito Lateral
LspL	Left Spine Lateral
LOP	Left Occipito Posterior
LR	Likelihood Ratio
LspP	Left Spine Posterior
NCT	National Childbirth Trust
OA	Occipito Anterior
OP	Occipito Posterior
OFP	Optimal Fetal Positioning
OR	Odds Ratio
RCT	Randomised Controlled Trial
ROA	Right Occipito Anterior
RspA	Right Spine Anterior
ROL	Right Occipito Lateral
RspL	Right Spine Lateral
ROP	Right Occipito Posterior
RspP	Right Spine Posterior
RR	Relative Risk

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1 INTRODUCTION

Appropriate intrapartum management is dependent on accurate assessment of in-utero fetal presentation and position. Identifying fetal position and presentation is essential when deciding on place, mode and position for delivery. Palpation of the gravid uterus to identify fetal presentation and position is used in routine obstetric practice worldwide. It is a low cost, non-invasive, easy to perform test and can be performed in all settings. However, there has been scant research into the accuracy of abdominal palpation to identify fetal position. This thesis addresses this gap in research with an accuracy study to identify the Left-Occipito-Anterior fetal position in nulliparous women at the onset of labour.

1.1 Anatomy and physiology of normal birth

The reproductive process ends with labour and the delivery of the fetus and this final stage has been described as the interaction of the ‘3Ps’ – the Power (uterine contractions), the Passage (the pelvis) and the Passenger (the fetus) (1). Understanding the mechanisms of labour relies on a thorough knowledge of the anatomy and physiology of the female pelvis and fetal skull and how they interact.

1.1.1 The female pelvis

Together the pelvic bones, joints and ligaments form the pelvic girdle, a strong bony ring which serves to support upper body weight and transmit this weight to the lower body. The pelvic girdle also protects the reproductive organs, bladder and rectum. The female pelvis, when considered as a whole, is further divided into two segments. The broad, upper part, *the false pelvis*, plays no part in the labour process. However, the shallow, lower part, *the true pelvis*, is integral to the birth process. The *true pelvis* forms a complete ring of bone. Bounded at the back by the sacrum, at the sides by the ischia and by the pubes in front, it is this through this bony 'ring' that the fetus must travel during the birth process. The true pelvis can further be segmented into the three pelvic regions of the pelvic brim, the pelvic cavity and the pelvic outlet. Each of these three regions of the pelvis plays an important part in the birth process.

The bony ridge of the pelvic brim is wider in its transverse measurement (13.5cms) than it's Anterior-Posterior (AP) measurement (11cms). In an erect position the female pelvic brim is normally angled at 60 degrees. Extending from the pelvic brim to the pelvic outlet, the pelvic cavity is almost circular with both transverse and AP measurements of 12cms. The pelvic cavity is deeper at the back and than the front and because of this the fetus passes through the pelvis during the birth process in a curved path. The pelvic outlet is the lowest level at which the fetus is constricted on all sides by pelvic bone during the birth process. The diameters of the pelvic outlet are the converse to that of the pelvic brim, with a transverse measurement of 11cms and AP measurement of 13.5cms. However, as the coccyx can move backwards and ligaments stretch there is sometimes more room for the fetus than is first apparent. This extra available room is sometimes called the ‘obstetrical outlet’ (2) or the ‘lower anatomical outlet’ (3).

The pelvic measurements detailed in Table 1.1 are standard in obstetric and midwifery textbooks and arise from the work by Cauldwell and Moloy and their studies of the female pelvis through X-Ray pelvimetry in the 1930s (4;5). They are based on the gynaecoid pelvic shape that is classified as the ‘normal’ pelvic shape. From classifications by Cauldwell and Moloy the four main pelvic types are Gynaecoid (50% prevalence), Android (20% prevalence), Platypelloid (5% prevalence) and Anthropoid (25%). Not only can the shape of the pelvis can help determine someone’s age, sex and ethnicity, differences in pelvic shape will influence the progress of labour (4;6).

Table 1.1 Measurements of the female pelvis

	Anterior-Posterior	Oblique	Transverse
Pelvic brim	11 cms	12 cms	13cms
Pelvic cavity	12 cms	12 cms	12cms
Pelvic outlet	13 cms	12cms	11cms

1.1.2 The fetal skull

The fetal skull that grows around the developing brain has two parts, the neurocranium and the viscerocranium. It is the neurocranium that forms a protective case around the brain. The viscerocranium is the primary jaw

skeleton. Dense connective tissue membranes (sutures) separate the bones of the skull and intersect at membrane filled spaces called fontanelles.
The two main fontanelles are the anterior (bregma) and the posterior (lambda) fontanelles. The diamond shaped anterior fontanelle is formed at the intersection of the frontal, sagittal and the two lateral coronal sutures. The triangular posterior fontanelle is formed by the intersection of the sagittal and the two oblique lambdoidal sutures. Moving from the anterior fontanelle towards the posterior fontanelle, the sagittal suture lies between the parietal bones and divides the cranium into left and right halves. The lambdoid suture moves laterally from the posterior fontanelle and separates the occiput from the parietal bones. Moving forwards from the anterior fontanelle, the coronal suture separates the parietal and frontal bones. The frontal suture lies between the frontal bones and extends from the anterior fontanelle down to the glabella.

There are other 'landmarks' on the fetal skull that are used to determine fetal skull measurements. The glabella is the elevated area that lies between the orbital ridges. The sinciput is the area that lies between the anterior fontanelle and the glabella. The Vertex is the area between the anterior and posterior fontanelles and bound laterally by the two parietal eminences. The Occiput is the area behind and inferior to the posterior fontanelle and the lambdoid sutures. As well as providing landmarks for evaluating the position of the fetal skull, the sutures and fontanelles facilitates movement and 'moulding' of the skull bones during labour and delivery which allows the fetus to negotiate the maternal pelvis without harming the brain.

1.1.3 Fetal position in utero

The fetal position in utero is categorised by the lie, presentation, attitude and position. All are important to the outcome of the labour, and indeed the ability of the fetus to deliver vaginally (7).

Fetal Lie is the relationship of the long axis of the fetus to the long axis of the uterus, and can be longitudinal, oblique, or transverse.

Fetal Presentation is that part of the fetus which is lying in the lower part of the uterus, and can be vertex, brow, face, breech or shoulder.

Fetal Attitude describes the relationship of the fetal head and limbs to the body and may be fully flexed, deflexed, or extended. When fully flexed the head is brought forward with the chin tucked tightly against the chest, the arms crossed over the body and legs crossed and brought up against the chest. In this flexed attitude the fetus forms a compact ovoid that although fits the uterus comfortably still allows adequate movement for the fetus (7). When deflexed the chin comes down and the head is straight, facing forward. A fully extended attitude results in the head being stretched back so the face is the presenting part (table 1.2). The degree of flexion in the fetal head determines the presenting diameter of the fetal skull and will influence the progress of labour (1).

Table 1.2 Measurements of the fetal skull and relationship to degree of flexion

Diameter of the fetal skull	Average measurement (cm)	Point of reference	Degree of flexion
Suboccipitobregmatic	9.5	Suboccipito region to the Bregma	Fully flexed (OA)
Suboccipitofrontal	10	Suboccipito region to the Frontal Prominence	Partially flexed
Occipitofrontal	11.5	Lambda to Bregma	Erect
Mentovertical	13.5	Mentum to Vertex	Partially extended ('Brow presentation')
Submentobregmatic	9.5	Submentum region to the Bregma	Fully extended ('Face presentation')

Fetal Position is the relationship between the fetal denominator and one of eight areas of the maternal pelvis. The fetal denominator relates to the specific area of the presenting fetal part that is then used to determine position. For cephalic presentations, the denominator is the occiput. In breech presentations the denominator is the sacrum, and in face presentations the denominator is the mentum. The eight areas on the maternal pelvis used to determine fetal position are direct anterior, direct posterior, left and right anterior, left and right lateral and left and right posterior (figure 1.1). Therefore, positions in a vertex presentation are:

Direct Occipito Anterior (DOA); The occiput points to the symphysis pubis and the sagittal suture is in the anterior posterior aspect of the pelvis.

Left Occipito Anterior (LOA); the occiput points to the left iliopectineal eminence and the sagittal suture is in the right oblique aspect of the pelvis.

Left Occipito Lateral (LOL); the occiput points left, midway between the iliopectineal eminence and the sacroiliac joint and the sagittal suture is in the transverse aspect of the pelvis.

Left Occipito Posterior (LOP); the occiput points to the left sacroiliac joint and the sagittal suture is in the left oblique aspect of the pelvis.

Direct Occipito Posterior (DOP); The occiput points to the sacrum and the sagittal suture is in the anterior posterior aspect of the pelvis.

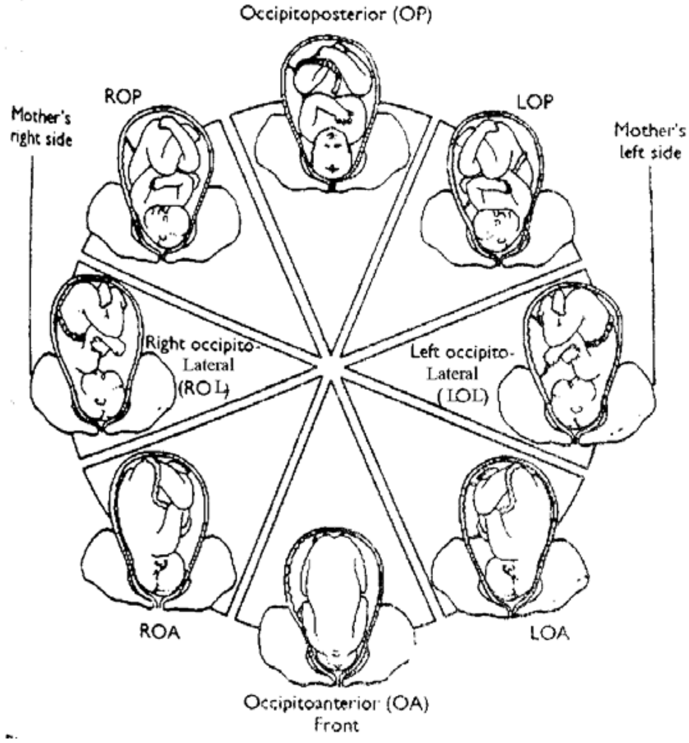
Right Occipito Anterior (ROA); the occiput points to the right iliopectineal eminence and the sagittal suture is in the left oblique aspect of the pelvis.

Right Occipito Lateral (ROL); the occiput points to the right, midway between the iliopectineal eminence and the sacroiliac joint and the sagittal suture is in the transverse aspect of the pelvis.

Right Occipito Posterior (ROP); the occiput points to the left sacroiliac joint, and the sagittal suture is in the right oblique aspect of the pelvis.

Breech and face presentations are described in similar ways with the denominators of Sacrum and Mentum respectively (8).

Figure 1.1   Classification of fetal position.



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1.1.4 Identifying fetal position in utero

Several methods can be used to identify fetal position in utero. These include radiography, ultrasonography, internal vaginal examination and abdominal palpation (9;10). Although being highly accurate and popular in the 1950s, the use of radiography is now rarely used in pregnancy due to the known harmful effects to the fetus of prolonged exposure to radiation (11;12). Ultrasonography provides the same level of accuracy as radiography but without the effects of radiation. However, it is costly, requires expensive equipment and is therefore not available in all clinical settings. Internal vaginal examination can be used to identify fetal position and presentation. However this method relies on the dilatation of the cervix and descent of the presenting part so is only reliable when the woman is in established labour (9). Abdominal palpation is non-invasive, involves no expensive equipment so can be undertaken in any setting, does not subject the woman or fetus to any ultrasound or radiation, and can be done at any point in the latter months of pregnancy or intrapartum. It therefore remains the popular and ubiquitous test for identifying fetal position and presentation in the gravid woman.

In 1892 Crede and Leopald later expanded on work done earlier by Pinard and published a technique for abdominal palpation of the gravid uterus in a German text entitled ‘Text-book of obstetrics for midwives’. Two chapters of this text were later translated by Edgar and published in English (13). These two chapters focused on four specific manoeuvres of abdominal palpation that could be used to determine fetal position and presentation and which became formalised as ‘Leopold’s Manoeuvres’. Crede and Leopold’s work was further expanded in 1894 and published in a book translated by Wilson titled ‘A short Guide to the Examination of Lying-in Women’(14). Developed primarily as a means of reducing infection and preventing puerperal fever, Crede and Leopold claimed that through their four-manoeuvre technique it was possible to identify the limbs, size, attitude presentation and position of the fetus in utero. In a lecture given at the Royal College of Midwives in 1951, Consultant Obstetrician and Gynaecologist C W Burnett described how abdominal palpation could be used not only to identify fetal presentation and position, but also estimate fetal size, placental position, fetal sex and in some cases identify intrauterine death (15).

The abdominal examination technique cited in modern midwifery and obstetric textbooks has changed very little since that first published by Crede and Leopold in the late 19th Century (7-9;16). The only major change has been to discourage the use of Pawlick's grip, the fourth manoeuvre, as it has been suggested that some women find this manoeuvre painful, and the promotion of a three manoeuvre examination (7;8;16). The abdominal palpation examination consists of the following manoeuvres (for all manoeuvres the women needs to be supine with her abdomen bared):

First manoeuvre *or* Fundal palpation: with the palms of both hands placed on either side of the fundus and the fingers held close together, the clinician is able to identify whether the fetal vertex or breech occupies the fundus and determine fetal lie (figure 1.2). The vertex will be hard and round to palpate, whilst the breech is softer and more irregular in outline.

Second manoeuvre *or* Lateral palpation: This is used to identify the position of the fetal back and/or limbs. This is done by placing the hands on either side of the uterus at the level of the umbilicus and exerting gentle pressure (figure 1.2). The fetal back is felt as a smooth, continuous object whereas the fetal limbs are small and irregular to palpate. In a posterior positioned fetus the smooth, firm outline of the back is often not easily palpated and instead the clinician can only palpate fetal limbs.

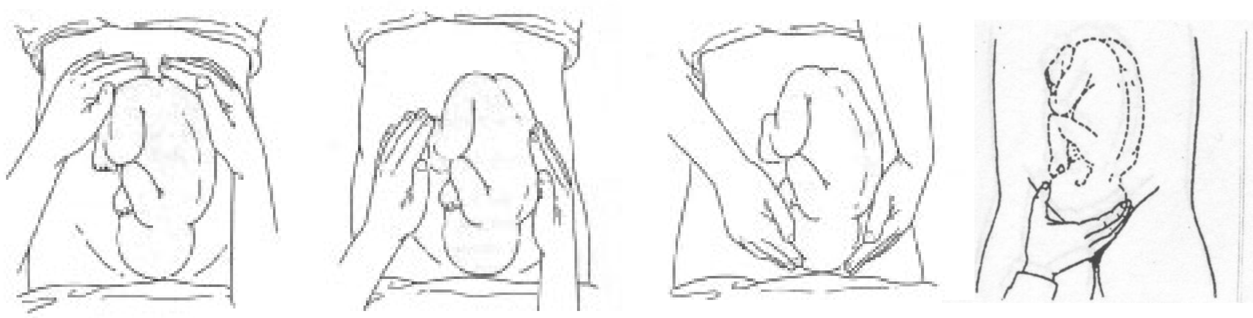
Third manoeuvre *or* Pelvic palpation: The clinician faces the woman's feet and positions the tips of the fingers of each hand just above the symphysis pubis (figure 1.2). Gentle pressure is exerted inwards and downwards in order for the clinician to identify the presenting part, estimate amount of engagement of the presenting part into the pelvis and clarify fetal position by palpating either the vertex or sacrum.

Fourth manoeuvre *or* Pawlick's grip: By using the thumb and forefinger of one hand placed over the symphysis pubis and gently gripping the presenting part, the clinician is able to judge the size, flexion and mobility of the presenting part (figure 1.2).

Competency of abdominal palpation is an essential part of modern midwifery practice (16). Despite this, a small study by My Mak and Wong (2000) found that although midwives had positive attitudes and moderate employment of abdominal palpation, they felt their knowledge and confidence of the practice was inadequate (17).

In his history of clinical midwifery, one of very few published texts on the subject, Rhodes (1995), only very briefly mentions abdominal palpation and incorrectly details clarification of fetal position from the position of the fetal spine. It is interesting that a clinical practice that has become ubiquitous and routine for midwives and obstetricians worldwide for over 100 years should be given such insufficient and inaccurate attention (18).

Figure 1.2 Individual elements of abdominal palpation



First manoeuvre	Second manoeuvre	Third manoeuvre	Fourth manoeuvre
or	*or*	*or*	*or*
Fundal palpation	Lateral palpation	Deep pelvic palpation	Pawlick's' grip

1.1.5 The mechanism of normal labour

Obstetrics became recognised as a science in the eighteenth century, and the works of Obstetricians such as Fielding Ould, William Smellie, Richard Manningham and William Hunter became the main contributors to the mechanism of labour as it is widely known in modern practice (19). It has been suggested that modern midwifery practice is based on theory from the 1950s with very little re-evaluation of this theory since (20).

Birth has been likened to a biomechanical process, with the uterus using the mechanism of contractions to expel the fetus (21). The passive movements of the fetus as it moves through the birth canal by uterine forces are collectively called the 'mechanisms of labour' (22). During vaginal birth the fetal presentation, position, attitude and size will govern the exact mechanism as the fetus responds to the uterine forces (23). Today's major midwifery textbooks outline the normal mechanisms of labour as an eight stage process with the fetus commencing the process of labour with a longitudinal lie, cephalic presentation, an attitude of good flexion with the occiput as the denominator and in the LOA position as follows (9;22-25):

Descent; throughout the first stage of labour uterine contractions exert pressure onto the fetus causing it to descent into the pelvis.

Flexion; as pressure is exerted down the fetal axis through descent, flexion of the fetal skull increases and the occiput becomes the leading part. This results in the presenting diameter changing from that of the suboccipitofronal diameter (10cms) at the onset of labour to that of the suboccipitobregmatic diameter (9.5cms).

Internal rotation; uterine contractions push the occiput onto the maternal pelvic floor, and the resistance from the pelvic floor causes internal rotation of the fetus. The anterior downward angle of the pelvic floor determines the direction of rotation therefore whatever presenting part of the fetus meets with the pelvic floor will be rotated forwards and towards the centre. Therefore when the fetus is cephalic in presentation with a flexed attitude, the occiput will lead descent and meet the muscles of the pelvic floor first. This will cause the vertex to rotate forwards by 45 degrees and allow the widest diameter of the fetal head (anterior-posterior) to lie in the widest diameter of the pelvic outlet (anterior-posterior). Subsequently the vertex will no longer be in direct alignment with the fetal shoulders.

Crowning of the head; the occiput slips beneath the subpubic arch and crowning of the head occurs when the fetal head no longer recedes between contractions and the bi-parietal diameter of the vertex is born.

Extension; when the bi-parietal eminences have crowned, the fetal head extends and sweeps the perineum to release the sinciput, face and mentum.

Restitution; the twist in the neck which resulted from the internal rotation of the vertex is now corrected as the occiput rotates posteriorly 45 degrees.

Internal rotation; just as the vertex rotates when it is pushed against the pelvic floor muscles, so too do the shoulders. The anterior shoulder is the first to reach the levator ani muscle and so rotates anteriorly by 45 degrees to lie under the symphysis pubis. The shoulders are now lying in the anterior-posterior aspect in the widest diameter or the pelvic outlet. This rotation occurs in the same direction as restitution and is visible as the now delivered vertex rotates to lie in the lateral position.

Lateral flexion; The shoulders and body are then born by lateral flexion.

Surprisingly, despite today's major midwifery and obstetric textbooks describing the normal birth process with the fetus commencing in the LOA position, published estimates of the prevalence of the LOA fetal position at the onset of labour are scarce. From their work involving X-Ray pelvimetry in the 1930s, Cauldwell et al (1934) estimate between 9-12% of fetuses enter labour in the LOA position, dependent of pelvic type (5). In a study designed to compare transvaginal digital examination and transabdominal ultrasound during the active stage of labour, Sherer et al (2002) found the LOA position at the onset of labour at just under 16% (n/N = *16*/102) (26). In Myles Textbook for Midwives, Fraser (2004) estimates the LOA fetal position at the onset of labour at 15% (8). However it is not clear whether this figure is one that has been historically reported and reproduced or whether it has been obtained from contemporary records as no references are provided. Other studies give estimates of OA positions at the onset of labour of less than 5% by McFarlin et al (1985), and up to 61% by Gardberg et al (1998), however, these studies do not differentiate between left and right side positions (10;27). Sutton (2001) argues that for nulliparous women the prevalence of the LOA position can be as high as 70%, however, this estimate is based on her own anecdotal evidence and should therefore be treated as such. Interestingly, Bean et al (1967) suggest from their X-ray pelvimetry studies that the most common position of engagement of the fetus is left occipito lateral (LOL), accounting for just over 40% of the women included in the study. Despite concluding that the maternal pelvic shape controls the incidence of the fetal position, the LOL position remained the most common fetal position in all of the three main pelvic types (gynaecoid, android and anthropoid). What is apparent from the above is that despite the complexity of the subject and the period of time of which it has been subject to scientific research, there is a scarcity of good quality research (20). As discussed in chapter 1.1.4, the technique of abdominal palpation has changed very little over the past 120 years and suggests that clinicians assume that the technique is accurate and may partly explain the lack of research in this area.

Measurements of the maternal pelvis and fetal skull suggest that the flexed Occipito Anterior (OA) or lateral presentation is favourable for labour. When adopting this attitude and position the fetal skull presents the smallest diameter of 9.5cms and is considered to be the best structural fit for the pelvic brim (28). However, the network of sutures and fontanelles of the fetal skull allow the bones to move during the labour process which help the fetus negotiate the birth canal and facilitate the ability of other fetal presentations – often termed ‘malpositions’ to birth vaginally (21;22). The most common malposition of the fetus at the onset of labour is the occipito posterior (OP) position.

1.2 The Occipito Posterior fetus

Unlike the OA position where the fetus has a flexed attitude and the occiput is towards the maternal front, the OP fetus enters the pelvis in a deflexed attitude with the fetal spine lying adjacent to the maternal spine. This orientation forces a larger diameter of the fetal head to lead descent into the pelvis (21). The reported incidence of OP position of the fetus at the onset of labour varies between 10-20% (27;29-31) and up to 25% (32). Rotation of the fetal head to the OA position tends to occur prior to delivery but in some instances the fetus will fail to rotate and the OP position will persist. Again, reported incidence of the persistent OP position varies from 1-2% (32) and up to 5% (29;31;33-36). As with reported figures for the OA fetal position at the onset of labour, it is not clear whether these figures are those that have been historically reported and reproduced in more recent literature or whether they have been obtained from contemporary records. This is surprising considering that the difficulties associated with a mal-positioned fetus and the related morbidity for the mother and baby have long been recognised. Most of the literature regarding malposition concerns itself with examining the morbidity linked with an occipito-posterior positioned fetus, as it remains the most common malposition.

Causes of occipito-posterior positioning relate to variations in the pelvic inlet space available to the fetal head and include android and anthropoid pelvic shapes. It is also claimed that an anteriorly situated placenta may predispose a fetus to the occipito-posterior position (34). An interesting later study by Gardberg et al (1998) concluded that occipito-posterior position at the beginning of labour was not the only determinant of persistent occipito-posterior position at delivery (27). Ultrasound examination was performed on 408 women with singleton pregnancies (>37 weeks) with vertex presentations at their initial examination on arrival to the delivery ward either in spontaneous labour (57%) or immediately prior to induction (43%). The study aimed to investigate the persistent occipito-posterior position during labour, and to identify parameters correlating with outcomes. The study found that 15% (n=61) of fetuses presented in the occipito-posterior position at the beginning of labour and that the majority of these (n=53, 87%) rotated to an occipito-anterior position. The actual incidence of occipito-posterior position at delivery was 5.1% (n=21). This included the 8 fetuses that had failed to rotate from the beginning of labour as well as another 13 fetuses that had apparently commenced labour in the occipito-anterior position and subsequently malrotated. These make intriguing findings although further studies are necessary. It would be interesting to know how those fetuses presenting in the occipito-posterior position at the onset of labour were distributed between the spontaneous onset group and the induction group given that induction of labour is said to be more common with an occipito-posterior positioned fetus (29). The authors only comment that there was no increase in the occurrence of persistent occipito-posterior position in the induction group or in the group of women who received epidural anaesthesia, which suggests that those fetuses which malrotated from occipito-anterior to occipito-posterior did not belong to either of these groups.

1.2.1 Maternal morbidity associated with the OP position

There has been much research published into the maternal morbidity of the fetus entering into labour and delivering in the occipito-posterior position. In a two year prospective observational study of 13,789 consecutive labours comparing 246 women with persistent OP fetal position and 13,543 OA fetal position, Fitzpatrick et al, 2001 concluded that the persistent OP position contributed disproportionately to caesarean section and instrumental delivery ($p<0.001$), with less than half of the OP labours ending in spontaneous vaginal delivery (29). The study also concluded that compared to the OA position, the OP position at birth was associated with a significantly higher incidence of induction of labour ($p<0.001$), need for augmentation of labour ($p<0.001$), epidural use ($p<0.001$), prolonged labour ($p<0.001$) and an increase in the incidence of obstetric anal sphincter injury (*p*<0.001). Interestingly, the incidence of persistent occipito-posterior was only 2%. The study was undertaken at the National Maternity Hospital in Dublin that is well known for its Active Management protocol. This includes strictly observed time limits for duration of 1st and 2nd stage, low cavity forceps and vacuum deliveries and the exclusion of rotational forceps. It is worth considering whether the management itself might have contributed to the less favourable results for some of the outcomes. Failure of the head to advance after 60 minutes of active pushing was the main reason for instrumental delivery. Dystocia was the main indication for caesarean section, which accounted for 78% compared with 40% in the OA group (*p*<0.001). Less than a quarter (23%) of the cases were diagnosed as persistent occipito-posterior before the procedure. It is important to acknowledge this association between occipito-posterior position and caesarean section and to wonder at its prevalence as a significant factor contributing to the caesarean section rate.

Neri et al (1995) compared the outcomes of a study group of 319 deliveries where the fetus was in the persistent OP position, to a control group of 319 women whose fetus delivered in a non-OP position during the same time period and who were matched with the study group for maternal age, gravidity, parity, gestational age at birth, and neonatal birth weight (32). They found statistically significant differences between the study and control groups concluding that for the persistent OP fetus there is an increased likelihood for an instrumental delivery (forceps delivery – 91 vs.13, *p*<0.0001; vacuum extraction – 22 vs. 8, *p*<0.0001), a prolonged second stage of labour (229 vs.

171, $p<0.0001$), increased rate of episiotomy (52 vs. 13, $p<0.0001$) and a reduction in spontaneous vaginal delivery rates (176 vs. 272, $p<0.0001$). In a study to find out how labour could be complicated by the persistent OP position, Gardberg M & Tupparainen M (1994), completed a retrospective study of 3648 labour and delivery records and also found that both the total length of labour and the length of the second stage of labour were significantly longer in the persistent OP group (both $p<0.0001$) (34). In a cohort study of 6434 consecutive deliveries, Ponkey et al, 2003, compared the outcomes from 6074 OA positions to those from 360 OP positions at the onset of labour (36). Their study supports an association between the OP position and a longer total length of labour ($p<0.001$) along with a higher rate of caesarean section and instrumental delivery ($p<0.001$). They also identified a higher rate of complications including chorioamnionitis, obstetric anal sphincter injury, excessive blood loss and postpartum infection (all $p<0.001$). However, the authors of this study recognise that these complications could be a reflection of the higher proportion of women with an OP positioned fetus that had caesarean section or instrumental delivery. Their work also reports that in nulliparous women the OP position reduces the chances for a spontaneous vaginal delivery to only 26%. This low rate is consistent with the rate of 27% reported by Floberg et al (1987), and 29% reported by Fitzpatrick et al (2001).

In a retrospective study, Pearl et al, 1993 compared the data from 564 persistent OP position deliveries to that of a control group of 1,068 OA position deliveries matched for race, parity and delivery method (33). Their study supports the findings from that of Neri et al (1995) and Fitzpatrick et al

(2001) by demonstrating that the persistent OP group had a higher incidence of severe perineal laceration and episiotomy than the control group ($p<0.05$). Likewise, Phillips & Freeman, 1974, in a retrospective review compared data from 552 persistent OP position cases, to data from 8116 deliveries of fetuses in the OA position for the same time period and found an increase in episiotomy rates and perineal trauma for the persistent OP positioned cases (31). In a retrospective cohort study of 588 singleton, cephalic forceps-assisted vaginal deliveries, Benavides et al (2005) found that anal sphincter injuries occurred significantly more often in OP position group compared to the OA group (51.5% vs. 32.9%, $p=0.003$). Therefore concluding that although it is known that forceps-assisted deliveries themselves increase the risk of sustaining an obstetric anal sphincter injury, this risk is further increased if the fetus is in the OP position (37)

1.2.2 Fetal morbidity associated with the OP position

In addition to the maternal risks it has been reported that neonatal morbidity is increased when the fetus is in the OP position. Cheng et al (2006) performed a retrospective cohort study of 31,392 term, cephalic singleton births comparing neonates born in the persistent OP position (n=2591, 8.2%) with those in an OA position (n=28,801, 91.8%) (38). They concluded that compared with OA neonates, those delivered in the OP position had a higher risk of acidemic cord blood gasses at delivery, meconium stained liquor, birth trauma, Apgar score <7 at 1 minute, admission to the neonatal unit following delivery and a longer neonatal stay in the hospital. Ponkey et al (2003) and Floberg et al (1987), also report significantly lower Apgar scores at 1 minute for neonates born in the OP position, compared to those presenting OA (35;36). However, Sizer & Nirmal (2000) reported no difference in 5 minute Apgar scores in neonates delivered in the OP position (n=776, 4.6%) compared to those delivered in the OA position (n=16,005), however their study was not adequately powered to detect such a difference (39). In a secondary analysis of data derived from their Randomised Controlled Trial (RCT) examining the effects of delayed versus early pushing during second stage for women with an epidural, Senecal et al (2005) reported a difference in Apgar scores <8 at 5 minutes between the OP and OA groups, but found no differences in abnormal fetal blood gasses, admissions to the neonatal unit or neonatal trauma. However, the authors acknowledge that the focus of the study was to examine determinants of prolonged second stage of labour and therefore the neonatal outcomes were not evaluated further (40).

1.3 The rising caesarean section rate

In the period 2007-2008, 63% of all hospital births in England were spontaneous, this figure having fallen steadily from 78% in 1989. Conversely, caesarean section delivery rates have continued to climb, from under 3% in the 1950's, to 9% in 1980 and further increasing to reach 25% in 2007-08. Instrumental deliveries have remained around 10%. The contribution that elective caesarean section makes to the rate is acknowledged however, the emergency caesarean section rate has increased threefold from 5% in 1980 to 15% in 2007-08 (41). During the triennium 1997-1999 the case fatality rate for direct deaths following caesarean section was around five times greater than for vaginal delivery, and for emergency caesarean section was 12 times as great (42).

The decision to intervene during labour and proceed with an emergency caesarean section is based on many factors, some of which have nothing to do with the mother. Fear of litigation is cited as a factor in the rising caesarean section rates (43), so too are experience and skill of the physician (44;45). The 2001 National Sentinel Caesarean Section Audit Report concluded that the most frequently cited indication for performing a caesarean section was presumed fetal compromise (46). The proportion of caesarean sections reported to be performed for this indication varied between regions from 20% to 24%. Failure to progress (labour dystocia) was the second most commonly cited reason with the proportion ranging between regions from 18% to 23%. In three UK regions labour dystocia accounted for the most common indication for performing a caesarean section (46). The Sentinel Audit illuminated areas requiring further critical examination relating to the modern management of pregnancy, labour and birth. This included the accurate identification of the prevalence of fetal malposition (notably persistent occipito-posterior position) at delivery at caesarean section, particularly where the indication given was labour dystocia.

1.4 Maternal Posturing and fetal rotation

Although the associated morbidity of the OP malposition is well understood, controversy exists as to the effect of the fetus occupying specifically the right or left region of the gravid uterus and pelvic cavity (47). El Halta (1995) and Sutton (2001) provide anecdotal evidence in support of diagnosing fetal position as left or right specific and using maternal posturing to rotate the fetus (6;48). Sutton has since developed and formalised her theories of antenatal maternal posturing into Optimal Fetal Positioning (OFP), which has been adopted and practiced extensively by midwives and birth educators such as the National Childbirth Trust (6).

1.4.1 Optimal Fetal Positioning (OFP).

OFP centres about the premise that a fetus in the LOA position is the most advantageous for a first time mother and advocates the use of maternal posturing such as hands and knees and left lateral, to encourage the fetus to adopt and maintain the LOA position in the latter weeks of pregnancy. Sutton argues that since the 1970s and the move of the place of birth from the home to the hospital, midwives have lost important knowledge about how the fetus and pelvis interact in labour (49;50). She further argues that modern living encourages the fetus to adopt an OP position in utero which has resulted in the worldwide decrease in the number of women giving birth unaided (51). Sutton believes that the conveniences of the modern life style such as comfortable lounge furniture, an increase in the number of women driving and more technology in the home such as washing machines, tumble dryers and dishwashers, facilitate a more sedentary lifestyle. Consequently women now spend more time lounging in positions where their knees are higher than their pelves, which encourages the heaviest parts of the fetus – the occiput and spine – to ‘fall’ backwards and hence adopt the OP position. Sutton advocates that for nulliparous women, adopting the hands and knees position for regular periods of time in the latter stages of pregnancy will encourage the fetus to adopt the LOA position. She is insistent that the shape of the nulliparous uterus (more 'pear' shaped than the multiparous uterus which is more rounded in shape, and gives more room on the maternal left), and its right obliquity encourage dextro-rotation of the fetus. Therefore for nulliparous women the fetus should commence labour on the maternal left which will facilitate the normal mechanisms of labour as described in chapter one. She argues that for nulliparous women, fetuses that commence labour on the maternal right will still attempt dextro-rotation but during the long rotation to the left side will stop in the OP position during labour and be subject to the well known maternal and fetal morbidity associated with the OP position (52).

1.4.2 Research evidence for maternal posturing to optimize fetal position

Although the principles of OFP are not research based it is, nevertheless, practised worldwide by midwives and there is much debate about its effectiveness (53). Coates (2002) is among those who published her concerns. She argues that practise tips and anecdotal evidence, such as OFP, although being useful to stimulate debate and identify areas for more research, further evidence is required before being integrated into everyday midwifery practice (54). There is anecdotal evidence from 1958 into the practice of changing maternal position in labour as a way of correcting the OP fetal position (55). However, there has been little research into the effectiveness of antenatal maternal posturing to encourage the fetus to adopt the LOA fetal position with a Cochrane systematic review of Randomised Controlled Trials (RCT) identifying only three trials (two concerned with antenatal maternal posturing and one with posturing in labour) of sufficient quality suitable for inclusion (56)

The first, a single centre RCT, was conducted in 1983 to compare the effects of antenatal maternal posturing on fetal rotation from OP to OA (57). 100 women of more than 38 weeks gestation, singleton pregnancy, both nulliparous and multiparous and not in labour were randomised into four different intervention groups and one control group (each group n=20). The interventions were variants on the hands and knees position used in an earlier pilot study (58), and were based on the physical theories of gravity, buoyancy and friction. Posturing positions were; group one - hands and knees with lower back arched; group two - hands and knees combined with pelvic rocking; group three – hands and knees with lower back arched combined with deep abdominal stroking; group four – hands and knees combined with pelvic rocking and deep abdominal stroking; group 5 (control group) – sitting in a straight chair. Following the 10 minutes of maternal posturing, fetal position was then reassessed and if the fetus had rotated from OP to OA from the initial set of posturing then the woman was asked to adopt a maintenance posture for a further 10 minutes, and if no rotation had occurred they were re-assigned back to the posturing group for a further 10 minutes. All fetal positions were identified by abdominal palpation and the examiner was blinded to the posturing group. Results showed the intervention groups had more rotations than the control group (p<0.000) with little difference between the treatment postures (RR=0.26, CI 0.18-0.38). However, although their findings suggest that hands and knees posturing may enhance fetal rotation from OA to OP, they did not follow-up fetal position at the onset of labour and therefore one can only conclude that fetal rotation from this intervention is temporary. The study is also limited due to small sample size and failure to describe the randomisation procedure (53;59).

More recently Kariminia et al (2004) attempted to evaluate the efficacy of hands and knees position and pelvic rocking exercises on the incidence of fetal OP position at birth (60). This was a multi-centre RCT encompassing seven maternity units. 2255 women at 37 weeks or more gestation were randomised to either an intervention group (*n*=1046) or to the control group (*n*=1209). The intervention group were asked to adopt the hands and knees position with pelvic rocking for ten minutes, twice daily from 37 gestational weeks until labour, whereas women in the control group were asked to walk daily. Both groups were asked to document their exercises in a diary. The results showed no significant difference between the groups for the incidence of OP position at birth (RR=1.04, CI 0.80-1.36). Secondary analysis of the data showed no difference between groups for induction of labour, use of epidural, duration of labour, mode of delivery, use of episiotomy or Apgar score. They also found that the practice of hands and knees exercise during the latter weeks of pregnancy was painful to the woman and concluded that as they had not shown it to be an effective intervention to reduce the incidence of persistent OP position at birth it should therefore not be encouraged (60). However, the lack of detail regarding the specific nature of the pelvic rocking motion limit the findings of the study and it could be argued that the authors cannot claim that hands and knees posturing per se, should be discontinued as a way of changing fetal position, but rather that their particular form of maternal posturing was ineffective and painful to the woman (61).

Stremler et al (2005) studied the use of intrapartum hands and knees position as a means to rotate the fetal head from OP position to OA (62). Only women with a fetus in the OP position were included in the study and fetal position in both groups was confirmed by abdominal ultrasound both prior to and at the end of the test period. In their thirteen unit, multi-centre trial, 147 labouring women, both nulliparous and multiparous, at 37 or more gestational weeks were randomised into two groups. Group one, the intervention group (n=70), were asked to adopt the hands and knees position for a minimum of 30 minutes over a one-hour period. Group two, the control group (n=77), did not adopt the hands and knees position or any other maternal position that suspended the abdomen. For the primary outcome of fetal rotation to the OA position following the one-hour period of intervention the authors found no significant difference between the two groups (p=0.18). Eleven women (16%) in the intervention group had fetal heads in the OA position compare to 5 women (7%) in the control group (RR =2.42, CI 0.88-6.62). Interestingly, unlike Kariminia et al, Stremler et al found the maternal hands and knees posture well tolerated by the study participants and using a visual analogue scale were able to report significant improvements in back pain (p=0.0083).

The Cochrane systematic review of Randomised Controlled Trials (RCT) concluded that in late pregnancy, the intervention of hands and knees posturing for 10 minutes twice daily to correct the OP fetal position cannot be recommended, although it is associated with reducing back pain in some women. Results from the three RCTs clearly demonstrate conflicting effectiveness of maternal posturing both as a means to rotate the fetus to the OA position and it's acceptability to women. Therefore, further research, including RCTs using larger sample sizes are necessary, not only to determine whether maternal posturing has any effect on fetal rotation from the OP to OA but also on left and right side specific rotation and its influence on labour and delivery outcomes.

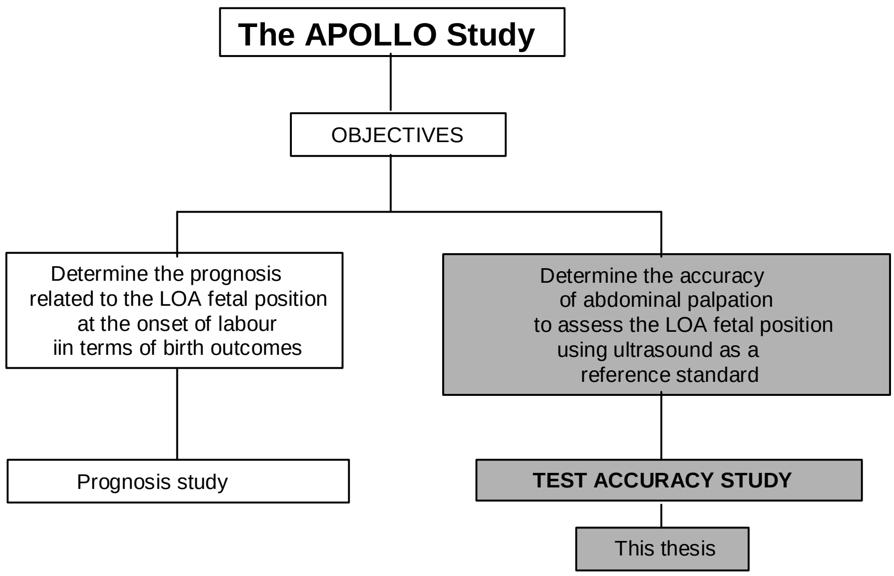
It is essential that before the practice of promoting a particular fetal position as optimal becomes routine, clinical impression is confirmed. In response to this, the APOLLO (Analysis of fetal Position at the Onset of Labour and Labour Outcomes) study was undertaken at Birmingham Women's Foundation NHS Trust.

1.5 The APOLLO Study

The APOLLO study is midwifery led research designed to answer several research questions examining the link between fetal position at the onset of labour and birth outcomes. The aim of the APOLLO study is to determine whether fetal position can be accurately palpated, whether it is left side specific and if it is associated with morbidity. The objectives of the APOLLO study were set to address the dearth of current knowledge relating to fetal position and the accurate identification of fetal position and prognosis in terms of the relationship between the LOA position and birth outcomes. The objectives were further divided into two separate analyses as illustrated in figure 1.3. Data used for the test accuracy study, the subject of this thesis were captured by the APOLLO study. Due to differing methods for accuracy and prognosis the sample sizes differed between the two objectives (see chapter 3).

If the prognostic part of the APOLLO study concludes that a particular fetal position(s) is associated with improved birth outcome, or conversely to poorer outcome then the usability of this information is contingent on the accuracy of the abdominal palpation carried out by midwives on labour wards. This thesis addresses the subject of accuracy to determine how good abdominal palpation is and what features influence the accuracy of palpation.

Figure 1.3 The APOLLO Study objectives and method of analysis



LOA = Left Occipito Anterior

2 SYSTEMATIC LITERATURE REVIEW OF TEST ACCURACY STUDIES ON ABDOMINAL PALPATION TO IDENTIFY FETAL POSITION IN UTERO

Systematic reviews are pieces of research that are accepted as an essential part of evidence-based medical practice and rely on a scientific, replicable approach that separates them from opinions and commentaries (63). They integrate existing information and establish whether findings are consistent and can be generalised, limit bias and improve the validity and reliability of conclusions (64). Systematic reviews have therefore become an integral part of obstetric practice used during the development of clinical practice guidelines by collating evidence to underpin evidence-based medicine (65;66). It is important to undertake reviews before primary research.

A protocol was developed using recommended methods for systematic review of accuracy literature on test accuracy studies for abdominal palpation as a means of identifying fetal position (67-69). This involved the formulation of a clear research question, identification of relevant literature, assessment of literature quality, summary and interpretation of results.

2.1 The review question

An unambiguous, clear and structured question is the key to the success of a systematic review. It involves formulating a structured question comprising components of population, intervention/exposure, outcomes and study design from the free form (63). Consequently, the free form question 'how accurate is abdominal palpation in identifying fetal position' became a structured question as follows:

The population	In pregnant women ….
The test	… does abdominal palpation accurately identify ..
The reference standard	… fetal position confirmed by abdominal ultrasound
The study design	A study that recruits pregnant women, uses the test of abdominal palpation and a reference standard of abdominal ultrasound to confirm fetal position, and determines the accuracy with which abdominal palpation identifies fetal position.

2.2 Literature search

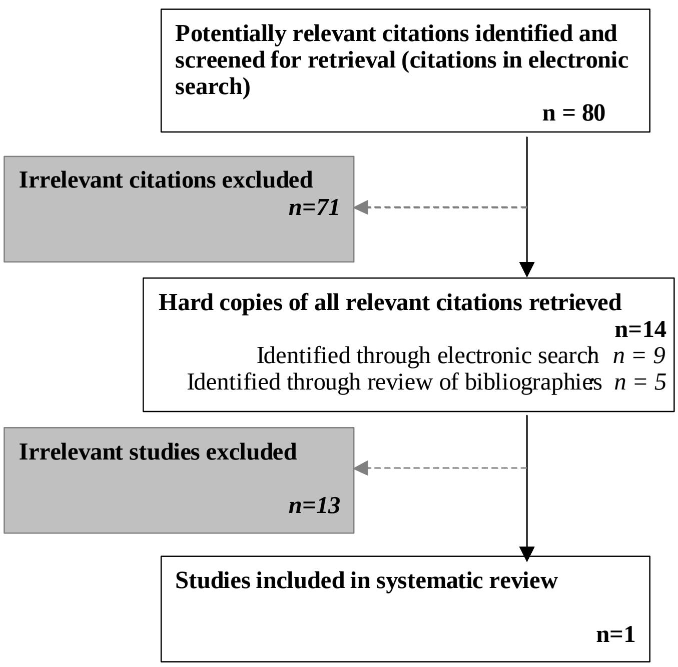
An electronic search was undertaken to capture all relevant citations about abdominal palpation and abdominal ultrasound relating to fetal position in pregnancy. MEDLINE, EMBASE, MIDIRS, and CINAHL databases were searched without language restrictions from database inception to 2009. The search term combination included MeSH, textwords and appropriate word variants of 'pregnancy' AND 'abdominal palpation OR Leopold's Manoeuvre' AND 'ultrasound' (appendix 1). The resultant set of citations was then limited to human studies. This electronic search was coupled with manual scanning of bibliographies of potentially relevant papers to increase the sensitivity of the search.

The review focused on prospective observational studies in which the results of the index test (abdominal palpation) were compared with the result of the reference standard (abdominal ultrasound). The population of interest were pregnant women. From selected studies data were collected on length of gestation, maternal weight, parity and clinician experience to see if these factors influenced the accuracy of assessment of fetal position by abdominal palpation. The selected studies were assessed against QUADAS quality criteria (70) and sensitivity, specificity and likelihood ratios for occipito-posterior position were calculated.

2.3 Identification of relevant literature

The electronic search generated 80 citations of which 9 articles which were considered potentially relevant (71-79). A further 5 were identified through examination of the reference lists of the known publications, 4 published in English and one in Cantonese (10;13;17;80;81). There was only one article which satisfied all of the inclusion criteria (10) as shown in Figure 2.1.

Figure 2.1 Identification of relevant literature on abdominal ultrasound and abdominal palpation to identify fetal position



2.4 Results

McFarlin *et al* (1985) collected data from a total of 176 women, in whom fetal position was documented on 131 of the cephalic presentations (10). The methodological features of the selected study showed that design was prospective with consecutive patient recruitment. Leopold manoeuvre, the index test, was described in sufficient detail and abdominal ultrasound was the independent blind reference standard.

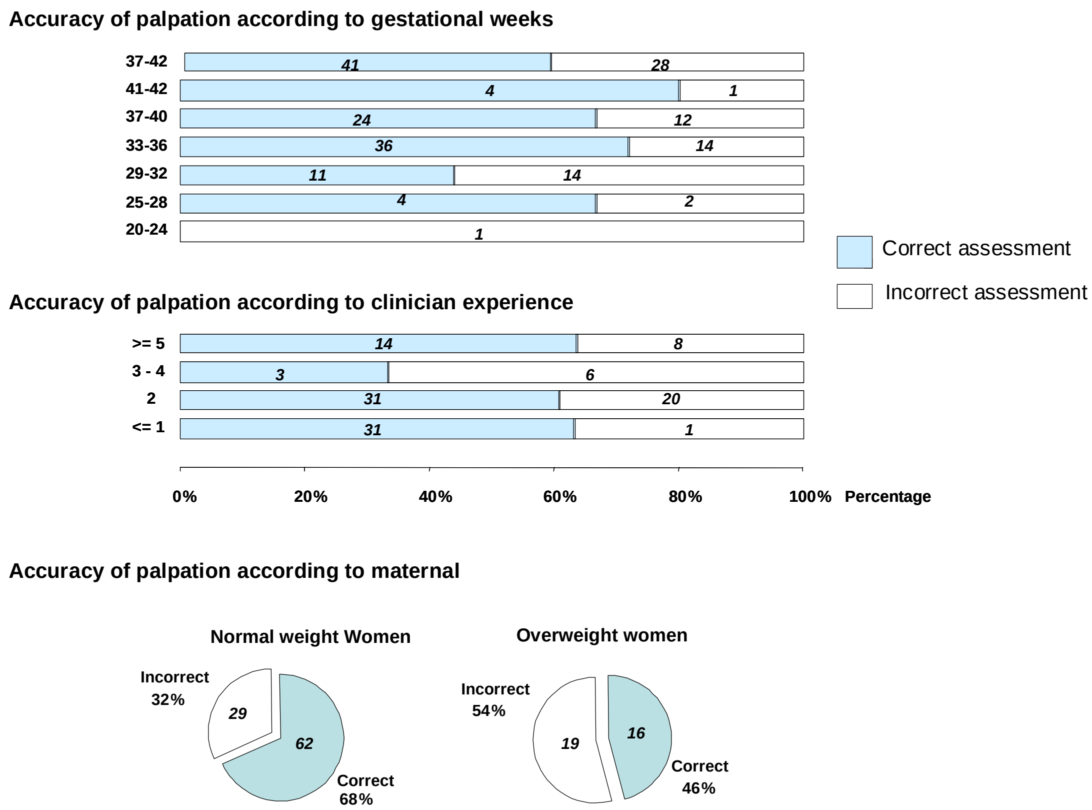
Of the 131 cephalic presentations accurate assessments were made in 79 cases (60%) as summarised in table 2.1. From the information given by the authors and reproduced in table 2.1, it was possible to calculate a sensitivity of 67% (95% CI 29-100), specificity of 60% (95% CI 51-69) for occipito-posterior position. The likelihood ratio for occipito-posterior position was 1.7 (95% CI 0.91-3.05) and for a non-posterior position was 0.55 (95% CI 0.18-1.74).

Table 2.1 Analysis of accurate assessment of fetal position by abdominal palpation in the study by McFarlin *et al* (1985)

Fetal Position	***Correct assessment***	
	n	***(%)***
Left- Occipito-Transverse	38/48	(79.2)
Right-Occipito-Transverse	18/28	(63.3)
Occipito-Posterior	4/6	(66.7)
All other fetal positions	19/49	(38.7)
Total	**79/131**	**(60.3)**

As shown in figure 2.2, the differences in overall accuracy between clinicians experience (*p* =*0*.388) and length of gestation (*p*=0.264) were not found to be statistically significant, however, there was a significant difference between accuracy of assessment in normal and overweight women.

Figure 2.2 Results of study by McFarlin *et al* (1985) on abdominal palpation to determine fetal position



2.5 *Interpretation of the findings*

This systematic review showed a dearth of research on the accuracy of a ubiquitous test employed routinely in obstetric practice. A single study (10) of relatively small sample size showed that the overall accuracy of clinicians' assessment of fetal position by abdominal palpation was at best moderate.

As the systematic review was conducted with an exhaustive search strategy and was not restricted by languages, one can be confident that important studies on this subject have not been missed. Therefore inference about scanty evidence in this area is robust.

The single study that was identified showed that the level of accuracy may increase slightly in gestations 37 weeks or more and that maternal obesity may reduce the accuracy of abdominal palpation. However, the precision of estimate for subgroups of gestations greater than 37 weeks and obese women was poor. It was obvious that more research in this area was needed using larger accuracy studies of the type identified to powerfully evaluate abdominal palpation especially in subgroups. If prognostic studies show that an optimal fetal position does exist then the question is whether midwives will be able to use the non-invasive clinical skill of abdominal palpation to confirm the LOA fetal position at the onset of labour. This thesis addresses this question of accuracy in a large prospective study evaluating whether palpation is accurate and if accuracy is associated with palpation method, maternal characteristics and midwifery characteristics.

3 METHODS OF TEST ACCURACY STUDY

The prospective study was designed and undertaken to test the accuracy of abdominal palpation (index test) as a method of assessing the LOA fetal position with abdominal ultrasound as the reference standard, using a classical diagnostic accuracy design (82;83), after obtaining research ethics committee and local research governance approval.

3.1 Research objectives

1. To determine if abdominal palpation is accurate in identifying LOA fetal position with ultrasound as a reference standard.
2. Are palpation methods, maternal characteristics and midwifery characteristics associated with accuracy of abdominal palpation?

3.2 Population

The study was undertaken in 2005-2007, at Birmingham Women's Foundation NHS Trust that serves a large, socio-economically and ethnically varied population in order to aid generalising of findings. There are over 3000 deliveries a year of nulliparous women at this obstetric unit and the following inclusion criteria were used to recruit women to the study:

Inclusion criteria

- labour spontaneous onset or induced
- Nulliparous women
- Singleton pregnancy
- >37 completed gestational weeks
- no known fetal abnormalities
- not in established labour (Cervix <4cms dilated)

Women were recruited to the study by written informed consent in one of three ways; by their community midwife at routine antenatal clinic from 28 gestational weeks; by National Childbirth Trust (NCT) education facilitators at Parenthood Education classes from 34 gestational weeks; by the research midwife or one of three ultrasound scan trained midwives on admission to hospital in early labour or for induction of labour, if not previously recruited during the antenatal period. This recruitment strategy was designed to try and ensure all eligible women were approached for consent to be included in the study in order to avoid selection bias and provide a suitably representative sample of the population.

The study was conducted in accordance with the Medical Research Council (MRC) Guidelines for Good Clinical Practice 1998 and any subsequent amendments. After consent in initial approach, participants were asked to reaffirm their consent to participate in the study on their admission to hospital. Where necessary the network of link-workers at Birmingham Women's Healthcare NHS Trust was used to inform and consent women to the study if English where not their first language and interpretation was required. As the study was of short duration and had no consequence on the management of labour or any after care, the woman's GP was not notified of her participation in the study.

The midwives informed consent to participate in the study was obtained by their agreement to complete the form detailing the findings of their abdominal palpation and information about their length of practice and main area of practice.

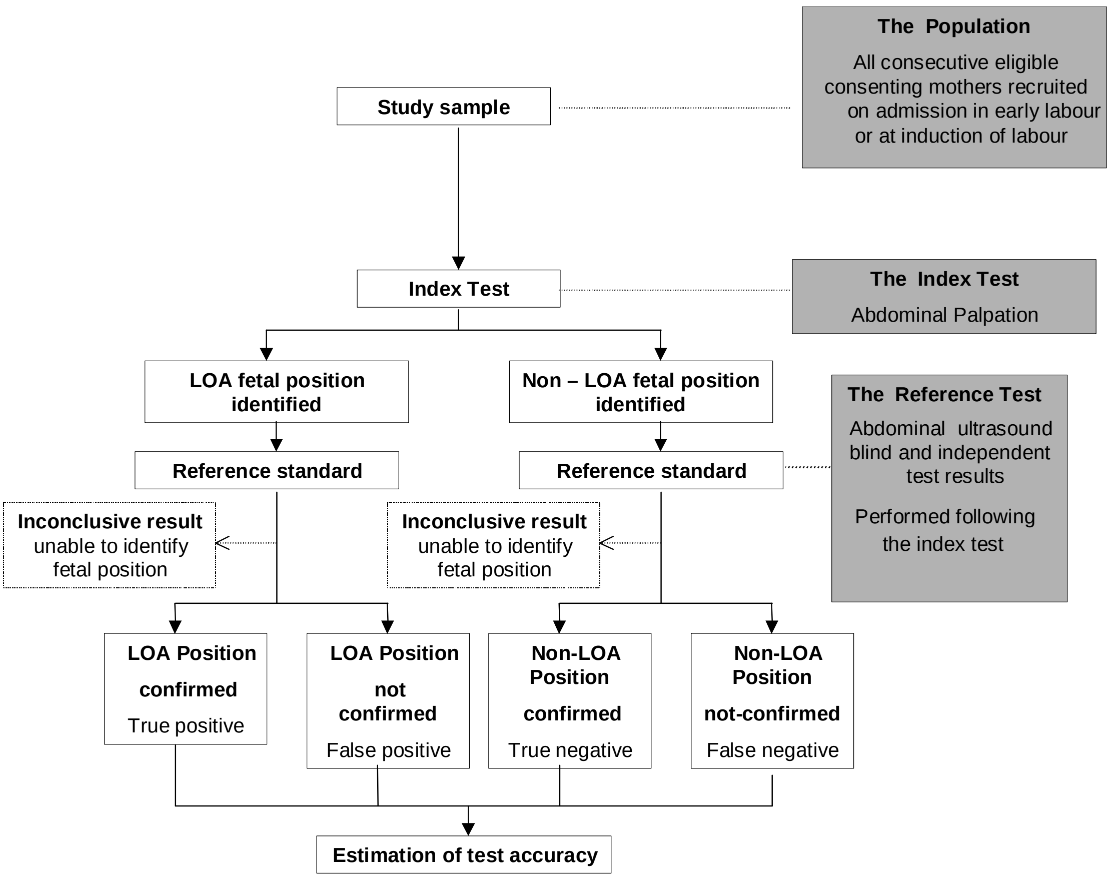
3.3 Design

The study was designed in order to meet the Standard for reporting of diagnostic accuracy Steering Committee (STARD) criteria for methodological quality of test accuracy studies (82;83). It was a prospective study with data collection planned prior to the performance of both the index test and reference standard. A diagnostic accuracy study is designed to generate a comparison of measurements obtained by an index test with those obtained by a reference standard. In this way the accuracy of index tests can be estimated. A reference standard is a test that confirms the 'condition' of interest, in this case fetal position, beyond reasonable doubt. Therefore it is sometimes also known as the 'gold' standard (82). An outline of the test accuracy study is shown in Figure 3.1.

It is standard practice that when a woman is admitted to hospital in early labour or for induction of labour the midwife caring for her performs an abdominal palpation in order to identify fetal position and presentation. Midwives were asked to complete a questionnaire detailing their findings from this examination. The participant then underwent a non-invasive abdominal ultrasound scan to provide an accurate fetal position for the purpose of this research.

There was no foreseeable risk of mortality or significant morbidity associated with either abdominal palpation or abdominal ultrasound examination. Apart from performing an abdominal ultrasound examination on the woman, all other aspects of labour management were entirely at the discretion of the local midwife and doctors. The woman's labour was managed entirely in whatever way appeared best for her, with no special treatments resulting from the research.

Figure 3.1 Flow Chart of the Test Accuracy Study



LOA = Left-Occipito-Anterior

3.4 The Index Test

Abdominal palpation, as described earlier in chapter 1, was the index test. Midwives are trained in palpation and perform this examination daily. We did not prescribe specific palpatory steps but simply asked them to record the palpation technique they employed. Following abdominal palpation on the study participant the clinical midwife was asked to complete a questionnaire detailing her findings, elements of palpation used, indicate if any specified factors helped, hindered or had no significance on her findings and information about her length of midwifery service and main area of practice (figure 3.2). In order to make the study practicable, study procedures were kept simple, with minimal extra workload placed on participating clinicians. This was achieved by ensuring that the data was captured from the use of a well-designed questionnaire that was quick to complete. To reduce bias the midwife was asked to place this completed form in a sealed envelope before handing it to the research midwife.

Figure 3.2 Abdominal Palpation form

The APOLLO Study

Form A
APOLLO Abdominal Palpation Form

Affix Patient Identification Label Here

Please tick as appropriate

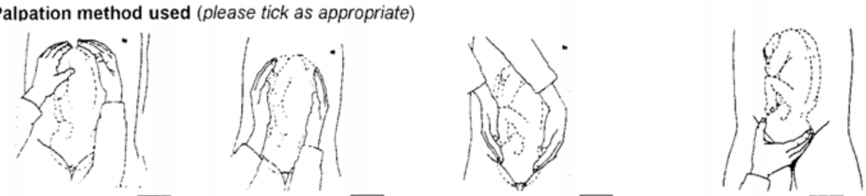
Patient is in early labour ☐
(ie; If VE performed, Cervix <4cms dilated with regular, painful contractions)

Induction of labour ☐
Please specify reason ....
Type of induction Prostin / Syntocinon
Prostin number 1^{st} / 2^{nd} / 3^{rd} / 4^{th}

Abdominal palpation
Fundus = ...
Lie = ...
Presentation = ...
Position = ...
Palpable above pelvic brim = /5ths

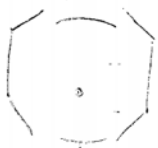
Examination date ....
Examination time ....

Palpation method used (*please tick as appropriate*)



Fundal Palpation ☐ Lateral Palpation ☐ Pelvic Palpation ☐ Pawlik's Grip ☐

Please mark on the diagram (with a x) where the FH was clearly auscultated?



Please tick as appropriate:
Pinard ☐ sonicaid ☐ CTG transducer ☐

Please tick as appropriate:

	Helped	Hindered	No influence
Maternal distress	☐	☐	☐
Maternal obesity	☐	☐	☐
Location of FMs	☐	☐	☐
Tender to palpate	☐	☐	☐
Abdominal shape	☐	☐	☐
Location of FH	☐	☐	☐

Was a Vaginal Examination Performed (please tick as appropriate) **Yes** ☐ **No** ☐

Cervical assessment (if VE performed)
Effacement thick/thin
Application to vertex close/loose
Membranes intact/ruptured
Os dilatation ....cms
Position anterior/mid/posterior

General information
Length of Midwifery service ☐ years

Area of main employment
ANC ☐
Antenatal ward ☐
Postnatal ward ☐
The Birth Centre ☐
Core Delivery suite ☐
Community ☐
Bank/Agency ☐
Other ....

Thank you for providing this additional information which will be anonymised and used in the research process to help inform the study.

Thank you for completing this form ☺

APOLLO Study/Form A – Sept 2005/version 7

3.5 The Reference Standard

Abdominal ultrasound scan was the ‘gold’ or reference standard for verification of fetal position. Only midwives trained in abdominal ultrasound scan techniques performed the abdominal ultrasound scan following the index test. A clearly documented midwife-training programme developed in conjunction with the Sonography Department of Birmingham Women’s Foundation NHS Trust was used for initial training, with four midwives completing the training programme and achieving competence to undertake the ultrasound scans for the study. For quality assurance of the abdominal ultrasound examination they received regular update training and periodic reassessment of their competence by trained sonographers. Only the four midwives trained and monitored were permitted to perform the ultrasound scans for the study.

The following two-step procedure was used for each scan to verify accurate fetal position:

(1) Positioning of the ultrasound transducer above the maternal pubic bone in the transverse position to give a coronal view of the pelvis. By angling and sliding the probe without rotation it was possible to identify the intercranial midline structure of the thalamus gland, facial skeletal structures of the orbits and the nasal bridge as ‘markers’ to be used to identify the fetal occipital position (26;84). The midwife performing the reference test was asked to draw the marker seen (an arrow to depict the thalamus and/or circles to

depict the fetal orbits) onto a circle reflecting the vertex on the form and pictures were taken at the time of scan to act as a record (Appendix 2; figure i and iv). The option was also given for the midwife performing the ultrasound scan to identify the fetal occiput position as DOA or DOP if the occipital bone was visualised (Appendix 2; figures ii and iii), or to select the option of ‘head too low’ if unable to identify any markers or occipital bones.

(2) Turning the ultrasound transducer to a longitudinal position to give a sagittal view of the pelvis and fetal cervical spine (Appendix 2; figure v) in order to identify the point along the maternal pelvis at which the fetal spine entered the maternal pelvis. The midwife performing the reference test was asked to mark this point with a cross on a circle depicting the maternal pelvis.

It was intended that the reference standard be done immediately following the index test. The midwife performing the ultrasound scan was kept blind to the results of the abdominal palpation. Details of the reference standard were captured on a separate form (Figure 3.3). The midwife was asked to record the placental location as documented at the mid-trimester anomaly scan, and the participant’s height, weight and BMI taken as recorded in her antenatal hospital notes.

Data from the reference standard captured on the abdominal ultrasound form was transferred to a validation form (figure 3.4) in order to classify the position of the fetal occiput and fetal spine. This process of tracing the markers to classify position was used to avoid marking quadrants on the ultrasound form to prevent bias from the midwife performing the index test. A data clerk who had no involvement in performing the index test or reference standard did this by tracing the markers drawn on the ultrasound form on to the validation form. In order to reduce data transfer errors when tracing the markers, the layout of the validation form, size and position of the circles was identical to that of the ultrasound form. Other data from the ultrasound form concerning placental location, patient height, weight and BMI were also transferred to the validation form.

3.5.1 Classifying position of the fetal occiput

The position of the fetal occiput was classified as OA, OP, LOA, LOL, LOP, ROA, ROL, ROP as previously described in chapter 1 and was achieved by dividing the circle that represented the maternal pelvis into eight equal sized sections and from this identifying the section in which the occiput fell. If the decision had been made at the time of scan for DOA or DOP by the midwife performing the ultrasound scan then this was accepted. If the midwife at the time of scan had recorded 'head too low' then this was recorded as position undetermined.

When only one orbit was identified the use of a template derived from the DOP and the location of the fetal spine (either left or right sided) was used to classify fetal position.

3.5.2 Classifying position of the fetal spine

The position of the fetal spine was classified as Direct Spine Anterior (DspA), Direct Spine Posterior (DspP), Left Spine Anterior (LspA), Left Spine Lateral (LspL), Left Spine Posterior (LspP), Right Spine Anterior (RspA), Right Spine Lateral (RspL), Right Spine Posterior (RspP). This was done in a similar way as determining fetal occiput position by dividing the circle that represented the maternal pelvic inlet into eight equal sized sections. The section in which the 'cross' fell determined the classification of fetal spine position.

3.6 Data management

Data from the index test and reference standard were transferred onto a specially designed ACCESS database and all data was input by a data clerk not involved in the index test or reference standard. The database was password protected and only the data input clerk had access to the passwords.

Figure 3.3 Abdominal Ultrasound form

FORM B **To be completed by Research Midwife**

The APOLLO Study
Abdominal Ultrasound Scan Findings

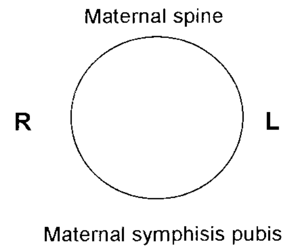
Initial check (*Please tick to confirm action carried out)*

Probe check ☐

Fetal Heart activity seen with normal rate ☐

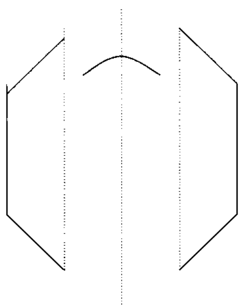
Position of fetal spine (1)

Please mark on diagram with small ' ***X*** *' location where the fetal spine enters the pelvis*



Position of fetal spine (2)

Please draw on picture position of the fetal spine

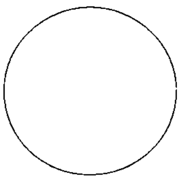


Position of vertex

Thalamus visualised?

Yes

Please draw position of thalamus below:



No *(Please tick as appropriate)*

Direct OP ☐

Direct OA ☐

Head too low to visualise ☐

Remember the scan pictures!
Please label and attach 2 scan pictures to this form

Placental Location
Please tick as appropriate

Anterior ☐ Posterior ☐ Fundal ☐

APOLLO Study/Form B – April 2005/version 2

Figure 3.4 Validation form

Unit Number:

Name:

Scan Date:

Scan Time:

Gestation Weeks:

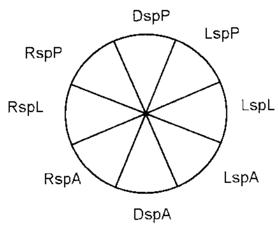
+ Days:

Initial check

Probe check done: Yes ☐ No ☐

This form to be used with APOLLO Study/Form B – Sept 2005/version 2

Position of fetal spine (1)



Validator decision on quadrant for position of fetal spine:

DspA ☐ DspP ☐

LspA ☐ RspA ☐

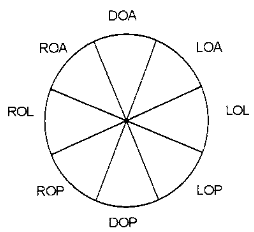
LspP ☐ RspP ☐

LspL ☐ RspL ☐

Unable to determine spine position ☐

Position of vertex

Trace drawing of thalamus or orbit onto the diagram below . **Remember**
Orbit in LOA quadrant = ROP position
Orbit in ROA quadrant = LOP position



Validator decision on quadrant for position of occiput:

DOA ☐ DOP ☐

LOA ☐ ROA ☐

LOP ☐ ROP ☐

LOL ☐ ROL ☐

Unable to determine occiput position ☐

Do scan pictures confirm drawing? Yes ☐ No ☐

Position by: Thalamus ☐ Orbit ☐ Thalamus & Orbit ☐ Head too low to measure ☐

Placental Location Anterior ☐ Posterior ☐ Fundal ☐ Lateral ☐
Please tick as appropriate

Patient Information BMI ☐ Height (cms) ☐ Weight (Kgs) ☐

APOLLO Study/Validation Form – Sept 2006/version 7 (B2)

3.7 Sample size and statistical analysis

3.7.1 Sample size and power

This test accuracy study was devised to determine the accuracy of abdominal palpation as a way to identify the LOA fetal position in nulliparous women at the onset of labour, using ultrasound as the reference standard. As previously discussed in chapter 1 the LOA fetal position has widely become adopted as the 'optimal' fetal position at the onset of labour based on work by Jean Sutton, resulting in midwives and women worldwide adopting maternal posturing in the latter stages of pregnancy to try to manipulate the fetus into this position (6;52;58;58;60). It is therefore important that the accuracy of abdominal palpation to detect the LOA fetal position is determined.

Calculation of an appropriate sample size is an important part of study design that, if done properly, can positively enhance the reliability, validity and generalization of the study results (85;86). As previously mentioned in chapter 1, published estimates of the prevalence of the LOA fetal position at the onset of labour vary from 9-12% by Cauldwell et al (1934), just under 16% by Sherer et al (2002), 15% by Fraser (2004) and from anecdotal evidence from Sutton (2001) as high as 70% in nulliparous women (5;6;8;10;26) . As the exact prevalence was unknown it was necessary to compute a range of sample sizes based on various levels of prevalence. There were no published estimates of sensitivity of abdominal palpation to detect the LOA position found through the systematic literature review as documented in chapter 2. McFarlin et al (1985) chose not to report the LOA position separately and therefore it was not possible to calculate the sensitivity for this position from their data (10). We estimated the numbers of cases of LOA on scan needed to reliably detect a range of sensitivities with 55% at the lower end of the range (table 3.1). At this level we wanted to exclude a sensitivity of < 50% reliably with a power of 80%. We used 95% CI and exact test to estimate this. We then estimated the sample size needed at various prevalences (table 3.1). Similarly, we estimated further sample sizes using sensitivity levels up to 85%.

Table 3.1 Sample size estimates dependent on prevalences and test sensitivity levels

			Sample size		
Sensitivity	**Sensitivity to exclude**	**Number of cases with LOA on scan**	**10% prevalence**	**30% prevalence**	**70% prevalence**
55%	50%	381	3810	1270	**544**
60%	53%	189	1890	**630**	270
62%	58%	179	1790	**597**	256
70%	63%	165	1650	**550**	236
80%	70%	62	**620**	207	89
85%	76%	61	**610**	203	87

Confidence level 95% Bilateral Test

3.7.2 Accuracy analysis

The diagnostic accuracy of abdominal palpation as a test was estimated by the calculation of sensitivity, specificity and likelihood ratios and their 95% confidence intervals (table 3.2). The usefulness of a test in clinical practice depends on the prevalence of a condition in the patients who are tested. This may differ widely from the prevalence of the condition in a study undertaken (87). Sensitivity, specificity and likelihood ratios were chosen, as, unlike positive and negative predictive values that are directly proportional to the prevalence, they do not depend on prevalence within the sample size. Likelihood ratios were also chosen as they are considered to be more clinically powerful than sensitivities or specificities (88), and it has been shown that authors in primary studies may overstate the value of tests in the absence of likelihood ratios (89). Analyses were carried out for the LOA position as the primary analysis. All other individual positions and their combinations were evaluated in a secondary analysis.

Table 3.2 Measures of accuracy of dichotomous test results for primary studies (90).

Sensitivity (true positive rate)
The proportion of people with disease who are correctly identified as such.

Specificity (true negative rate)
The proportion of people without disease who are correctly identified as such.

Positive predictive value
The proportions of test positive people who truly have disease.

Negative predictive value
The proportions of test negative people who truly do not have disease.

Likelihood ratios (LR)
The ratio of the probability of a positive (or negative) test result in the patients with disease to the probability of the same test result in the patients without the disease.

Diagnostic odds ratio
The ratio of the odds of a positive test result in patients with disease compared to the odds of the same test result in patients without disease.

3.7.3 Factors associated with accuracy

Statistical analysis explored if palpation method, maternal characteristics and midwifery characteristics were associated with the accuracy of palpation.

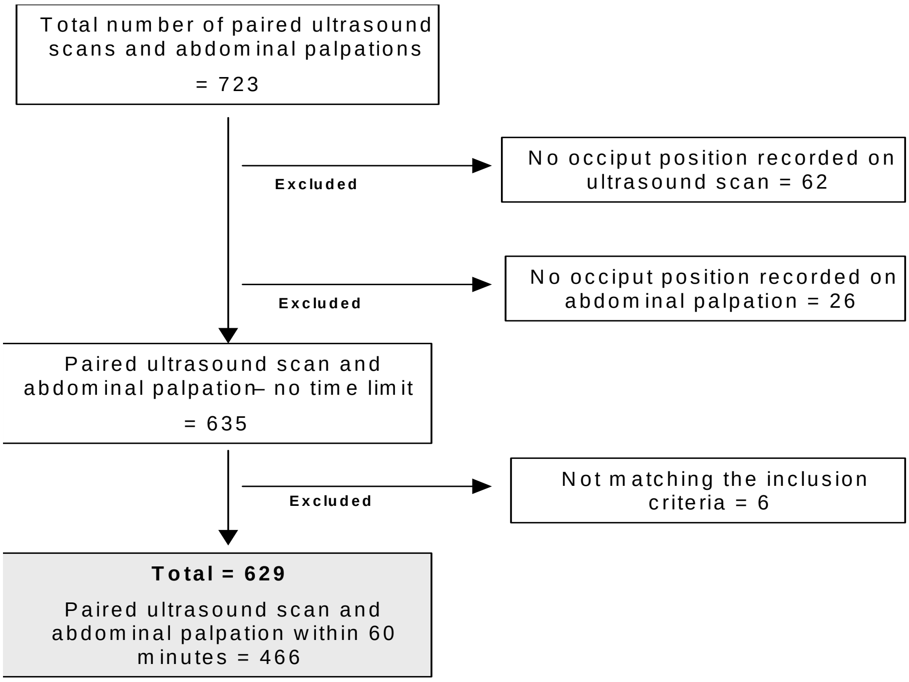
Logistic regression analysis was performed to see if there were any maternal or midwife characteristics that may be predictive of the accuracy of the abdominal palpation. We separately analysed the effect of midwife or maternal characteristics on sensitivity and specificity. To analyse the impact on sensitivity, we selected the subgroup of women with LOA position as determined by ultrasound and the dependent variable in the logistic model was whether or not the abdominal palpation detected the LOA position. For the analysis of specificity, the subgroup of women with non-LOA position as determined by ultrasound were selected and the dependent variable in this case was whether or not the abdominal palpation detected the non-LOA position. In other words, the dependent variable for the analyses was whether or not the abdominal palpation agreed with the ultrasound.

Maternal BMI, gestational age, length of midwife practice, area of midwifery expertise and palpation technique were chosen as predictor variables partly from the results of the literature review in chapter 2 (10). Placental location and whether membranes were intact or ruptured were chosen as predictors as it has been suggested that the accuracy of abdominal palpation may be impaired with an anterior located placenta or if there is excessive amniotic fluid (9).

4 RESULTS

The test accuracy study was undertaken between May 2005 and September 2007 at Birmingham Women's NHS Foundation Trust. A total of 723 paired ultrasound scans and abdominal palpations were performed with no adverse effects reported. Exclusion of data with inconclusive index and reference standard results (*n*=88), gave a sample of 635 patients who had complete data on both the index test (abdominal palpation) and reference standard (abdominal ultrasound) (figure 4.1). Inconclusive results were found in 26 abdominal palpations where the midwife had not recorded a fetal position, and in 62 ultrasound scans whereby the research midwife had recorded that the fetal head was too low in the pelvis for any reference markers to be seen and she was therefore unable to identify the occipital position. From the 635 patients who underwent both the index test and reference standard, 629 patients were selected for final analysis as four patients did not meet the inclusion criteria (≥ 37+1 gestational weeks) and two had data missing on this variable. Within the final sample, 466 patients received the reference standard of abdominal ultrasound within sixty minutes of the index test. At the time this accuracy study was completed the prognostic study (see figure 1.3), had a group of 653 patients in which only scans were performed. Their features are shown in appendix 3.

Figure 4.1 Flow chart depicting patients satisfying inclusion criteria



4.1 *Sample Characteristics*

Table 4.1 Description of the sample

	Group One		Group Two	
	Total sample (no time limit between reference standard and index test) *n= 629*		Reference standard performed <60mins following index test *n= 466*	
	n	(%)	*n*	(%)
Weeks gestation	Mean = 282.2 days SD=8		Mean = 281.8 days SD=8	
37+1-38 gestational weeks	25	4.0	21	4.5
38+1-39 gestational weeks	73	11.6	58	12.4
39+1-40 gestational weeks	143	22.7	104	22.3
40+1-41 gestational weeks	212	33.7	160	34.3
41+1-42 gestational weeks	165	26.2	117	25.1
> 42 gestational weeks	11	1.7	6	1.3
BMI	Mean = 25.6 SD=5.2		Mean = 25.4 SD=5	
Underweight (BMI <18.5)	15	2.4	15	3.2
Ideal weight (BMI 18.5-25)	323	51.4	244	52.4
Overweight (BMI 25-30)	172	27.3	121	26
Obese (BMI 30-40)	106	16.9	77	16.5
Clinically Obese (BMI >40)	9	1.4	6	1.3
Not stated	4	0.6	3	0.6
Age	Mean = 26.6 SD=5.7		Mean = 26.5 SD=5.8	
< 20 years	74	11.8	56	12.0
20-25 years	183	29.1	144	30.9
25-30 years	166	26.4	114	24.5
30-35 years	142	22.6	103	22.1
35-40 years	60	9.5	45	9.7
> 40 years	4	0.6	4	0.9
Spontaneous onset of labour	443	70.4	338	72.5
Induction of labour	186	29.6	128	27.5
Spontaneous rupture of membranes	242	38.5	182	39.1
Location of placenta on ultrasound:				
Anterior placenta	274	43.6	195	41.8
Posterior placenta	268	42.6	202	43.3
Fundal placenta	38	6.0	30	6.4
Lateral placenta	23	3.7	19	4.1
Not stated	26	4.1	20	4.3

We were interested, not only in the characteristics of the total sample, but also in comparing the total sample with those women who received the reference standard within 60 minutes of the index test to see if the characteristics differed (table 4.1).

Patient BMI (mean 25.6/25.4/25.9) and age (mean 26.6/26.5/26.3 years) was similar across the two groups. The majority of patients were classified as being of ideal weight (BMI 18.5-25) at their first antenatal visit. Over 50% of the patients were aged 20-30 years in both groups. Placental location was similar across both groups with over 80% of placentas being either anterior or posterior. Average patient gestation was similar in patients who had received both the index test and reference standard regardless of time difference, with means of 282.2 days (±8 days) and 281.8 (±8 days) days respectively. Likewise, whether labour was spontaneous or induced was similar across both groups with over 70% of labours being spontaneous in these groups.

4.2 Midwife Characteristics

The characteristics of the midwife undertaking each of the reference standards are shown in table 4.2. In over 85% of the abdominal palpations midwives had completed between 1-10 years of service (*n*=422). The three main areas of midwife employment were the delivery suite, the birth centre and the antenatal ward and accounted for just over 60% of palpations performed by all midwives (*n*=380). The majority of the midwives were hospital based with just over 13% of palpations (*n*=86) being performed by midwives who were based in the community.

Table 4.2 Midwife characteristics

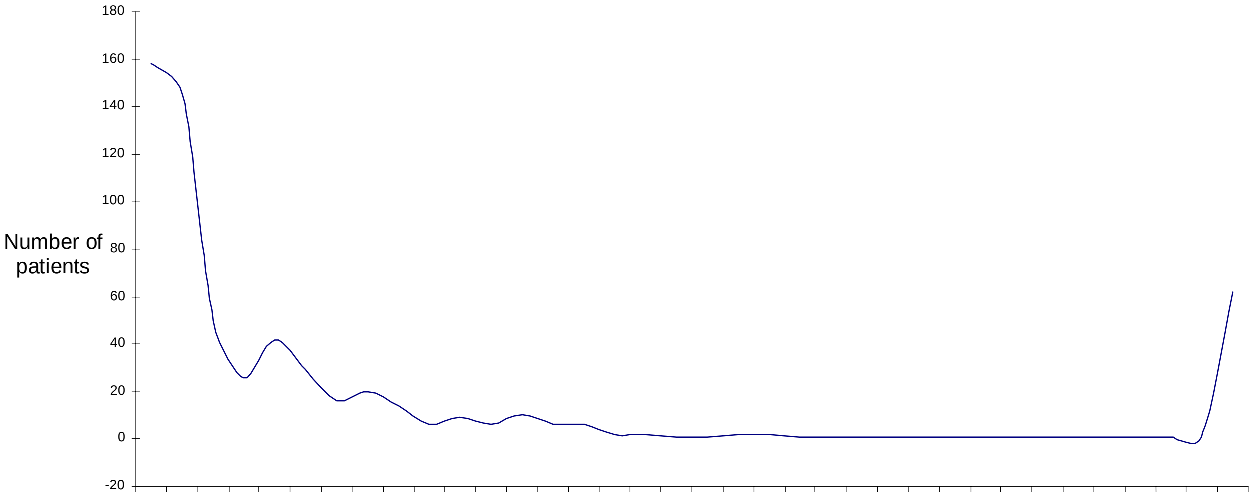
	n	(%)
Length of service (years)		
< 1	58	9.2
1-5	244	38.8
6-10	120	19.1
>10	171	27.2
Not stated	36	5.7
Main area of employment		
Core Delivery Suite	121	19.2
The Birth Centre	137	21.8
Antenatal Ward	122	19.4
Postnatal Ward	19	3.0
Community	86	13.7
Bank/Agency	11	1.7
Antenatal clinic	9	1.4
Rotational	77	12.2
Not stated	47	7.5

4.3 The performance of the index test

It was planned that the reference standard would be performed as soon as possible following the index test. For the total sample of 629 patients the mean time difference between the index test and the reference standard was 18.53 minutes. Time difference in minutes was positively skewed (figure 4.2), with a median difference of 20 minutes and mode of <1 minute with the ultrasound examination being performed immediately following the abdominal palpation.

Correlation analysis comparing a time difference between the index test and reference standard of less than 12 hours versus greater than 12 hours showed no significant difference between the correct assessment of the LOA (p=0.35) or the non-LOA (p=0.77) fetal position (Table 4.3). Therefore the total sample of 629 patients was used for analysis.

Figure 4.2 **Graph to show distribution of time difference in minutes between abdominal palpation (index test) and abdominal ultrasound (reference standard)**



Minutes	<3	10	20	30	40	50	60	70	80	90	100	110	120	130	140	160	170	180	200	220	230	250	350	410	420	430	440	460	500	560	630	660	880	980	1040	1440
Number of patients	158	145	50	26	42	29	16	20	14	6	9	6	10	6	6	2	2	1	1	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	62

Table 4.3 **Comparison of time difference between index test and reference standard**

Time difference between index test and reference standard >= 12hours versus < 12 hours	Odds Ratio	95%CI	*p*
Correct assessment of LOA	0.35	0.04-3.21	0.353
Correct assessment of non-LOA	1.09	0.60-1.99	0.777

There were a total of 61 LOA fetal positions identified by ultrasound of which 21 (34.4%) were identified correctly by abdominal palpation (table 4.4). Prevalence of the LOA position from the total sample was 9% (*61*/629) (table 4.5). The data in table 4.4 were then used to calculate the sensitivity, specificity and likelihood ratios for abdominal palpation as a method of identifying the LOA fetal position (table 4.5). The sensitivity and specificity were 34% (95% CI 24-47) and 71% (95% CI 67-75) respectively. The positive likelihood ratio for the LOA position was 1.2 (95% CI 0.83-1.74) and the negative likelihood ratio was 0.92 (95% CI 0.76-1.11).

The accuracy of abdominal palpation to correctly identify any single fetal position was poor. The association between abdominal palpation and abdominal ultrasound for all of the eight fetal positions is shown in table 4.6.

Table 4.4 Association between abdominal palpation and ultrasound for the LOA fetal position

Abdominal Palpation	Ultrasound					
	LOA		Non-LOA		Total	
	n	(%)	*n*	(%)	*n*	(%)
LOA	21	(34.4)	163	(28.7)	184	(29.3)
Non-LOA	40	(65.6)	405	(71.3)	445	(70.7)
Total	61	(100.0)	568	(100.0)	629	(100.0)

Table 4.5 Sensitivity, specificity and likelihood ratios for abdominal palpation as a method of identifying the LOA fetal position

Abdominal palpation to diagnose the LOA position	Estimate	95% Confidence Interval
Sensitivity	34%	23 - 46
Specificity	71%	67 - 74
False positive	28%	25 - 32
False negative	65%	53 - 76
Likelihood Ratio:		
Positive	1.20	0.83-1.74
Negative	0.92	0.76-1.11
Prevalence	9%	

Sensitivity ranged from 3-34% across all the eight positions and was highest in the LOA (34%, *n=21/*61) fetal position and lowest in the DOA position (3%, *n=1/*39). Specificity ranged from 71-98%, and likelihood ratios ranged from 0.77-3.23 across the eight fetal positions (table 4.7). However, the use of abdominal palpation to determine if the fetal occiput was in any left or ride sided position showed a much higher sensitivity of 69% and 63% and likelihood ratios of 2.02 and 2.04 respectively (table 4.7).

Table 4.6 Association between abdominal palpation and ultrasound for all fetal positions, with prevalence.

Fetal position by abdominal palpation	Fetal position by ultrasound										
	LOA	LOL	LOP	Any left positon	DOA	ROA	ROL	ROP	Any right position	DOP	Total
LOA	**21**	71	37	129	18	3	15	12	30	7	184
LOL	13	**31**	13	57	3	0	6	7	13	4	77
LOP	4	27	**7**	38	1	0	15	6	21	8	68
Any left position	38	129	57	**224**	22	3	36	25	64	19	*324*
DOA	3	2	1	6	**1**	2	4	0	6	0	*13*
ROA	9	23	8	40	7	**9**	36	22	67	18	132
ROL	7	14	2	23	5	9	**18**	12	39	4	71
ROP	4	4	12	20	3	3	14	**10**	27	9	59
Any right position	20	41	22	83	15	21	68	44	**133**	31	*262*
DOP	0	8	2	10	1	3	4	1	8	**6**	*25*
Total	61	180	82	323	39	29	112	70	211	56	*629*
Prevalence (%)	9	29	13	69	6	5	18	11	63	9	

Any left position = LOA + LOL + LOP
Any right position = ROA + ROL + ROL

Table 4.7 Estimated sensitivity, specificity and likelihood ratios for all fetal positions.

Estimates	Fetal position by ultrasound									
	LOA	LOL	LOP	Any left position	DOA	ROA	ROL	ROP	Any right position	DOP
Sensitivity (%)	34	17	9	69	3	31	16	14	63	11
Specificity (%)	71	90	89	66	98	80	90	91	69	97
False positive (%)	28	10	11	32	2	20	10	8	49	3
False negative (%)	65	83	91	33	97	69	84	85	21	89
Likelihood Ratio:										
Positive	1.20	1.68	0.77	2.02	1.26	1.51	1.57	1.63	2.04	3.23
Negative	0.92	0.92	1.03	0.47	0.99	0.87	0.94	0.94	0.53	0.92

4.4 Association between palpatory method and accuracy

Table 4.8 Association between individual and combined elements of abdominal palpation and accurate assessment of LOA fetal position.

Element(s) of abdominal palpation used	Correct assessment LOA	
	n/N	(%)
Pawlick's grip only	1/1	100.0
Deep pelvic palpation only	0/0	0.0
Lateral palpation only	0/1	0.0
Fundal palpation only	0/0	0.0
	0/0	0.0
Deep pelvic & Pawlick's grip		
Fundal & Pawlick's grip	0/0	0.0
Lateral & Pawlick's grip	1/4	25.0
Lateral & Deep pelvic palpation	1/2	50.0
Fundal & Lateral palpation	1/3	33.3
Fundal & Deep pelvic palpation	0/1	0.0
Lateral & Deep pelvic & Pawlick's grip	0/0	0.0
Fundal & Deep pelvic & Pawlick's grip	0/0	0.0
Fundal & Lateral & Pawlick's grip	4/11	36.4
Fundal & Lateral & Deep pelvic palpation	12/30	40.0
All four manoeuvres (fundal & lateral & deep pelvic & pawlick's grip)	1/7	14.3
None	0/1	0.0
Total	21/61	34.4

n: correct assessment
N: total assessment LOA by USS

As previously described in chapter 1 the index test consists of four individual manoeuvres. We were therefore interested to see whether or not the use of any individual or combination of these manoeuvres were associated with the correct assessment of the LOA fetal position. The association of the individual element of abdominal palpation and correct assessment of the LOA fetal position is shown in table 4.8 (for non-LOA position see appendix 4).

There was no significant association between the use of any one individual manoeuvre and the correct assessment of the LOA fetal position (table 4.9).

3% of patients with an LOA fetal position confirmed by ultrasound had an abdominal palpation consisting of a single manoeuvre (*n/*N=*2*/61). From the use of a single manoeuvre Pawlick's grip was the most accurate in correctly identifying the LOA fetal position (*n/*N=*1*/1). Of the patients with an LOA fetal position confirmed by ultrasound, 16% were examined using two manoeuvres during a single abdominal palpation (*n/*N=*10*/61). Of these patients, correct assessments of the LOA position a combination of lateral and deep pelvic palpation was most accurate (*n/*N=*1*/2).

67% of patients with LOA fetal position confirmed by ultrasound were examined by a combination of three manoeuvres during a single abdominal palpation (*n/*N=*41*/61). Correct assessments of the LOA fetal position were made in 40% (*n/*N=*12*/30) of cases by using the combination of fundal, lateral and deep pelvic palpation. The use of Pawlick's grip instead of deep pelvic palpation resulted in a slightly lower rate of correct assessments for the LOA of 36% (*n/*N=*4*/11). Abdominal palpation consisting of all four manoeuvres accounted for only 11% (*n/*N=*7/*61) of ultrasound confirmed LOA fetal positions, and correct assessment of the LOA fetal position by abdominal palpation was made in only 14% (*n/*N=*1*/7) of these.

Table 4.9 Odds ratio and *p* values for correct assessment of LOA fetal position by individual element of abdominal palpation.

	Correct assessment LOA		
Examination technique	Odds Ratio	95% CI	*p*
Fundal palpation	1.059	0.24-4.74	0.940
Lateral palpation	1.053	0.09-12.33	0.967
Deep pelvic palpation	1.077	0.35-3.29	0.896
Pawlick's grip	0.750	0.25-2.27	0.610

4.5 Association between position of fetal spine and accuracy

We were interested in the relationship of the position of the fetal spine and the correct assessment of the LOA fetal position by abdominal palpation (table 4.10). Correct identification of the LOA fetal position was made most often when the spine was in the left lateral pelvic area (53%, *n=8*/15). The relationship of the fetal spine by ultrasound to the correct assessment of the non-LOA fetal position by abdominal palpation can be found in appendix 6.

Table 4.10 Relationship of fetal spine by ultrasound to correct assessment of LOA fetal position by abdominal palpation

Position of fetal spine	Correct assessment LOA	
	n/N	(%)
LspA	11/40	27.5
LspL	8/15	53.3
LspP	0/1	0.0
RspA	0/0	0.0
RspL	0/0	0.0
RspP	0/0	0.0
DspA	2/5	40.0
DspP	0/0	0.0
Undetermined	0/0	0.0
Total	21/61	34.4

n: correct assessment
N: total assessment LOA by ultrasound scan

4.6 Association between patient characteristics and accuracy

We were interested to see whether or not the accurate assessment of fetal position by abdominal palpation would be associated with various patient characteristics. These are summarised in table 4.11 (for data on non-LOA fetal position see appendix 7).

Table 4.11 Association between patient characteristics and accurate assessment of LOA fetal position by abdominal palpation

	Correct assessment LOA	
	n/N	(%)
	21/61	34.4
Gestational age (weeks + days)		
37+1- 38	0/1	0.0
38+1- 39	3/8	37.5
39+1 - 40	3/13	23.1
40+1 - 41	9/19	47.4
41+1 - 42	6/18	33.3
>42	0/2	0.0
	p = 0.814	
	OR 0.94	CI 0.59-1.52
BMI		
Underweight (BMI <18.5)	0/1	0.0
Ideal weight (BMI 18.5-25)	17/39	43.6
Overweight (BMI 25-30)	3/11	27.3
Obese (BMI 30-40)	1/7	14.3
Clinically Obese (BMI >40)	0/1	0.0
	p = 0.073	
	OR 0.87	CI 0.75-1.01
Membranes		
Intact	15/41	36.6
Ruptured	6/20	30.0
	p = 0.612	
	OR 1.34	CI 0.43-4.24
Placental location		
Anterior	10/24	41.7
Posterior	8/27	29.6
Lateral	0/2	0.0
Fundal	1/4	25.0
Not known	2/4	50.0
	p = 0.351	
	OR 0.58	CI 0.19-1.79

n: correct assessment
N: total assessment LOA by ultrasound scan

Correct assessment of the LOA fetal position by abdominal palpation was highest when the patient was between 40+1 to 41 completed gestational weeks (47.5%, *n=9/*19), although there was no significant association between gestational age and the correct assessment of the LOA fetal position (*p* =0.814, OR 0.94, CI 0.59-1.52).

For the LOA position, correct assessment was highest in patients classified as having an ideal weight at the first antenatal visit (BMI 18.5 - 25), being 43.6%, *(n=17/*39). There were no accurate assessments of the LOA fetal position for women in the clinically obese group. However, patient BMI was not found to be statistically significantly associated with the correct assessment of the LOA fetal position (*p* =0.073, OR 0.87, CI 0.75-1.01).

Correct assessment of the LOA and fetal position was evenly spread between women who had intact membranes at the time of the test or whose membranes had ruptured (either spontaneously or surgically). Correct assessment of the LOA position was made in 36.6%, *(n=15/*41) of patients with intact membranes and 30%, *(n=6/*20) of patients with ruptured membranes. Whether membranes were intact or ruptured at the time of the test, however, was not found to be statistically significantly associated with the correct assessment of the LOA fetal position (*p* =0.612, OR 1.34, CI 0.43-0.24).

Where the placental location was known, for the LOA position correct assessment was markedly higher in patients with a placenta in the anterior position at 41.7%, *(n=10/*24). Again, however, placental position (posterior/lateral versus anterior/fundal) was not found to be statistically significantly associated with the correct assessment of the LOA position (*p* =0.351, OR 0.58, CI 0.19-1.79).

4.7 *Association between midwifery characteristics and accuracy*

Abdominal palpation is a clinical skill and it would therefore be reasonable to expect the accuracy of this skill to improve with length of experience. We were therefore interested to see whether or not midwife characteristics were associated with greater accuracy in identifying fetal position by abdominal palpation. There were significant associations found between length of clinical experience and main area of clinical practice of the midwife undertaking the abdominal palpation and the correct assessment of the LOA fetal position.

Where the length of midwifery experience was given, correct assessment of the LOA position was higher when made by midwives with more than 6 years experience, with 53.3% of correct LOA assessments being made by midwives with greater than 10 years experience and 41.7% by midwives with between 6 and 10 years experience (table 4.12). Overall, significantly more palpations undertaken by midwives with over 5 years relative to under 5 years clinical experience, (48.1% versus 18.8%), were found to be accurate in correctly assessing the LOA position (p =0.019, OR 4.02, CI 1.26-12.90).

Where the main area of midwifery expertise was given correct assessment of the LOA position was highest when the palpation was undertaken by a community midwife (71%, n=5/7) (table 4.12). The main area of midwife expertise was found to be significantly associated with the accurate assessment of the LOA position comparing palpations by midwives practicing in the community setting relative to those practicing within the hospital (71.4% versus 27.5%; *p* =0.038,OR 0.15, CI 0.026-0.90). The association between years of clinician experience and main area of clinical practice and accurate assessment of the non-LOA fetal position by abdominal palpation can be found in appendix 8.

Table 4.12 Association between years of clinician experience and main area of clinical practice and accurate assessment of LOA fetal position by abdominal palpation

	Correct assessment LOA	
	n/N	(%)
	21/61	34.4
Clinician experience (years)		
< 1	1/8	12.5
1-5	5/24	20.8
6-10	5/12	41.7
>10	8/15	53.3
Not stated	2/2	100.0
>5 years versus <= 5 years	***p* = 0.019**	
	OR 4.02	CI 1.26-12.90
Main area of midwife employment		
Core Delivery Suite	3/10	30.0
The Birth Centre	3/15	20.0
Antenatal Ward	3/11	27.3
Postnatal Ward	1/2	50.0
Community	5/7	71.4
Bank/Agency	0/1	0.0
Antenatal clinic	1/2	50.0
Rotational	2/9	22.2
Not stated	3/4	75.0
Hospital versus Community	***p* = 0.038**	
	OR 0.15	CI 0.03-0.90

n: correct assessment
N: total assessment LOA by ultrasound scan
Hospital midwives include Core Delivery Suite, The Birth Centre, Antenatal ward, Postnatal ward, Bank/Agency, Antenatal clinic and Rotational midwives

4.8 *Summary of results*

- The prevalence of the LOA fetal position was 9%.

- Clinicians in this study were only able to correctly identify 21 out of the 61 LOA cases by abdominal palpation, demonstrating a sensitivity of 34% (95% CI 24-47) and specificity of 71% (95% CI 67-75) for detecting the LOA fetal position.

- Midwives with >5 years experience (vs <5 years), and those working in the community (vs hospital), more accurately identified the LOA fetal position.

- There was no significant association between maternal BMI, gestational age, rupture of membranes and placental location and the correct assessment of the LOA fetal position.

- There was no significant association between the use of any one individual abdominal palpation manoeuvre and the correct assessment of the LOA fetal position.

5 DISCUSSION

There is a move within midwifery towards the practice of optimal fetal positioning which involves the promotion of maternal posturing in the latter stages of pregnancy to encourage the fetus to adopt the LOA position at the onset of labour (6;49-52). Professionals who practice optimal fetal positioning do so by diagnosing the position of the fetus in utero using the clinical skill of abdominal palpation. However a systematic literature review detailed in chapter two highlighted a dearth of research pertaining to the accuracy of abdominal palpation to determine fetal position. Only one piece of published research assessing the accuracy of abdominal palpation to identify fetal position (10) was identified, which, based on a small sample size, concluded that the ability of clinicians to diagnose fetal position from abdominal palpation was, at best, moderate.

If prognostic studies show that the optimal fetal position of LOA does exist and that maternal posturing can in fact be used to maneuver the fetus into this position, then the question is whether midwives will be able to use the clinical skill of abdominal palpation to confirm this fetal position at the onset of labour and avoid women undergoing unnecessary interventions. This thesis addressed the question of accuracy in a large prospective study by firstly evaluating whether abdominal palpation is accurate in assessing the LOA fetal position at the onset of labour and secondly, whether accuracy is associated with palpation method, or with maternal factors or with characteristics of the midwife who undertook the abdominal palpation.

5.1 Main findings

Abdominal palpation had a sensitivity to detect the LOA fetal position of only 34% (95% CI 24-47) and a specificity of 78% (95% CI 67-75). Likelihood ratios were calculated to give further information about the clinical effectiveness of abdominal palpation as a way to accurately identify fetal position. The likelihood ratio indicates the value of a test for increasing certainty about a positive diagnosis by comparing the probability of getting a true positive result with that of a true negative (87). This study demonstrated a positive likelihood ratio of 1.20 and a negative likelihood ratio of 0.92 for the correct assessment of the LOA fetal position by abdominal palpation. This suggests that the use abdominal palpation as a means to correctly identify the LOA fetal position is poor.

Although the study was primarily concerned with the accurate assessment of the LOA fetal position, the correct assessment of other fetal positions by abdominal palpation was also recorded. In total only 16% of all fetal positions were accurately identified by abdominal palpation by the midwives in this study (*n*/N = *103*/629). Although it is acknowledged that the study was not powered for the detection of the non-LOA fetal positions, sensitivity to detect other fetal positions was low in all groups. Interestingly, the highest sensitivity was for correct assessment of the LOA fetal position, which as already discussed was still poor. Likelihood ratios were also low across all fetal positions and this low rate of accuracy raises questions about the validity of clinical decisions based on the findings of abdominal palpation to detect fetal position at the onset of labour.

As previously mentioned in chapter 1, published estimates of the prevalence of the LOA fetal position at the onset of labour are varied. From their extensive work involving X-Ray pelvimetry in the 1930s, Cauldwell et al (1934) estimate between 9-12% of fetuses enter labour in the LOA position, dependent of pelvic type (5). In a small study designed to compare transvaginal digital examination and abdominal ultrasound during the active stage of labour, Sherer et al (2002) found the LOA position at the onset of labour at just under 16% (n/N = *16*/102) (26). In Myles Textbook for Midwives, Fraser (2004) estimates the LOA fetal position at the onset of labour at 15% although it is not clear whether this figure is one that has been historically reported and reproduced or whether it has been obtained from contemporary records as no references to research are provided. (8). This study demonstrated a prevalence for the LOA fetal position of just below 10% that was more in keeping with estimates by Cauldwell et al (1934) (5).

As previously discussed in chapter one, the abdominal palpation examination of the gravid uterus has not changed significantly since it became established as recognised clinical practice in the late nineteenth century (13). The correct method of abdominal palpation as outlined in chapter one, requires the use of the combination of fundal palpation, lateral palpation and deep pelvic palpation and/or Pawlick's grip. This study demonstrated that 78% (*n*/N=*48*/61) of the abdominal palpation examinations undertaken on LOA cases confirmed by ultrasound were performed using this recommended combination, and of those 80% (*n*/N=*17*/21) were correctly identified as LOA by abdominal palpation.

Although the numbers are small, 22% (*n/*N=*13*/61) of examinations were undertaken using a non-recommended set of palpatory elements. This is interesting as it demonstrates clinical practice that is not in line with routine teaching. Regarding individual palpatory elements, as the recommended abdominal palpation is a combination of palpatory elements, it is not surprising that no single element was found to be of greater use when performed individually. It is therefore reasonable to explain the high level of accuracy in correct assessments with the use of individual elements of palpation in this study as a result of the very low numbers of cases in these groups (Pawlick's grip (*n/*N=*1*/1), lateral and deep pelvic palpation (*n/*N=*1*/2)).

We were interested to see whether or not our test accuracy study would confirm or dispute the findings from McFarlin et al (1985) concerning the association of patient characteristics and the accurate assessment of fetal position by abdominal palpation (10). Length of gestation, maternal BMI, whether membranes were intact or ruptured and placental position were not associated with accuracy of the correct assessment of the LOA fetal position by abdominal palpation. Interestingly, this study did not confirm the findings from the study by McFarlin (1985) that demonstrated that maternal obesity reduced the accuracy of abdominal palpation to detect fetal position.

We were also interested to see whether or not midwife characteristics were associated with greater accuracy in identifying fetal position by abdominal palpation. As a clinical skill it would be reasonable to expect the accuracy of abdominal palpation to improve with length of experience. The finding that clinicians of more than five years clinical experience were more accurate than those with less than five years (p=0.019) was therefore not surprising. This result concurs with findings from the 1985 study by McFarlin (10). However, McFarlin et al (1985) also found a higher level of accuracy in clinicians with less than one-year experience that this study did not demonstrate. It is acknowledged that the number of clinicians in this study with less than one year of clinical experience was much smaller than in the other groups. With regard to main area of practice, midwives practicing in the community were found to be more accurate than those working in the hospital (p=0.038). However, the number of palpations performed by midwives in the study who were based in the community (n=86, 13.7%) was disproportionate to those practicing in the hospital (n=529, 86.3%). It is possible that in the community setting, where it is unfeasible to rely on ultrasound, midwives hone their technique much better out of necessity.

5.2 Strengths and weaknesses

In order to make the study robust and reduce influence of bias this accuracy study was designed to meet the STARD criteria for methodological quality of test accuracy studies (82). The STARD recommended checklist for reporting accuracy studies was completed and is shown in table 5.1 (82;83). Strengths and weaknesses of the study were also identified and discussed.

Table 5.1 Completed STARD checklist for the reporting of studies of diagnostic accuracy

Section and Topic	Item #		On page #
TITLE/ABSTRACT/ KEYWORDS	1	Identify the article as a study of diagnostic accuracy (recommend MeSH heading 'sensitivity and specificity').	37
INTRODUCTION	2	State the research questions or study aims, such as estimating diagnostic accuracy or comparing accuracy between tests or across participant groups.	37
METHODS		Describe	
Participants	3	The study population: The inclusion and exclusion criteria, setting and locations where the data were collected.	37
	4	Participant recruitment: Was recruitment based on presenting symptoms, results from previous tests, or the fact that the participants had received the index tests or the reference standard?	38
	5	Participant sampling: Was the study population a consecutive series of participants defined by the selection criteria in items 3 and 4? If not, specify how participants were further selected.	38
	6	Data collection: Was data collection planned before the index test and reference standard were performed (prospective study) or after (retrospective study)?	39
Test methods	7	The reference standard and its rationale.	43
	8	Technical specifications of material and methods involved including how and when measurements were taken, and/or cite references for index tests and reference standard.	43
	9	Definition of and rationale for the units, cutoffs and/or categories of the results of the index tests and the reference standard.	43
	10	The number, training and expertise of the persons executing and reading the index tests and the reference standard.	43
	11	Whether or not the readers of the index tests and reference standard were blind (masked) to the results of the other test and describe any other clinical information available to the readers.	49
Statistical methods	12	Methods for calculating or comparing measures of diagnostic accuracy, and the statistical methods used to quantify uncertainty (e.g. 95% confidence intervals).	49
	13	Methods for calculating test reproducibility, if done.	Not done
RESULTS		Report	
Participants	14	When study was done, including beginning and ending dates of recruitment.	53
	15	Clinical and demographic characteristics of the study population (e.g. age, sex, spectrum of presenting symptoms, comorbidity, current treatments, recruitment centers).	55
	16	The number of participants satisfying the criteria for inclusion that did or did not undergo the index tests and/or the reference standard; describe why participants failed to receive either test (a flow diagram is strongly recommended).	54
Test results	17	Time interval from the index tests to the reference standard, and any treatment administered between.	57
	18	Distribution of severity of disease (define criteria) in those with the target condition; other diagnoses in participants without the target condition.	59
	19	A cross tabulation of the results of the index tests (including indeterminate and missing results) by the results of the reference standard; for continuous results, the distribution of the test results by the results of the reference standard.	59
	20	Any adverse events from performing the index tests or the reference standard.	53
Estimates	21	Estimates of diagnostic accuracy and measures of statistical uncertainty (e.g. 95% confidence intervals).	59
	22	How indeterminate results, missing responses and outliers of the index tests were handled.	53
	23	Estimates of variability of diagnostic accuracy between subgroups of participants, readers or centers, if done.	Not done
	24	Estimates of test reproducibility, if done.	Not done
DISCUSSION	25	Discuss the clinical applicability of the study findings.	69

5.2.1 Study strengths

The study was undertaken at Birmingham Women's Foundation NHS Trust, a maternity unit that serves a large, socio-economically and ethnically representative population in order to aid generalising of findings. The recruitment via the community midwife at routine antenatal clinic from 28 gestational weeks, or by National Childbirth Trust (NCT) education facilitators at Parenthood Education classes from 34 gestational weeks or by the research midwife or one of three ultrasound scan trained midwives on admission to hospital in early labour or for induction of labour, if not previously recruited during the antenatal period was designed to ensure all eligible women were approached for consent to be included in the study in order to avoid selection bias and provide a suitably representative sample of the population.

The sample size for this accuracy study was large with 629 patients who underwent both the index test and reference standard. From this sample size the study was able to demonstrate a prevalence of 9% and consequently was adequately powered to exclude a sensitivity of < 70% reliably with a power of 80% (see table 3.1), and therefore enhanced the reliability, validity and generalization of the study results.

The study benefited from ensuring that only four midwives who had undergone a clearly documented training programme developed in conjunction with the Sonography department of the Birmingham Women's Foundation NHS Trust performed the abdominal ultrasound scan following the index test. Periodic reassessment and update training by trained sonographers ensured quality assurance of the abdominal ultrasound examination. This meant that the reference standard was consistently applied to a high quality throughout the study.

The reduction of bias was built into the study and ensured in several ways. The research midwife was blinded to the result of the abdominal palpation (index test) as the clinical midwife was asked to place her documentation of the abdominal palpation in a sealed envelope. The clinical midwife and the patient were both blinded to the ultrasound examination (reference test). Furthermore, all data from the index test and reference standard were transferred onto a specially designed ACCESS database and input by a data clerk not involved in the index test or reference standard. The database was password protected and only the data input clerk had access to the passwords.

5.2.2 Study weaknesses

In order to make the study robust it was intended that the ultrasound examination be undertaken immediately following the abdominal palpation in order to provide immediate verification. However, from the results delayed verification between the two tests was found. A study by Clark et al (2004) demonstrated an empirical bias in estimation of accuracy in test accuracy studies with delayed verification of diagnosis (91). Within the final sample of this study, 74% of patients (*n*/N = *466*/629) received the reference standard of abdominal ultrasound within sixty minutes of the abdominal palpation index test. It is known that the mechanisms of labour, discussed in chapter 1, require the fetus to rotate and it is entirely possible that the fetus could have moved position during the interval between the index test and reference standard. Such movement of the fetus resultant from the normal mechanisms of labour has previously been documented in a study by Kreiser et al (2001), between the performance of the two tests of vaginal examination and perineal ultrasound to confirm fetal position in the second stage of labour (84). Consequently this delay in performance of the reference standard could have resulted in false positives and false negatives which, as Clark et al (2004) suggest, may lead to an underestimation of the test accuracy demonstrated in this study (91). Future studies would benefit from a repeat scan one hour from the initial scan to see if the fetus has moved during this time and to know if the delay between abdominal palpation and ultrasound has any effect.

However, although acknowledging delay, Clarke et al (2004) recognised that delay between tests is sometimes inevitable and a reflection of the situation present in clinical practice (91). In this study, one reason for the delay was due to the study participant having her abdominal palpation whilst on the antenatal ward and not receiving her ultrasound examination until she was admitted to the delivery suite or birth centre, which could have been some time later, again due to the availability of one of the four ultrasound trained midwives to perform the scan. Clarke et al (2004) also found that reporting of the time delay between index test and reference standard in test accuracy studies was poor (91). Therefore, although there was a delay in verification between the two tests in this study, this time difference was reported and the mean time difference was an acceptable 18 minutes. The study is also strengthened by the fact that for a significant delay of over 12 hours there was no statistically significant relationship with the overall accuracy estimation.

At the time this accuracy study was completed the prognostic study (see figure 1.3), had a group of 653 patients in which only the reference standard of abdominal ultrasound was recorded. Their features are shown in appendix 3. It was disappointing that no data on the index test of abdominal palpation was collected for these women. This could be partly explained by the higher rate of women having induction of labour within this group (39%) compared to that of women receiving both tests (29%). Women booked for induction were generally admitted to a busy antenatal ward where one midwife was responsible for the care of up to 8 women undergoing induction of labour. It was not always possible to get the midwife to perform the abdominal palpation before the ultrasound examination, as she was busy with other duties. Interestingly, the characteristics of the women who underwent the reference standard only are similar to those of the women included in the accuracy study who underwent both procedures, only differing in regard to whether their labour was spontaneous or induced. This strengthens the generalisation of the findings from the accuracy study sample size.

Another possible reason for the high rate of women who did not have the index test could be that the study relied on the goodwill of the clinical midwives to complete the abdominal palpation forms and notify the research midwife when having done so. Despite the procedure being simple and straightforward and designed to take minimal time and effort, midwives were not always willing to participate. This highlights other issues surrounding midwives acceptance to participate in research studies that warrants further research.

Taking into account the strengths and weaknesses, on balance, this study provides reliable, valid evidence that merits consideration

5.3 Clinical implications

Appropriate antenatal and intrapartum management is dependent on accurate assessment of in-utero fetal presentation and position with decisions regarding place, mode and position for delivery relying on correct assessment of fetal presentation and position. The use of abdominal palpation of the gravid uterus to identify fetal presentation and position is a worldwide routine obstetric practice. Competency in abdominal palpation is an essential part of modern midwifery practice (16), despite being regarded as a subjective assessment tool and subject to error (53). The poor accuracy of abdominal palpation as a means to identify fetal position shown by this study raises questions as to whether abdominal palpation has ever been an accurate way to determine fetal position or whether reliance on ultrasound and medical intervention has lessened midwives skills in this area.

Midwives, childbirth educators and women are increasingly practicing optimal fetal positioning that involves the use of maternal posturing to manoeuvre the fetus into the LOA position. This practice relies on the assessment of fetal position by abdominal palpation. In light of the low rate of accuracy of abdominal palpation to identify the LOA fetal position, or any other fetal position, found in this study, the ability to successfully practice optimal fetal positioning without ultrasound confirmation of fetal position before or following maternal posturing is debateable. However, if prognostic studies show that the fetal occiput being either left or right side at the onset of labour are predictive of labour outcomes then this study demonstrates that using abdominal palpation to determine if the fetus is on the left or right side is going to be clinically worthwhile.

Indeed, the recommendations drawn by the authors of the Cochrane Systematic review (56) into the effectiveness of maternal posturing could be viewed as questionable, as in two out of the three trials conclusions were drawn using abdominal palpation to identify fetal position of which the accuracy remains unproven (57;60). Consequently, future intervention studies using maternal posturing should employ ultrasound to determine fetal position and the use of routine abdominal ultrasound on labour wards may now be necessary if fetal position needs to be confirmed.

5.4 Implications for future research

From the results of this accuracy study the following areas for future research have been identified:

1. More studies are needed to improve midwifery training in abdominal palpation and to determine how the learning of this clinical skill could be enhanced.

2. Prognosis for labour and delivery outcomes from specific fetal position needs to be established (such as the prognostic arm of the APOLLO study).

3. Research into midwives acceptance to participate in studies concerning clinical skills.

6 CONCLUSION

Abdominal palpation has been an essential part of midwifery and obstetric practice since its development in 1870s. It is therefore surprising that research into its accuracy at determining fetal position is so sparse. This thesis addressed this knowledge gap by the use of a large prospective study (*n*=629) evaluating whether abdominal palpation is accurate in identifying the LOA fetal position at the onset of labour and if the accuracy is associated with the palpation method, maternal and midwifery characteristics.

Implications from the findings from this test accuracy study will impact on those practicing optimal fetal positioning and the conclusions based on research using abdominal palpation to confirm fetal position. Indeed the findings from this study will influence the interpretation of results and conclusions from any study that has been based on the use of abdominal palpation to confirm fetal position without ultrasound.

This study, of a relatively large sample size has demonstrated that the accuracy of abdominal palpation to identify fetal position is poor, and confirms the findings from an earlier study by McFarlin et al (1985). If future prognostic studies highlight the existence of a fetal position that improves birth outcome, midwives will need to be trained in ultrasound to confirm fetal position at the onset of labour to improve birth outcomes.

References

(1) Baker P. Labour. In: Baker P N, editor. Obstetrics by Ten Teachers. 18th edition ed. London: Hodder Arnold; 2006. p. 220-54.

(2) Verralls S. The Female Pelvis. Anatomy and Physiology Applied to Obstetrics. Churchill Livingstone; 1993. p. 23-46.

(3) Sweet B. The Female Pelvis. In: Sweet B, Tiran D, editors. Maye's Midwifery - a textbook for midwives. 12th ed. London: Bailliere Tindall; 1997. p. 13-25.

(4) Cauldwell WE, Moloy HC. Anatomical variations in the female pelvis and their effect in labour with a suggested classification. Am J Obstet Gynecol 1933;26:479-505.

(5) Cauldwell WE, Moloy HC. Further studies on the pelvic architecture. Am J Obstet Gynecol 1934;28:482-97.

(6) Sutton J. Let birth be born again. Rediscovering and Reclaiming our Midwifery Heritage. Middlesex: Birth Concepts; 2001.

(7) Sweet B. Antenatal Care. In: Sweet B, Tiran D, editors. Maye's Midwifery: A Textbook for Midwives. 12th ed. London: Bailliere Tindall; 1997. p. 208-38.

(8) Fraser D. Antenatal Care. In: Fraser D, Cooper M, editors. Myle's Textbook for Midwives. 14th Edition ed. London: Churchill Livingstone; 2004. p. 251-73.

(9) Cunningham FG, Leveno MD, Bloom S, Hauth JC, Gilstrap L, Wenstrom K. Normal Labour & Delivery. Williams Obstetrics. 22nd Edition ed. London: McGraw-Hill; 2008. p. 409-42.

(10) McFarlin B, Engstrom J, Sampson M, Cattledge F. Concurrent validity of leopold's maneuvers in determining fetal presentation and position. Journal of Nurse-Midwifery 1985;30(5):280-4.

(11) Bithell JF, Stewart A. Prenatal irradiation and childhood malignancy: A review of British data from the Oxford survey. British Journal of Cancer 1975;31(3):271-87.

(12) Diamond EL, Schmerler H. The relationship of intrauterine radiation to subsequent mortality and development in leukemia in children. Am J Epidemiol 1973;97(5):283-313.

(13) Crede E, Leopold G. The obstetrical examination: A short guide for physicians, students of medicine, midwives, and students in midwifery, in Edgar JC (ed & transl). NY J Gynecol Obstet 1892;2:1129.

(14) Crede E, Leopold G. A Short Guide to the Examination of Lying-in Women (Wilson W, transl). London: H Kimpton; 1894.

(15) Burnett CW. Abdominal palpation during pregnancy. Nursing Mirror Midwives Journal 1951 Jul 27;93(2413):297-301.

(16) Gibson J. How to perform an abdominal examination. Midwives 2008;October/November:22.

(17) My Mak C, Wong H S. Assessing Women in Pregnancy and Labour: Is it Better to Palpate? A Perspective From Midwives. Hong Kong Journal of Gynaecology Obstetrics and Midwifery 2000;1(2):86-95.

(18) Rhodes P. A short history of clinical midwifery. The development of ideas in the Professional Management of Childbirth. 1st Edition ed. Cheshire: Books for Midwives Press; 1995.

(19) Donnison J. Midwives and Medical Men. A history of inter-professional rivalries and women's rights. London: Heinemann Educational Books; 1977.

(20) Dietze M. A re-evaluation of the Mechanism of Labour for Contemporary Midwifery Practice. Midwifery Matters 2001;Spring 2001(88):3-8.

(21) Caruthers B. Structural and mechanical factors associated with the birth process. The Surgical Technologist 2000 Oct 1;19-27.

(22) Norrin M. Midwifery care in the second stage of labour. In: Sweet B, Tiran D, editors. Maye's Midwifery: A Textbook for Midwives. 12th ed. London: Bailliere Tindall; 1997. p. 385-401.

(23) Fraser D. Transition and Second stage of Labour. In: Fraser D, Cooper M, editors. Myles Textbook for Midwives. 14th Edition ed. London: Churchill Livingstone; 2004. p. 487-507.

(24) Steer P. The mechanism and management of normal labour. In: Chamberlain G, Steer P, editors. Turnbill's Obstetrics. 3rd Edition ed. London: Churchill Livingstone; 2001. p. 431-8.

(25) Symonds EM, Symonds IM. Normal Labour. Essential Obstetrics and Gynaecology. 4th Edition ed. London: Churchill Livingstone; 2004. p. 151-70.

(26) Sherer DM, Miodovnik M, Bradley KS, Langer O. Intrapartum fetal head position I: comparison between transvaginal digital examination and transabdominal ultrasound assessment during the active stage of labor. Ultrasound Obstet Gynecol 2009;2002(19):258-63.

(27) Gardberg M, Laakkonen E, Salevaara M. Intrapartum Sonography and Persistent Occiput Posterior Position: A Study of 408 Deliveries. Obstetrics and Gynecology 1998;91(5):746-9.

(28) Chamberlain G, Steer P. ABC of labour care: unusual presentations and positions and multiple pregnancy. BMJ 1999;318(7192):1192-4.

(29) Fitzpatrick M, McQuillan K, O'Herlihy C. Influence of persistent occiput posterior position on delivery outcome. Obstetrics and Gynecology 2001;(98):1027-31.

(30) Biancuzzo M. The Patient Observer: Does the Hands-and-Knees Posture During Labor Help to Rotate the Occiput Posterior Fetus? Birth 1991;18(1):40-7.

(31) Phillips R, Freeman M. The Management of Persistent Occiput Posterior Position. A Review of 552 Consecutive Cases. Obstetrics and Gynecology 1974;42(2):171-7.

(32) Neri A, Kaplan B, Rabinerson D, Sulkes J, Ovadia J. The management of persistent occipito-posterior position. Clinical Expertise in Obstetrics and Gynaecology 1995;1995(2):126-31.

(33) Pearl M, Roberts J, Laros R, Hurd W. Vaginal Delivery from the Persistent Occiput Posterior Position. Influence on Maternal and Neonatal Morbidity. Journal of Reproductive Medicine 1993;38(12):955-61.

(34) Gardberg M, Tuppurainen M. Persistent occiput posterior presentation - a clinical problem. Acta Obstetricia et Gynecologica Scandinavica 1994;1994(73):45-7.

(35) Floberg J, Belfrage P, Ohlsen H. Influence of the pelvic outlet capacity on fetal head presentation at delivery. Acta Obstetricia et Gynecologica Scandinavica 1987;1987(66):127-30.

(36) Ponkey S, Cohen A, Heffner L, Lieberman E. Persistent Fetal Occiput Posterior Position: Obstetric Outcomes. Am J Obstet Gynecol 2003;101(5):915-20.

(37) Benevides L, Wu J, Hundley A, Ivester A, Visco A. The impact of occiput posterior fetal head position on the risk of anal sphincter injury in forceps-assisted vaginal deliveries. Am J Obstet Gynecol 2005;192(5):1702-6.

(38) Cheng Y W, Shaffer B L, Caughey A B. The Association Between Persistent Occiput Posterior Position and Neonatal Outcomes. Am J Obstet Gynecol 2006;107(4):837-44.

(39) Sizer A R, Nirmal D M. Occipitoposterior position: associated factors and obstetric outcomes in nulliparas. Obstetrics and Gynecology 2000;2000(96):749-52.

(40) Senecal J, Xiong Xu, Fraser William D, for the PEOPLE (Pushing Early Or Pushing Late with Epidural) Study Group. Effect of Fetal

Position on Second-Stage Duration and Labor Outcome. Am J Obstet Gynecol 2005;105(4):763-72.

(41) The Health and Social Care Information Centre. Hospital Episode Statistics: Table 9: Method of delivery, 1980-2007-08. 2009. 17-5-2009.
Ref Type: Internet Communication

(42) Department of Health. Why Mother's Die 1997-1999. the Confidential Enquiries into Maternal Deaths in the UK. HMSO; 2000.

(43) Cetrulo CL, Cetrulo LG. Medicolegal Dystocia. Clinical Expertise in Obstetrics and Gynaecology 1987;30(1):106-13.

(44) Dermott RK, Sandmire HH. The Green Bay Caesarean Section Study. The physician factor as a determinant of caesarean birth rates for failed labor. Am J Obstet Gynecol 1992;166(6 (part1)):1799-810.

(45) Goyert GL. The physician factor in caesarean birth rates. New England Journal of Medicine 1989;320(11):706-9.

(46) Thomas J, Paranjoty S. Royal College of Obstetricians and Gynaecologists Clinical Effectiveness Support Unit. National Sentinel Caesarean Section Audit Report. RCOG Press; 2001.

(47) Bibi A. The effect of position. Midwives 2007;10(5):216-7.

(48) El Halta V. Posterior labor: A pain in the back. Midwifery Today 1995;Winter 1995(36):19-21.

(49) Sutton J. Birth: medical emergency or engineering miracle? A midwifery approach to keeping birth normal. MIDIRS: Midwifery Digest 1996;6(2):170-3.

(50) Sutton J. Occipito-posterior positioning and some ideas about how to change it! The Practising Midwife 2000;13(6):20-2.

(51) Sutton J. Birth without active pushing and a physiological second stage of labour. The Practising Midwife 2000;3(4):32-4.

(52) Sutton J. Optimal fetal positioning. A midwifery approach to increasing the number of normal births. MIDIRS: Midwifery Digest 1994;4(3):283-6.

(53) Ridley RT. Diagnosis and Intervention for Occiput Posterior Malposition. Journal of Obstetric, Gynacologic and Neonatal Nursing 2007;2007(36):135-43.

(54) Coates T. Malpositions and malpresentations of the occiput: current research and practice tips. MIDIRS: Midwifery Digest 2002;12(2):152-4.

(55) Puddicombe JF. Maternal posture for correction of posterior fetal position. International College of Surgeons 1958;1958(23):73-7.

(56) Hunter S, Hofmeyr GJ, Kulier R. Hands and knees posture in late pregnancy or labour for fetal malposition (lateral or posterior). Chichester, England: John Wiley & Sons Ltd; 2007 Jul 30. Report No.: The Cochrane Database of Systematic Reviews, Issue 4, 2007.

(57) Andrews C M, Andrews E C. Nursing, maternal postures, and fetal position. Nursing Research 1983;(32):336-41.

(58) Andrews C M. Nursing intervention to change a malpositioned fetus. Journal of Advanced Nursing 1981;(3):53-6.

(59) Faber P. The persistent OP. Can maternal position rotate the baby? The Practising Midwife 1998;1(3):16-9.

(60) Kariminia A, Chamberlain M E, Keogh J, Shea A. Randomised controlled trial of effect of hands and knees posturing on incidence of occiput posterior position at birth. British Medical Journal 2004 Feb 28;328:490-3.

(61) Webb S, Bibi A, Earley B. Validity is flawed - what about the laws of gravity and buoyancy? Rapid response. BMJ com 2004 April 8

(62) Stremler R, Hodnett E, Petryshen P, Stevens B, Weston J, Wilan AR. Randomized controlled trial of hands-and-knees positioning for occipitoposterior position in labor. Birth 2005;32(4):243-51.

(63) Khan K S, Kunz R, Kleijnen J, Gerd A. Systematic Reviews to Support Evidence-based Medicine. London: Royal Society of Medicine Press Ltd; 2003.

(64) Mulrow CD. Rationale for systematic reviews. In: Chalmers I, Altman DG, editors. Systematic Reviews.London: BMJ Publishing Group; 1995. p. 1-8.

(65) Honest H, Khan K S. Systematic Reviews of Test Accuracy Studies in Reproductive Health. WHO Reproductive Health Library 2002;(Number 5)(2002).

(66) Moher D, Liberati A, Tetzlaff J, Altman D, and the PRISMA Group. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The Prisma Statement. Annals of Internal Medicine 2009 Aug 18;151(4):1-7.

(67) Cochrane Methods Working Group on Systematic Review of Screening and Diagnostic Tests: Recommended Methods. 1996. Report No.: updated June.

(68) Khan K S, Ter Riet G, Popay J, Nixon J, Kleijnen J. Study quality assessment. York: NHS Centre for Reviews and Dissemination (CRD), University of York; 2001.

(69) Khan K S, Kleijnen J, Dinnes J. Systematic reviews to evaluate diagnostic tests. European Journal of Obstetrics Gynaecology and Reproductive Biology 2001;(95):6-11.

(70) Whiting P, Rutjes A, Reitsma J, Bossuyt P, Kleijnen J. The development of QUADAS: a tool for the quality assessment of studies of diagnostic accuracy included in systematic reviews. BMC Medical Research Methodology 2003;3(1):25.

(71) Bais JMJ, Eskes M, Pel M, Bonsel GJ, Bleker OP. Effectiveness of detection of intrauterine growth retardation by abdominal palpation as screening test in a low risk population: An observational study. European journal of obstetrics gynecology and reproductive biology 2004 Oct;116(2):164-9.

(72) Banerjee K, Mittal S, Kumar S. Clinical vs ultrasound evaluation of fetal weight. International journal of gynaecology and obstetrics: the official organ of the International Federation of Gynaecology and Obstetrics 2004;86(1):41-3.

(73) Euans DW, Connor PD, Hahn RG, Rodney WM, Arheart KL. A comparison of manual and ultrasound measurements of fundal height. The Journal of family practice 1995;40(3):233-6.

(74) Hughey M. Fetal position during pregnancy. Am J Obstet Gynecol 1985;153:885-6.

(75) Lydon R, Albers L, Gorwoda J, Craig E, Qualls C. Accuracy of Leopold manoeuvres in screening for malpresentation: a prospective study. Birth 1993;20(3):132-5.

(76) Raman S, Urquhart R, Yusof M. Clinical versus ultrasound estimation of fetal weight. The Australian & New Zealand journal of obstetrics & gynaecology 1992;32(3):196-9.

(77) Thorp J, Jenkins T, Watson W. Utility of Leopold manoeuvres in screening for malpresentation. Obstetrics and Gynecology 1991;78(3 I):394-6.

(78) Vause S, Hornbuckle J, Thornton JG. Palpation or ultrasound for detecting breech babies? British Journal of Midwifery 1997;5(6):318-9.

(79) Nassar N, Roberts CL, Cameron CA, Olive EC. Diagnostic accuracy of clinical examination for detection of non-cephalic presentation in late pregnancy: cross sectional analytic study. BMJ 2006 Sep 16;333(7568):578-80.

(80) Burnett C. Abdominal palpation during pregnancy. Nursing Mirror 1951;(July 27):297-301.

(81) Olsen K. 'Now just pop up here, dear...' Revisiting the art of antenatal palpation. The Practising Midwife 1999 Oct 1;2(9):13-5.

(82) Bossuyt PM, Reitsma JB, Bruns DE, Gatsonis CA, Glasziou PP, Irwig LM, et al. Towards Complete and Accurate Reporting of Studies of Diagnostic Accuracy: The STARD Initiative. Clinical Chemistry 2003;49(1):1-6.

(83) Khan K S, Bakour S H, Bossuyt P M. Evidence-based obstetric and gynaecologic diagnosis: the STARD checklist for authors, peer-reviewers and readers of test accuracy studies. BJOG: an International Journal of Obstetrics and Gynaecology 2004;111(May 2004):1-3.

(84) Kreiser D, Schiff E, Lipitz S, Kayam Z, Avarham A, Achiron R. Determination of fetal occiput position by ultrasound during the second stage of labour. The Journal of Maternal-Fetal Medicine 2001;2001(10):283-6.

(85) Bartlett JE, Kotrlick JW, Higgins CC. Organizational Research: Determining Appropriate Sample Size in Survey Research. Information Technology Learning and Performance Journal 2001;19(1):43-50.

(86) Macfarlane TV. Sample size determination for research projects. Journal of Orthodontics 2003;30(2):99-100.

(87) Altman DG, Bland JM. Diagnostic test 2: Predictive values. BMJ 1994 Jul 9;309(6947):102.

(88) Jaeschke R, Guyatt G, Sackett D L, For the Evidence-Based Medicine Working Group. Users' guides to the medical literature, III. How to use an article about a diagnostic test. B. What are the results and will they help me in caring for my patients? JAMA 1994;(271):703-7.

(89) Khan K S, Khan S F, Nwosu C R, Chien P FW. Misleading authors' inferences in obstetric diagnostic test literature. Am J Obstet Gynecol 1999;(181):112-5.

(90) Honest H, Khan K S. Reporting of measures of accuracy in systematic reviews of diagnostic literature. BMC Medical Services Research 2002;2002:2-4.

(91) Clark T J, Ter Riet G, Coomarasamy A, Khan K S. Bias associated with delayed verification in test accuracy studies: accuracy of tests for endometrial hyperplasia may be much higher than we think! BMC Medicine 2004;(2):18-26.

Appendix 1

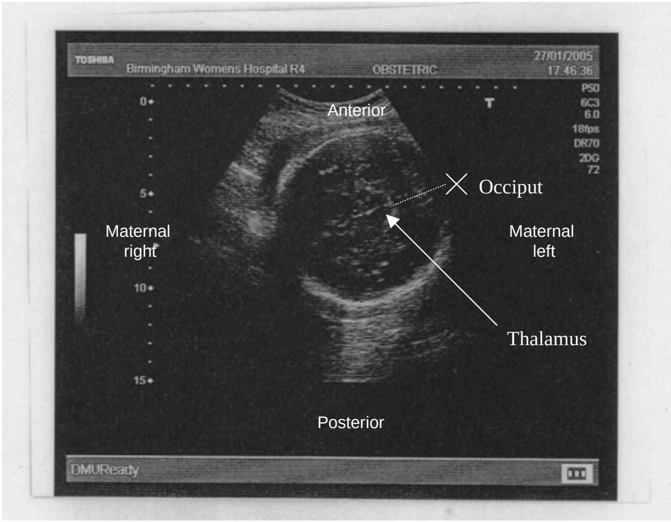
Search strategy for literature review

Name		Search strategy	Delete search	
Permanent Search:				
	CINAHL 1		1. SEARCH: PREGNANCY 2. SEARCH: PRENATAL-CARE#.DE. 3. SEARCH: 1 OR 2 4. SEARCH: ABDOM$ ADJ PALPATION 5. SEARCH: PALPATION#.W..DE. 6. SEARCH: LEOPOLD$ ADJ MANEUV$ 7. SEARCH: 4 OR 5 OR 6 8. SEARCH: ULTRASOUND 9. SEARCH: ULTRASONOGRAPHY#.W..DE. 10. SEARCH: 8 OR 9 11. SEARCH: 3 AND 7 AND 10	delete
	EMBASE 1		1. SEARCH: PREGNANCY 2. SEARCH: PREGNANCY#.W..DE. 3. SEARCH: 1 OR 2 4. SEARCH: ABDOM$ ADJ PALPATION 5. SEARCH: PALPATION#.W..DE. 6. SEARCH: LEOPOLD$ ADJ MANEUV$ 7. SEARCH: 4 OR 5 OR 6 8. SEARCH: ULTRASOUND 9. SEARCH: ULTRASOUND#.W..DE. 10. SEARCH: 8 OR 9 11. SEARCH: 3 AND 7 AND 10 AND HUMAN=YES	delete
	MEDLINE 1		1. SEARCH: PREGNANCY 2. SEARCH: PREGNANCY#.W..DE. 3. SEARCH: ABDO$ ADJ PALPATION 4. SEARCH: PALPATION 5. SEARCH: PALPATION#.W..DE. 6. SEARCH: LEOPOLD$ ADJ MANEUV$ 7. SEARCH: ULTRASOUND 8. SEARCH: 1 OR 2 9. SEARCH: 3 OR 4 OR 5 OR 6 10. SEARCH: 7 AND 8 AND 9 11. SEARCH: 10 AND HUMAN=YES	

Appendix 2

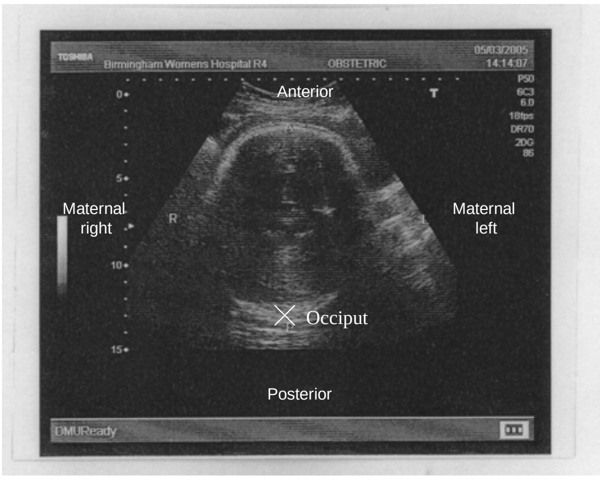
Ultrasound images

Figure i **Transverse suprapubic sonographic view depicting the LOA fetal position.**



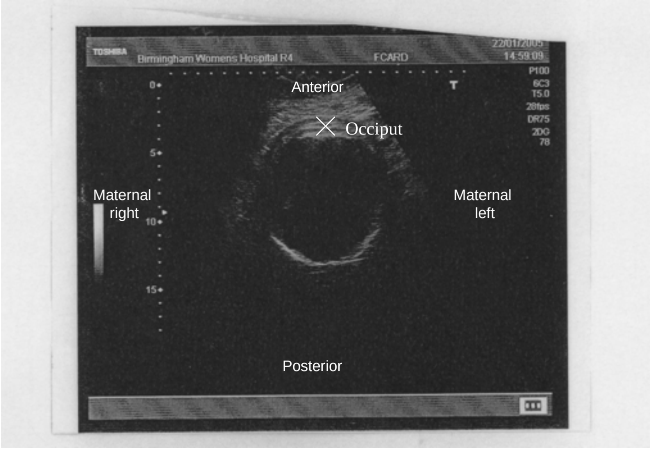
This figure clearly demonstrates how the intercranial structure of the thalamus in relation to the maternal pelvis, was used to designate the occipital position.

Figure ii **Transverse suprapubic sonographic view depicting the fetal head in the DOA position.**



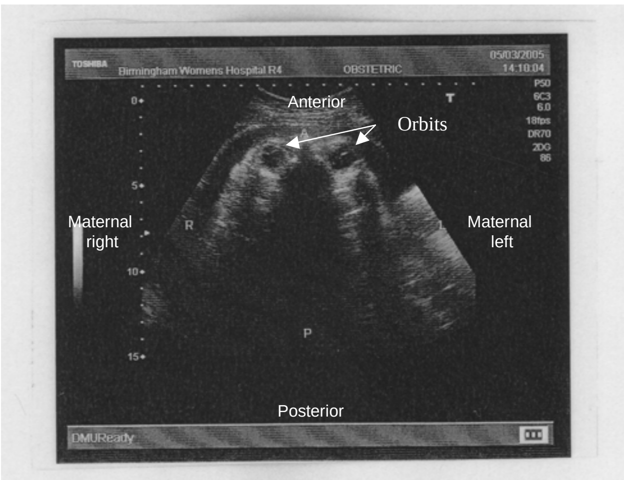
The occipital bone is clearly visible anteriorly and in relation to the maternal pelvis has been used to designate the occipital position.

Figure 2.iii **Transverse suprapubic sonographic view depicting the fetal head in the DOP position by visualising occipital bone.**



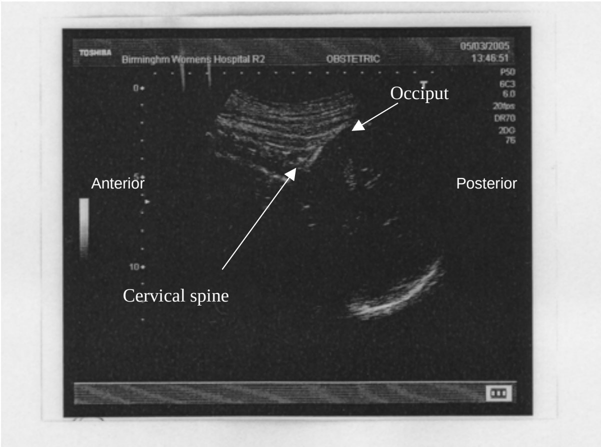
The occipital bone is clearly visible posteriorly and in relation to the maternal pelvis has been used to designate the occipital position.

Figure iv **Transverse suprapubic sonographic view depicting the fetal head in the DOP position by visualising orbits.**



By keeping the probe in the transverse suprapubic position and angling the probe anteriorly both fetal orbits can be visualised.

Figure v **Longitudinal suprapubic sonographic view depicting the sagittal fetal cervical spine**



Appendix 3

Characteristics of patients to which only reference standard of abdominal ultrasound was performed

	Reference standard only *n= 653*	
	n	(%)
Weeks gestation	Mean = 260 days SD=8.5	
37+1-38 gestational weeks	37	5.7
38+1-39 gestational weeks	86	13.2
39+1-40 gestational weeks	140	21.4
40+1-41 gestational weeks	187	28.6
41+1-42 gestational weeks	196	30.0
> 42 gestational weeks	7	1.1
BMI	Mean = 25.9 SD=5.8	
Underweight (BMI <18.5)	13	2.0
Ideal weight (BMI 18.5-25)	318	48.7
Overweight (BMI 25-30)	199	30.5
Obese (BMI 30-40)	105	16.1
Clinically Obese (BMI >40)	8	1.2
Not stated	10	1.5
Age	Mean = 26.3 SD=5.9	
< 20 years	95	14.5
20-25 years	174	26.6
25-30 years	190	29.1
30-35 years	124	19.0
35-40 years	66	10.1
> 40 years	4	0.6
Spontaneous onset of labour	394	60.3
Induction of labour	259	39.7
Spontaneous rupture of membranes		
Location of placenta on ultrasound:		
Anterior placenta	301	46.1
Posterior placenta	271	41.5
Fundal placenta	23	3.5
Lateral placenta	23	3.5
Not stated	35	5.4

Appendix 4

Table of association between individual and combined elements of abdominal palpation and accurate assessment of non-LOA fetal position.

Element(s) of abdominal palpation used	Correct Assessment Non-LOA *n/N*	(%)
Pawlick's grip only	2/3	66.7
Deep pelvic palpation only	3/8	37.5
Lateral palpation only	2/5	40.0
Fundal palpation only	1/2	50.0
Deep pelvic & Pawlick's grip	0/0	0.0
Fundal & Pawlick's grip	6/9	66.7
Lateral & Pawlick's grip	25/33	75.8
Lateral & Deep pelvic palpation	10/17	58.8
Fundal & Lateral palpation	7/9	77.8
Fundal & Deep pelvic palpation	15/19	78.9
Lateral & Deep pelvic & Pawlick's grip	2/2	100.0
Fundal & Deep pelvic & Pawlick's grip	2/5	40.0
Fundal & Lateral & Pawlick's grip	71/108	65.7
Fundal & Lateral & Deep pelvic palpation	205/277	74.0
All four manoeuvres (fundal & lateral & deep pelvic & pawlick's grip)	44/58	75.9
None	10/13	76.9
Total	405/568	71.3

n: correct assessment
N: total assessment non-LOA by ultrasound scan

The association of the individual element of abdominal palpation and correct assessment of fetal position is shown in the above table. For patients with a non-LOA fetal position confirmed by ultrasound, only 3% had an abdominal palpation consisting of a single manoeuvre (*n/*N=*18*/568). From the use of a single manoeuvre, Pawlick's grip was the most accurate in correctly identifying the non-LOA fetal positions (*n/*N=*2*/3). Of the 568 patients with a non-LOA fetal position confirmed by ultrasound, 15% were examined using two manoeuvres during a single abdominal palpation (*n/*N=*87*/568). For patients having an abdominal palpation consisting of two manoeuvres, correct assessment of the non-LOA fetal position was most accurate from the use of a combination of fundal and deep pelvic palpation (*n*/N=*15*/19).

69% of patients with LOA fetal position confirmed by ultrasound were examined by a combination of three manoeuvres during a single abdominal palpation (*n*/N=*392*/568). Correct assessments of the non-LOA fetal position were made in 74% of cases by using the combination of fundal, lateral and deep pelvic palpation. The use of Pawlick's grip instead of deep pelvic palpation resulted in slightly lower number of correct assessments for the non-LOA fetal positions (65%). Abdominal palpation consisting of all four manoeuvres accounted for only 10% (*n*/N=*58/*568) of ultrasound confirmed non-LOA fetal positions, and correct assessment of the non-LOA fetal position by abdominal palpation was made in 75% (*n*/N=*44*/58) of these cases.

Appendix 5

Table of odds ratio and *p* values for correct assessment of non-LOA fetal position by individual element of abdominal palpation.

	Correct assessment		
	Non-LOA		
Examination technique	Odds Ratio	95% CI	*p*
Fundal palpation	1.290	0.78-2.13	0.320
Lateral palpation	1.313	0.74-2.33	0.352
Deep pelvic palpation	1.252	0.85-1.84	0.252
Pawlick's grip	0.883	0.61-1.28	0.512

None of the individual abdominal palpation manoeuvres were found to significantly improve the accurate assessment of the non-LOA fetal position.

Appendix 6

Table of relationship of fetal spine by ultrasound to correct assessment of non-LOA fetal position by abdominal palpation

Position of fetal spine	Correct assessment Non-LOA	
	n/N	(%)
LspA	36/69	52.2
LspL	75/127	59.1
LspP	54/75	72.0
RspA	41/46	89.1
RspL	76/90	84.4
RspP	65/75	86.7
DspA	23/41	56.1
DspP	26/34	76.5
Undetermined	5/6	83.3
Total	405/568	71.3

n: correct assessment
N: total assessment non-LOA by ultrasound scan

Correct identification of the non-LOA fetal position was made most often when the spine was in the right anterior pelvic area (89%, *n*/N=*41*/46).

Appendix 7

Table of association between patient gestational age, BMI, membranes and placental location and accurate assessment of non-LOA fetal position by abdominal palpation

	Correct assessment Non-LOA	
	n/N	(%)
	405/568	71.3
Gestational age (weeks + days)		
37+1- 38	22/24	91.7
38+1- 39	49/65	75.4
39+1 - 40	85/130	65.4
40+1 - 41	138/193	71.5
41+1 - 42	107/147	72.8
>42	4/9	44.4
	p = 0.229	
	OR 0.905	CI 0.77-1.06
BMI		
Underweight (BMI <18.5)	8/14	57.1
Ideal weight (BMI 18.5-25)	212/284	74.6
Overweight (BMI 25-30)	110/161	68.3
Obese (BMI 30-40)	68/99	68.7
Clinically Obese (BMI >40)	6/8	75.0
	p = 0.389	
	OR 0.985	CI 0.95-1.02
Membranes		
Intact	248/346	71.7
Ruptured	157/222	70.7
	p = 0.806	
	OR 1.048	CI 0.72-1.52
Placental location		
Anterior	187/250	74.8
Posterior	161/241	66.8
Lateral	16/21	76.2
Fundal	25/34	73.5
Not known	16/22	72.7
	p = 0.068	
	OR 0.707	CI 0.49-1.03

n: correct assessment
N: total assessment non-LOA by ultrasound scan

Correct assessment of the non-LOA position was highest for patients between 37+1 to 38 completed gestational weeks (91.7%, *n=22/*24). Gestational age was not found to be of statistical significance for the correct assessment of the non-LOA fetal position (*p* =0.229,OR 0.905, CI 0.77-1.06).

For the non-LOA position correct assessment was highest in women classified as being clinically obese at their first antenatal visit (BMI >40) at 75%, *(n=6/8*), closely followed by women of ideal weight at 74.6%, *(n=212/*284). Patient BMI was not found to be of statistical significance in the correct assessment of the non-LOA position (*p* =0.389,OR 0.985, CI 0.95-1.02) fetal position.

Correct assessment of the non-LOA fetal positions were evenly spread between women who had intact membranes at the time of the test or whose membranes had ruptured (either spontaneously or surgically). Correct assessment of the non-LOA position was made in 71.7%, *(n=248/*346) of patients with intact membranes and 70.7%, *(n=157/*222) of patients with ruptured membranes. Whether membranes were intact or ruptured at the time of the test was not found to be of statistical significance in the correct assessment of the non-LOA position (*p* =0.806,OR 1.048, CI 0.72-1.52).

Where the placental location was known, for non-LOA position correct assessment was evenly spread across the four groups being highest in patients with a laterally positioned placenta (76.2%, *n=16/*21), and lowest in patients with a posterior sited placenta (66.8%, *n=161/*241). Placental position (posterior/lateral versus anterior/fundal) was not found to be of statistical significance in the correct assessment of the non-LOA position (p =0.068,OR 0.707, CI 0.49-1.03).

Appendix 8

Table of association between years of clinician experience and main area of clinical practice and accurate assessment of LOA fetal position by abdominal palpation

	Correct assessment Non-LOA	
	n/N	(%)
	405/568	71.3
<u>Clinician experience</u> (years)		
< 1	34/50	68.0
1-5	156/220	70.9
6-10	83/108	76.9
>10	112/156	71.8
Not stated	20/34	58.8
>5 years versus <= 5 years	*p* = 0.368	
	OR 1.190	CI 0.82-1.74
<u>Main area of midwife employment</u>		
Core Delivery Suite	80/111	72.1
The Birth Centre	89/122	73.0
Antenatal Ward	79/111	71.2
Postnatal Ward	12/17	70.6
Community	59/79	74.7
Bank/Agency	8/10	80.0
Antenatal clinic	4/7	57.1
Rotational	48/68	70.6
Not stated	26/43	60.5
Hospital versus Community	*p* = 0.596	
	OR 0.860	CI 0.49-0.60

n: correct assessment
N: total assessment non-LOA by ultrasound scan

Correct assessment of non-LOA position was evenly spread across the four groups being highest with midwives with 6-10 years experience (76.9%, *n=83/*108), and lowest with midwives of less than 1 year's clinical experience (68%, *n=34/*50). No statistical significance was found when comparing length of midwife experience, > 5 years compared to ≤ 5 years, to the accurate assessment of the non-LOA position (*p* =0.368, OR 1.190, CI 0.82-1.74).

Correct assessment of non-LOA position was fairly evenly spread across all employment groups, when stated, being highest with Bank/Agency midwives (80%, *n=8/*10), and lowest with antenatal clinic midwives (60.5%, *n=26/*43). Area of clinical expertise did not have a statistical significance on the accuracy of identifying the non-LOA position (*p* =0.596, OR 0.860, CI 0.49-0.60).

Appendix 9

Author's contribution to this test accuracy study

I was involved with the application process for gaining ethical approval and funding.

I was responsible for the design of the test accuracy study, including that of data capture forms and the format of the ACCESS database.

I was one of the trained research midwives who carried out ultrasound scans.