Sonographic Measurement of the Lower Uterine Segment Thickness in Women With Previous Caesarean Section

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Abstract

Objectives: To evaluate the accuracy of prenatal sonography in determining the lower uterine segment (LUS) thickness in women with previous Caesarean section and to assess the usefulness of measuring LUS thickness in predicting the risk of uterine rupture during a trial of vaginal birth.

Methods: Sonographic examination was performed in 102 pregnant women with one or more previous Caesarean sections at between 36 and 38 weeks' gestation to assess the LUS thickness, which was defined as the shortest distance between the urinary bladder wall-myometrium interface and the myometrium/chorioamniotic membrane-amniotic fluid interface. Of the 102 women examined, 91 (89.2%) had transabdominal sonography only, and 11 (10.8%) had both transabdominal and transvaginal examinations. The sonographic measurements were correlated with the delivery outcome and the intraoperative LUS appearance.

Results: The mean sonographic LUS thickness was 1.8 mm, standard deviation (SD) 1.1 mm. An intraoperatively diagnosed paper-thin or dehisced LUS, when compared with an LUS of normal thickness, had a significantly smaller sonographic LUS measurement (0.9 mm, SD 0.5 mm, vs. 2.0 mm, SD 0.8 mm, respectively; $P < 0.0001$). Two women had uterine dehiscence, both of whom had prenatal LUS thickness of < 1 mm. Thirty-two women (31.4%) had a successful vaginal delivery, with a mean LUS thickness of 1.9 mm, SD 1.5 mm; none had clinical uterine rupture. A sonographic LUS thickness of ≤ 1.5 mm had a sensitivity of 88.9%, a specificity of 59.5%, a positive predictive value of 32.0%, and a negative predictive value of 96.2% in predicting a paper-thin or dehisced LUS.

Conclusions: Sonography permits accurate assessment of the LUS thickness in women with previous Caesarean section and therefore can potentially be used to predict the risk of uterine rupture during trial of vaginal birth.

Résumé

Objectifs : Évaluer la précision de l'échographie prénatale aux fins du calcul de l'épaisseur du segment inférieur chez les femmes ayant déjà subi une césarienne, ainsi que l'utilité de mesurer l'épaisseur du segment inférieur en vue de prévoir le risque de rupture utérine pendant l'épreuve d'accouchement vaginal.

Méthodes : Un examen échographique a été effectué sur 102 femmes enceintes ayant déjà subi au moins une césarienne entre la 36e et la 38e semaine, en vue de mesurer l'épaisseur du segment inférieur. Cette épaisseur se définit comme étant la distance la plus courte entre l'interface paroi de la vessie-myomètre et l'interface myomètre/membrane chorioamniotique-liquide amniotique. Des 102 femmes examinées, 91 (89,2 %) ont subi une échographie transabdominale uniquement, et 11 (10,8 %) ont subi un examen transabdominal et un examen transvaginal. Les mesures obtenues par échographie ont été mises en corrélation avec l'issue de l'accouchement et l'apparence peropératoire du segment inférieur.

Résultats : L'épaisseur moyenne du segment inférieur, mesurée par échographie, était de 1,8 mm, avec un écart-type (ÉT) de 1,1 mm. Un segment inférieur déhiscent ou extrêmement mince, constaté pendant la période peropératoire, présentait une épaisseur de beaucoup inférieure à celle d'un segment inférieur d'épaisseur normale (0,9 mm, ÉT 0,5 mm, par rapport à 2,0 mm, ÉT 0,8 mm, respectivement; P < 0,0001). Deux femmes présentaient une déhiscence utérine; dans les deux cas, l'épaisseur prénatale du segment inférieur était < 1 mm. Trente-deux femmes (31,4 %) ont connu un accouchement vaginal réussi, avec un segment inférieur d'une épaisseur moyenne de 1,9 mm, ÉT 1,5 mm. Aucune des patientes n'a subi de rupture utérine clinique. Une mesure échographique ≤ 1,5 mm présentait une sensibilité de 88,9 %, une spécificité de 59,5 %, une valeur prédictive positive de 32,0 % et une valeur prédictive négative de 96,2 % relativement à l'établissement d'un diagnostic de segment inférieur déhiscent ou extrêmement mince.

Conclusions : L'échographie permet d'évaluer avec précision l'épaisseur du segment inférieur chez les femmes ayant déjà subi une césarienne, ce qui pourrait permettre de prévoir les risques de rupture utérine pendant l'épreuve d'accouchement vaginal.

J Obstet Gynaecol Can 2005;27(7):674–681

Key Words: Caesarean section, lower uterine segment thickness, sonography, ultrasound, uterine rupture, vaginal birth after Caesarean section

Competing interests: None declared.

Received on March 3, 2005

Accepted on March 31, 2005

INTRODUCTION

Uterine rupture is a recognized complication of a trial of vaginal birth after previous Caesarean section (VBAC). It has a reported incidence of 0.2% to 1.5% in women who attempt labour after a previous transverse lower uterine segment (LUS) incision.[1] However, the maternal and fetal consequences associated with uterine

rupture can be serious and potentially life threatening.[2,3] In a recent review that examined 142 075 trials of labour, the overall rate of uterine rupture was 0.62%, with a maternal death rate of 0.002%, a hysterectomy rate of 0.09%, and a transfusion rate of 0.18%.[4]

In a recent guideline on VBAC, the Society of Obstetricians and Gynaecologists of Canada recommended that, in the absence of any contraindications, a woman with one previous transverse lower segment Caesarean section should be offered a trial of labour with appropriate discussion of maternal and perinatal risks and benefits.[1] Presently, there are no reliable methods for predicting the risk of uterine rupture in women attempting VBAC. It is generally accepted that a uterus with a thinner LUS is more likely to rupture during attempted VBAC than is a uterus with a normal LUS.[5,6] The value of applying sonographic LUS thickness measurement in the management of VBAC remains unclear, although 16% of obstetricians in Canada currently use LUS thickness measured by sonography at or near term to determine which women are good candidates for VBAC.[7]

Sonographically, the LUS appears as a 2-layered structure that consists of the echogenic muscularis and mucosa of the bladder wall, including part of the visceral-parietal peritoneum, and the relatively hypoechoic myometrial layer (Figure 1).[5,8] In late pregnancy, the chorioamniotic membrane and the decidualized endometrial layer usually cannot be seen separate from the myometrium. If the fetus is presenting as a vertex, the presenting part may be firmly applied against the LUS with no amniotic fluid visible between these 2 structures.

Since the completion of our preliminary study,[9] which demonstrated that sonographic evaluation of the LUS was potentially capable of diagnosing a uterine defect and determining the degree of LUS thinning, we have been convinced that sonographic LUS measurement is a valuable tool for estimating the risk of uterine rupture, and we have continued to examine the LUS of women with previous Caesarean section. This report describes our 2-year experience with use of prenatal sonographic LUS thickness measurement in women with a previous Caesarean section. The objectives of this study were to assess the accuracy of prenatal sonography in diagnosing an extremely thin LUS and to determine a threshold LUS thickness to identify women with potentially higher risk of uterine rupture during attempted VBAC.

METHODS

This study was a continuation of our previously reported study.[9] We obtained approval from the Research Ethics Committee at North York General Hospital. During the study period, from January 2003 to December 2004, 102 pregnant women (53 from the previous study[9] and 49 additional women recruited in this study) with one or more previous Caesarean sections underwent sonographic assessment. All sonographic examinations were performed at 36 to 38 weeks' gestation. We calculated gestational age using the date of the last menstrual period and measurements from first- or second-trimester sonography. None of the women were in labour at the time of scanning. Because the uterine thickness might be affected by abnormal intrauterine volume, women with multiple gestations and abnormal amniotic fluid volumes were excluded from the study, as were women with placenta previa in whom the LUS might not be clearly identifiable.

All women underwent transabdominal sonographic examination. Beginning in September 2004, transvaginal examination was also performed in 11 women (10.8%) to allow better visualization of the LUS near the pericervical area (Figure 2). Both examinations were carried out with a full urinary bladder (to the extent that the patient had the urge to void) to allow good imaging of the LUS. The LUS was examined longitudinally and transversely to identify any areas of obvious dehiscence or rupture. The thinnest zone of the lower segment was identified visually at the midsagittal plane along the cervical canal. This area was magnified at least to the extent that any movement of the caliper would produce a change in measurement of not more than 0.1 mm. The measurement was taken with the calipers at the urinary bladder wall-myometrium interface and the myometrium/chorioamniotic membrane-amniotic fluid interface (Figure 3).[10] At least 2 measurements were made, and the lowest value obtained from either transabdominal or transvaginal examination was taken as the LUS thickness. All examinations were performed with an Aloka SSD 5000 or Toshiba SSH-140A ultrasound machine with a 3.5- or 5.0-MHz convex transabdominal transducer or a 5.0- or 7.5-MHz transvaginal transducer, and all examinations were performed by a single sonographer (V.Y.T.C). The referring physicians were aware of the sonographic findings.

The patients' labour and delivery outcomes were reviewed. After a vaginal delivery, routine manual palpation of the LUS was not performed. Following a repeat Caesarean section, the obstetrician who performed the surgery was asked to assign the appearance of the LUS to one of the following categories (modified from those of Michaels et al.[8] and Fukuda et al.[11]): (a) normal thickness, similar to that seen with primary Caesarean section; (b) evidence of rupture (represented by complete separation of the uterine scar of any length, resulting in communication between the uterine and peritoneal cavities)[5] or dehiscence (represented by

Figure 1. Transabdominal longitudinal sonogram of the LUS showing the urinary bladder wall-myometrium interface (arrows) and the myometrium/chorioamniotic membrane-amniotic fluid interface (arrowheads). B indicates urinary bladder, and H indicates fetal head.

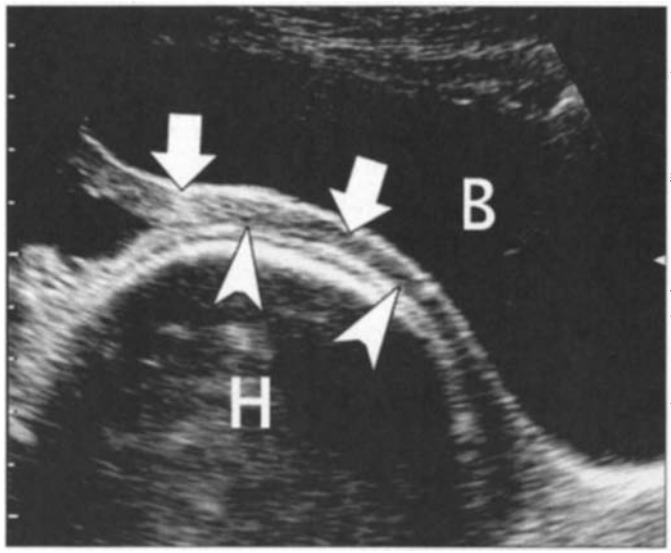


Figure 2. Transvaginal longitudinal sonogram showing better visualization of the LUS near the pericervical area. The arrow indicates the internal os of the cervix, B, urinary bladder, and H indicates fetal head.

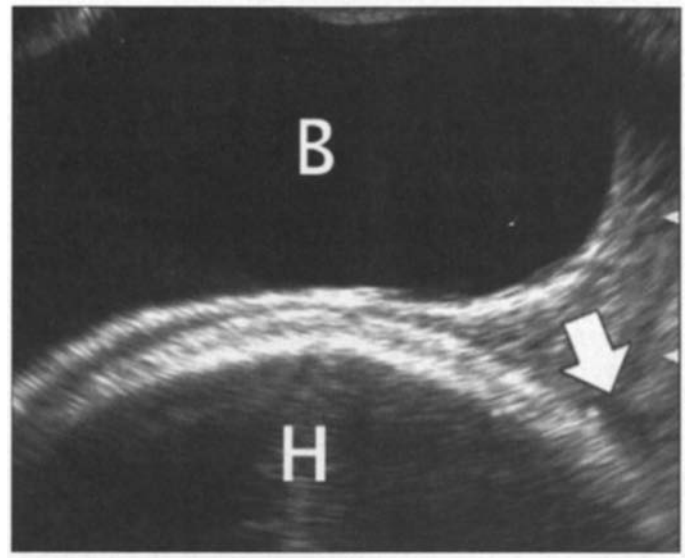


Figure 3. Transabdominal longitudinal sonogram indicating where the LUS thickness is measured (2.2 mm between arrows). The LUS was reported to be of normal thickness during repeat Caesarean section.

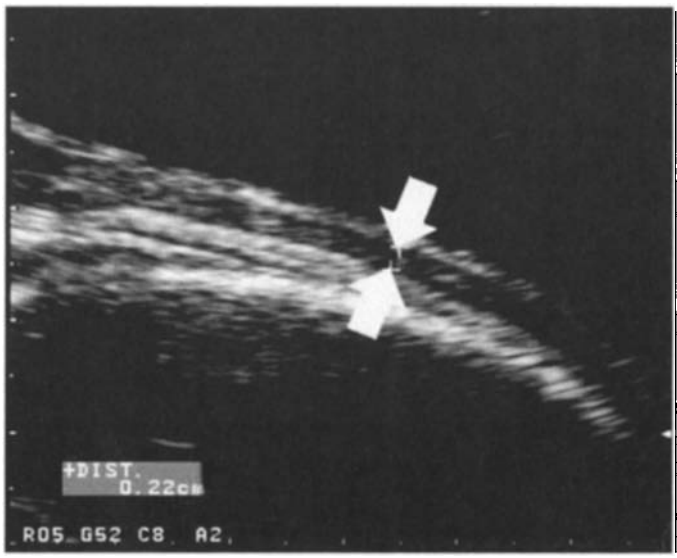
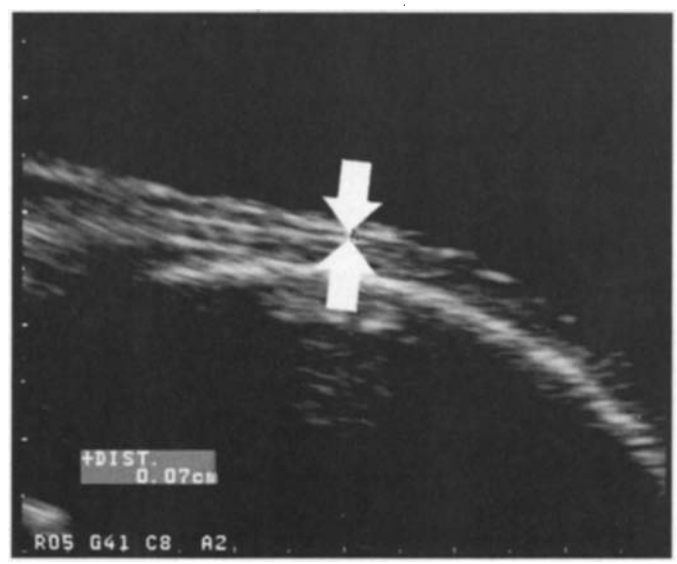


Figure 4. Transabdominal longitudinal sonogram showing an extremely thin LUS (0.7 mm between arrows). The LUS was confirmed to be paper-thin during repeat Caesarean section.



subperitoneal separation of the uterine scar, with chorioamniotic membrane visible through the peritoneum of the LUS);[5] and (c) paper-thin but not thin enough to visualize the uterine contents.

We estimated a required sample size of 83 women to determine the overall mean LUS thickness, knowing that the standard deviation (SD) was 1.4 mm,[9] with 95% confidence intervals no more than 0.3 mm above or below the mean. To compare the difference between the mean LUS thickness in women with intraoperatively diagnosed paper-thin/dehisced and normal LUS, a study population of 13 women per group was required for an alpha of 0.05 and a power of 0.80, with an anticipated difference in the mean LUS thickness of 0.9 mm and an anticipated SD of 0.8 mm.[9] With a repeat Caesarean section rate of 66.0% and an incidence of paper-thin/dehisced LUS of 28.6%,[9] a total

Table 1. Comparison of women who underwent VBAC and women who had elective Caesarean section

	VBAC (n = 50)	Elective Caesarean section (n = 52)	*P*
	Mean ± SD		
LUS thickness, mm	1.8 ± 1.2	1.8 ± 1.0	NS
Maternal age, years	32.8 ± 6.7	34.7 ± 3.8	NS
Maternal weight, kg	66.7 ± 7.9	68.5 ± 9.2	NS
Gestation at scanning, week	36.8 ± 0.6	36.9 ± 0.6	NS
Gestation at delivery, week	39.0 ± 1.0	38.8 ± 0.8	NS
Scanning-delivery interval, week	2.3 ± 1.3	2.0 ± 1.0	NS
Birthweight, g	3392.5 ± 391.9	3413.7 ± 495.6	NS
	n (%)		
Parity ≥ 2	11 (22.0)	5 (9.6)	NS
Obstetric history			
≥ 1 spontaneous abortion	10 (20.0)	9 (17.3)	NS
≥ 1 therapeutic abortion	22 (44.0)	22 (42.3)	NS
≥ 1 preterm delivery	2 (4.0)	0 (0)	NS
Cephalic presentation at scanning	49 (98.0)	45 (86.5)	NS
Apgar < 7 at 5 min	1 (2.0)	0 (0)	NS

Data are presented as mean ± standard deviation or n (%); NS: not significant ($P > 0.05$).
LUS: lower uterine segment; SD: standard deviation; VBAC: vaginal birth after Caesarean.

population of over 100 in a 2-year period was presumed to be adequate for the required sample size.

Statistical analysis was performed with Student *t* test, chi-square test, and Fisher exact test when appropriate. A *P* value of < 0.05 was taken as significant. The correlation between the sonographic LUS thickness and the intraoperative LUS appearance was assessed. The sensitivity, specificity, positive predictive value, and negative predictive value of the use of sonography in predicting dehisced or paper-thin LUS were calculated at an interval of 0.5 mm, from 0 to 2.5 mm, and the receiver operating characteristic (ROC) curve was plotted.

RESULTS

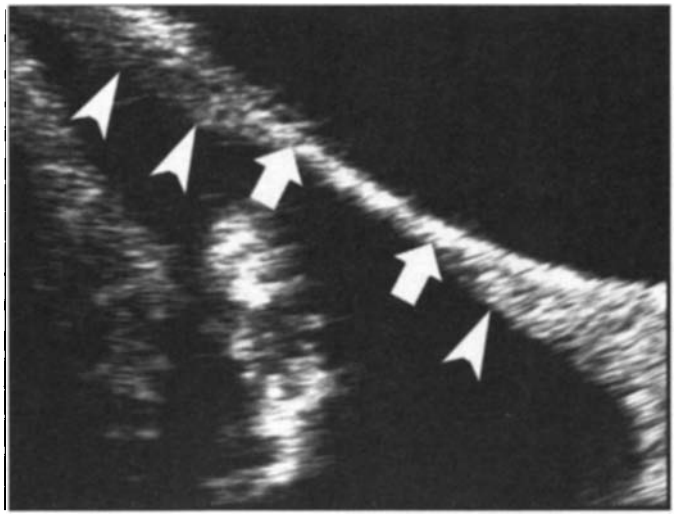
The study population comprised 102 women with a history of previous Caesarean section. The mean age was 34.1 years, SD 4.4 years, and the mean parity was 1.2, SD 0.7. Nineteen women (18.6%) had one or more previous miscarriages; 44 women (43.1%) had one or more previous therapeutic abortions; and 2 women (1.9%) had a previous preterm delivery. Five women (4.9%) had 2 previous Caesarean sections, and 11 women (10.8%) had one or more vaginal births in addition to the Caesarean section. Previous surgical reports were available for 74 women (72.5%) and all described a previous lower segment transverse uterine scar. Of these 74 women, 66 (89.2%) had a 2-layered uterine closure. In the remaining 8 women, the type of closure was not reported.

Figures 3 and 4 are sonograms obtained from women showing different LUS thickness. The mean LUS thickness was 1.8 mm, SD 1.1 mm (range 0–9.0 mm). At the time of scanning, the mean gestational age was 36.9 weeks, SD 0.6 weeks, and 94 fetuses (92.2%) were in cephalic presentation.

Fifty-two women (51.0%) underwent elective repeat Caesarean section; 18 women (17.6%) had an emergency Caesarean section after a trial of labour; and 32 women (31.4%) had a successful VBAC, with a prenatal sonographic mean LUS thickness of 1.8 mm, SD 1.0 mm (range 0–5.5); 1.7 mm, SD 0.8 mm (range 0.6–3.2); and 1.9 mm, SD 1.5 (range 0.9–9.0), respectively. Of the 50 women who attempted VBAC, 48 women (96.0%) had spontaneous labour and 16 women (32.0%) had oxytocin infusion during their labour. Table 1 shows the demographic data and the obstetric outcomes for women who underwent a trial of VBAC versus elective repeat Caesarean section.

The principal author performed 44.1% of the deliveries. All other women had their delivery attended by the on-call or their own attending obstetrician. In all women who had a

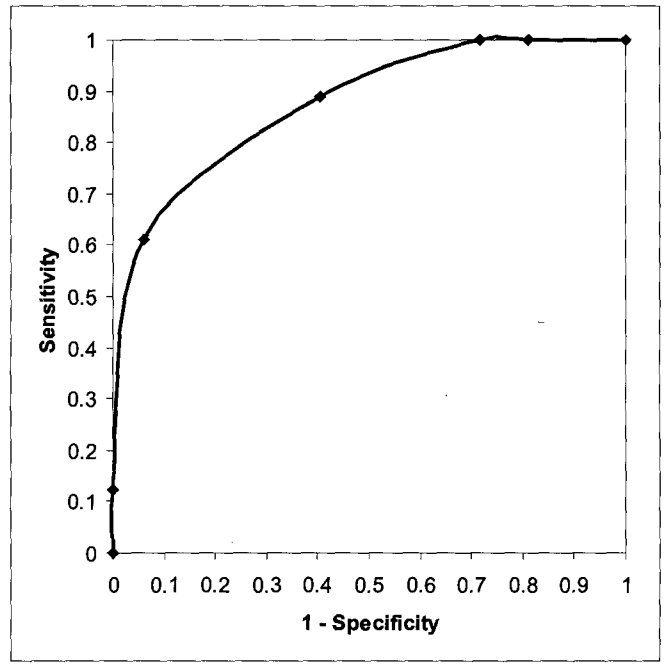
Figure 5. Transabdominal longitudinal sonogram showing the uterine defect (between arrows). The myometrial layer was clearly seen adjacent to the defect (arrowheads).



Caesarean section, the intraoperative findings were compared with the sonographic LUS measurements. These comparisons were not totally blinded, because some elective repeat Caesarean sections were performed by the obstetricians who were aware of the sonographic findings. Of the 70 women who had a repeat Caesarean section, 2 had confirmed uterine dehiscence, 16 were reported to have a paper-thin LUS, and 46 had normal LUS thickness, with preoperative sonographic mean LUS thicknesses of 0.3 mm, SD 0.4 (range 0–0.6 mm); 1.1 mm, SD 0.5 (range 0–1.9 mm); and 2.0 mm, SD 0.8 (1.0–4.0 mm), respectively. In 6 women (8.6%), the intraoperative LUS appearance was not described, but neither dehiscence nor rupture was reported. All 6 women had prenatal sonographic LUS thickness of greater than 1 mm, and they likely had normal uterine thickness because most obstetricians would report a uterine defect if noted during surgery. An LUS defect was identified sonographically (Figure 5) in 1 of the 2 women who had confirmed uterine dehiscence during repeat Caesarean section. Table 2 shows the comparison between women with intraoperatively diagnosed dehisced or paper-thin LUS and those with normal LUS.

Table 3 shows the relationships between various LUS measurements with respect to the delivery outcome and the intraoperative LUS appearance. Table 4 shows the sensitivity, specificity, and predictive values for different sonographic LUS cut-off measurements in predicting dehisced or paper-thin LUS. The area under the ROC curve, which was plotted using different LUS thickness cut-off values (Figure 6), was 0.86, indicating the usefulness of sonography as a tool in the diagnosis of dehisced or paper-thin LUS.

Figure 6. ROC curve showing the true-positive rate and the false-positive rate for different LUS thickness cut-off values.



The mean LUS thicknesses measured in the 11 women who were examined both transabdominally and transvaginally were 1.2 mm, SD 0.4, and 1.3 mm, SD 0.4, respectively, with a correlation of 0.81.

DISCUSSION

The main objectives of this study were to evaluate the accuracy of sonographic measurements in assessing the LUS thickness in women with previous Caesarean section and to determine the usefulness of this measurement in predicting the risk of uterine rupture. Several studies have shown that sonography can predict uterine rupture in women with previous Caesarean section.[6,8,11–13] However, because uterine rupture is so rare, most of these studies used uterine dehiscence, rather than just rupture, as the outcome measure.[6,8,11–13] Rozenberg et al. indicated that the risk of uterine rupture in the presence of a defective scar was related directly to the degree of thinning of the LUS as measured by transabdominal sonography at or near 37 weeks' gestation.[5] They demonstrated that the risk of a defective scar increased significantly when the LUS thickness was 3.5 mm or less, with a high negative predictive value (99.3%).[5] Several other studies have concluded that an LUS thickness of 2 mm or less was a potential sign of uterine defect.[6,11,12] Recently, Sen et al. suggested that an LUS thickness of 2.5 mm or above could allow for a safe vaginal delivery.[13] Most studies demonstrated a strong negative predictive value but a weak positive predictive value, suggesting that a normal LUS thickness is a strong indicator that a safe VBAC may

Table 2. Comparison between women with dehisced or paper-thin and normal LUS

	Dehisced or paper-thin LUS (n = 18)	Normal LUS (n = 46)	*P*
	Mean ± SD		
LUS thickness, mm	0.9 ± 0.5	2.0 ± 0.8	0.0001
Maternal age, years	34.5 ± 3.9	34.6 ± 3.9	NS
Maternal weight, kg	67.6 ± 5.7	69.4 ± 9.8	NS
Gestation at scanning, week	37.0 ± 0.5	36.8 ± 0.6	NS
Gestation at delivery, week	38.9 ± 0.8	38.9 ± 0.9	NS
Scanning-delivery interval, week	1.9 ± 1.0	2.1 ± 1.1	NS
Birthweight, g	3447.3 ± 410.6	3410.6 ± 385.9	NS
	n (%)		
Parity ≥ 2	3 (16.7)	2 (4.3)	NS
Obstetric history			
≥ 1 spontaneous abortion	4 (22.2)	8 (17.4)	NS
≥ 1 therapeutic abortion	8 (44.4)	21 (45.7)	NS
≥ 1 preterm delivery	0 (0)	0 (0)	NS
Cephalic presentation at scanning	15 (83.3)	42 (91.3)	NS
Labour			
No	15 (83.3)	34 (73.9)	NS
Spontaneous	3 (16.7)	11 (23.9)	NS
Induced	0 (0)	1 (2.2)	NS
Oxytocin infusion	2 (11.1)	5 (10.9)	NS
Delivery			
Elective Caesarean	15 (83.3)	34 (73.9)	NS
Failed VBAC	3 (16.7)	12 (26.1)	NS
Caesarean at second stage	1 (5.6)	1 (2.2)	NS
Apgar < 7 at 5 min	0 (0)	1 (2.2)	NS

Data are presented as mean ± SD or n, %; NS: not significant ($P > 0.05$); LUS: lower uterine segment; SD: standard deviation.

be anticipated.[5,13] However, a high negative predictive value may be related to the rarity of uterine rupture. To allow a wider margin of safety while trying to identify those women with higher risk of uterine rupture, this study included women with paper-thin LUS in the high-risk category, in addition to those with uterine dehiscence. This study demonstrates that an LUS thickness on sonograph of more than 1.5 mm excludes most women (88.9%) with extremely thin LUS at surgery and allows the identification of women with normal LUS for potential safe VBAC. However, determination of a paper-thin LUS simply by intraoperative inspection may be associated with considerable observer bias.

Our findings are supported by those of Asakura et al., who measured only the myometrial layer as the LUS thickness instead of the full thickness and suggested a cut-off value of 1.6 mm to predict the presence of uterine dehiscence.[14] As stated in our previous report,[9] the outer bladder wall including part of the visceral-parietal peritoneal layer is unlikely to contribute to the functional integrity of the LUS. The fact that 13.2% of women showed an increase in the full LUS thickness with selective thinning of the myometrial layer suggested that measurement of only the myometrial layer is more representative of the LUS thickness.[9]

Studies, except that of Sen et al.,[13] used only transabdominal[5,11,12] or transvaginal[6,14] scanning. Sen et al. showed a strong interclass correlation (0.965) between transabdominal and transvaginal sonography in measuring the LUS thickness.[13] With increasing experience, we find that transvaginal sonography permits better visualization of the LUS in the pericervical area, which is not readily accessible by transabdominal sonography. Although our study also

Table 3. Relation between sonographic LUS measurement, delivery outcome, and intraoperative LUS appearance

	Sonographic LUS measurement, mm				
	≤ 1.0	1.1–1.5	1.6–2.0	2.1–2.5	> 2.5
Delivery outcome	(n = 11)	(n = 39)	(n = 28)	(n = 8)	(n = 16)
Vaginal	2	16	8	0	6
Elective Caesarean	7	16	16	6	7
Failed VBAC	2	7	4	2	3
LUS appearance*	(n = 9)	(n = 23)	(n = 20)	(n = 8)	(n = 10)
Normal	0	13	16	8	9
Thin	7	7	2	0	0
Defect	2	0	0	0	0
Not described	0	3	2	0	1

*Caesarean sections only; LUS: lower uterine segment; VBAC: vaginal birth after Caesarean.

Table 4. Prediction of paper-thin or dehisced lower uterine segment (LUS) at different cut-off measurements

LUS thickness, mm	Sensitivity, %	Specificity, %	Positive predictive value, %	Negative predictive value, %
≤ 0.5	11.1	100	100	84
≤ 1.0	50.0	97.6	81.2	90.9
≤ 1.5	88.9	59.5	32	96.2
≤ 2.0	100	28.6	23.1	100
≤ 2.5	100	19.1	20.9	100

showed strong correlation between the 2 sonographic approaches, the number of measurements was too small to reach a valid conclusion. We are continuing our study with a larger population to determine the value of using transvaginal sonography in measuring the LUS thickness.

Although our findings suggest that sonographic LUS measurement is capable of identifying those women with an extremely thin LUS, further studies are required to establish the relation between the degree of LUS thinning and the risk of uterine rupture during a subsequent trial of VBAC. This study, like those of Rosenberg et al.[5] and Sen et al.,[13] demonstrated that the positive predictive value of sonographic LUS measurement in the diagnosis of extremely thin LUS is low (32.0% at a cut-off value of 1.5 mm), indicating that a thin LUS is not necessarily abnormal. Conversely, the high negative predictive value of LUS measurement may encourage obstetricians to offer women a trial of labour when the LUS thickness is above 1.5 mm.

This study had several limitations. The obstetricians who were aware of the sonographic findings might have been biased in selecting candidates for VBAC. All sonographic examinations were performed by a single operator; the results might have been different if multiple operators had been involved. A validity trial to determine interobserver variability would be informative. Because it is unlikely that a prospective randomized study of patients with extremely thin LUS in labour will be conducted, and because there is no universally agreed standard for measuring LUS thickness, physicians will be forced to rely on less rigorous evidence, such as the present study, for guidance in counselling and managing women with a previous Caesarean section.

CONCLUSIONS

Sonography permits accurate assessment of the LUS thickness in women with previous Caesarean section and therefore can potentially be used to predict the safety of VBAC. Sonographic evaluation of the LUS provides an additional

tool to estimate the risk of uterine rupture and should be more widely used in the management of VBAC.

ACKNOWLEDGEMENTS

This study was funded in part by the Iris and Dalton Bales Research Endowment Fund, North York General Hospital. The author wishes to thank Dr BS Ahluwalia and the sonographers at BSA Diagnostic Imaging for their technical assistance during ultrasound examinations. Figures 3, 4, and 5 are published with permission from the American Institute of Ultrasound in Medicine.

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