Prediction of cesarean section scar dehiscence before delivery using three-dimensional transabdominal ultrasonography

Mahmoud Abosrie, Mohamed A. Elhadi Mohamed Farag

Introduction

Cesarean section (CS) is the most common operation in obstetrics, with increasing incidence in most countries. As a result of this operation, late scar dehiscence may occur, which may lead to uterine rupture in a subsequent pregnancy [1]. Wound dehiscence and wound evisceration are serious complications, being associated with maternal mortality rates of 12 and 30% of, respectively [2]. Cesarean scar defects have long been recognized in hysterosalpingograms as anterior out-pouching [3]. As noninvasive alternative procedures, MRI and computed tomography can also be diagnostic [4].

To assess the risk of uterine rupture in a subsequent pregnancy, researchers have used two-dimensional (2D) ultrasonography (US) in the evaluation of the uterine scar in the third trimester [5]. However, it remains insufficient because the portion observed by 2D US is actually 1–2 cm caudal to the scar tissue [6]. Among the newest technological advances in the evaluation of cesarean scar defect is the ability to use three-dimensional (3D) US, which can demonstrate more precisely the location, shape, and size of a defective scar [7]. The advantage of 3D US is the possibility of obtaining coronal planes and their surface reconstruction, which provides new image features that are cannot be obtained with conventional 2D US [8]. A combination of multiplanar views and 3D-rendered images usually enhances our ability to identify anatomic details and enables a comprehensive diagnosis [9]. 3D US is highly accurate in detecting cesarean scar dehiscence [8].

Patients and methods

This prospective study was carried out at Benha University Hospital. The study was carried out from...
April 2014 to November 2014 to evaluate the efficacy of 3D US in the prediction of cesarean scar dehiscence in pregnant women at term and comparing the outcome of measurement with the intraoperative visual assessment of the scar. Qureshi et al. [10] showed that the incidence of dehiscent scar during a CS was 3%. Calculation according to these values produced a minimal sample size of 70 cases. A total of 70 women were recruited in the study. All included women were pregnant at more than or equal to 36 weeks' gestation at recruitment and had undergone at least one previous CS. Inclusion criteria were as follows: (i) history of one CS delivery at least, (ii) singleton pregnancy, (iii) cephalic presentation, (iv) gestational age (GA) between 36 and 39 weeks, (v) average amniotic fluid volume, and (vi) not in labor. We excluded women with (i) multiple pregnancies, (ii) malpresentations, (iii) suspected placental abruption, acrète, or previa, (iv) fetal anomalies, (v) abnormal amniotic fluid volume (oligohydramnios and polyhydramnios), (vi) active labor, and (vii) uterine leiomyomata. After obtaining informed written consent, all the women included were subjected to the following: (i) a thorough assessment of detailed history, (ii) obstetrics history, (iii) physical examination to exclude any associated medical disorder, and (iv) 3D US examination at 36–39 weeks' gestation to assess the thickness of the CS scar. On US, the lower uterine segment (LUS) appeared as a three-layered structure: the chorioamnionitic membrane (on the inner side). 3D US was performed with a partially full bladder (2 h after the last micturition). The lower segment was visualized in the sagittal section in the midline and lateral planes and the average value was obtained. The LUS thickness was measured from the muscularis and the mucosa of the bladder. The LUS thickness was measured from the muscularis and the mucosa of the bladder (on the outer side) to the chorioamnionitic membrane (on the inner side). 3D US was performed with a partially full bladder (2 h after the last micturition). The lower segment was visualized in the sagittal section in the midline and lateral planes and the average value was obtained. The LUS was assessed intraoperatively during the CS and graded according to the system developed by Qureshi et al. [10]: grade I: well-developed LUS; grade II: thin LUS but the content is not visible; grade III: translucent lower segment and contents are visible; grade IV: well-circumscribed defect, either dehiscence or rupture.

**Statistical analysis**

**Sample-size justification**

Sample size was calculated using the following formula:

\[ N = \left(\frac{Z}{2}\right)^2 \cdot P \cdot Q / (D)^2, \]

where \( N \) is the minimal sample size, \( Z = 1.96 \), \( P \) is the estimate of the prevalence of dehiscence, which can be obtained from published studies (= 3%), \( Q = 1 - P \), and \( D = 0.04 \). The clinical data were recorded on a report form. These data were tabulated and analyzed using the computer program statistical package for the social sciences (SPSS, version 16; SPSS Inc., Chicago, Illinois, USA) to obtain descriptive data. Descriptive statistics were calculated for the data in the form of (i) mean and SD for quantitative data and (ii) frequency and distribution for qualitative data.

**Analytical statistics**

In the statistical comparison between the different groups, the significance of difference was tested using one of the following tests:

1. Student's \( t \)-test was used to compare the mean of two groups of quantitative data.
2. \( F \) test was used to compare the mean of more than two groups of quantitative data.
3. Intergroup comparison of categorical data was performed using the Fisher exact test.
4. Correlation coefficient was used to find relationships between variables.
5. Receiver–operator characteristic (ROC) curve was used to determine the validity of 3D US.

A \( P \) value of less than 0.05 was considered statistically significant (S), whereas a \( P \) value more than 0.05 was considered statistically insignificant. A \( P \) value of less than 0.01 was considered highly significant (HS) in all analyses.

**Results**

**Characteristics of the study group**

The basic characteristics of the study group including age, interval from the time of CS, number of previous deliveries, GA at delivery, and maternal weight are presented in Tables 1–3.

The numbers of the patients had one previous CS (42.9%) and with two previous CS (31.4%) and with intraoperative LUS grade I (50%), intraoperative LUS grade II of LUS (44.3%), intraoperative grade of III LUS (5.7%) according to Qureshi et al. [10] grading (Table 4).

There were no statistically significant differences between intact and abnormal CS scars in terms of previous CS numbers (\( P > 0.05 \)), LUS thickness using 3D US (\( P > 0.05 \)), maternal age, maternal weight, GA, and duration since last previous CS (\( P > 0.05 \)).

A ROC curve was constructed using the scar thickness in the third trimester and then determining the sensitivity and specificity with a range of cut-offs.
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The best cut-off value was more than or equal to 2.75 mm and this yielded the highest diagnostic accuracy with sensitivity 25%, specificity 100%, positive predictive value (PPV) 100%, and negative predictive value (NPV) 95%. The area under the curve (AUC) was 51.1%.

Discussion

Cesarean delivery rates have been increasing over the past two decades [11]. The CS rate increased from 4% in 1970 to 9% in 1980, and it almost doubled again during the 1990s, with estimated rates of 16% in 1995 and 19% by 1999; in Egypt, the CS rate reached 52% [12]. Little information has been gained from studies of CS scar healing. It was believed that it heals by regeneration of the muscular fibers and by scar tissue formation [13]. The scar may be composed entirely of fibrous tissue and may be a thin linear scar or a wide one, or it may contain a few regenerated muscle fibers. Collagen deposition, which is a main step in the scarring process, is also governed by growth factors [14]. Transforming growth factor β, connective tissue growth factor, basic fibroblast growth factor, vascular endothelial growth factor), tumor necrosis factor α (TNFα), and platelet-derived growth factor have all been implicated in scar healing. The differences in the biologic behavior of the LUS transverse section scarring process at the time of the first CS may explain the variable clinical phenotypes of LUS in a subsequent pregnancy [15]. Balanced collagen deposition in the wound area is under growth factor control and is also a key step for good wound healing outcome and tissue function restitution [14]. Various factors have been related to an increased risk of scar dehiscence, including type of previous CS, surgical technique of closure of the uterine incision, intraoperative complications, duration since previous CS, and estimated fetal weight in the current pregnancy. However, these factors have no clear predictability and lack objectiveness, and do not enable definitive risk estimation. Most repeated CSs are performed because of fear of intrapartum rupture. Uterine rupture is a rare complication, but has the potential of causing severe fetal morbidity, including asphyxia, neurological sequelae, and even death. Uterine rupture can also be responsible for maternal complications, such as genitourinary tract damage, hemorrhage, and hysterectomy. Therefore, it is important to improve the evaluation of the risk of uterine rupture before attempting vaginal delivery after a previous CS. Some studies suggest that this risk can be estimated by measuring sonographically the thickness of the LUS at the end of pregnancy. These studies showed that US measurement of the LUS may increase the safety of labor after a previous CS because it provides additional information on the risk of uterine rupture [16]. Uterine rupture is an uncommon although potentially fatal complication of vaginal birth following a CS. The rate in women undergoing labor after a previous CS is about (0.6–1.5%) [1]. Studies have

Table 1 General characteristics of patients who underwent cesarean delivery

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean</th>
<th>SD</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal age (years)</td>
<td>26.34</td>
<td>5.1</td>
<td>18.0</td>
<td>40.0</td>
</tr>
<tr>
<td>Parity</td>
<td>2.33</td>
<td>1.22</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>GA at delivery (weeks)</td>
<td>37.77</td>
<td>1.14</td>
<td>36.0</td>
<td>40.0</td>
</tr>
<tr>
<td>Maternal weight (kg)</td>
<td>88.13</td>
<td>7.59</td>
<td>70.0</td>
<td>105.0</td>
</tr>
<tr>
<td>Duration of last previous CS (years)</td>
<td>3.65</td>
<td>3.05</td>
<td>1.0</td>
<td>11.0</td>
</tr>
</tbody>
</table>

CS, cesarean section; GA, gestational age.

Table 2 Three-dimensional ultrasonographic lower uterine segment thickness measurement in patients who underwent cesarean delivery

<table>
<thead>
<tr>
<th>LUS thickness by 3D US (mm)</th>
<th>Mean</th>
<th>SD</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4.63</td>
<td>0.85</td>
<td>2.5</td>
<td>7.5</td>
</tr>
</tbody>
</table>

The mean LUS thickness measurement by 3D US was 4.63 ± 0.85 mm; 3D US, three-dimensional ultrasonography; LUS, lower uterine segment.

Table 3 Obstetric characteristics of the study group

<table>
<thead>
<tr>
<th>Obstetric characteristics</th>
<th>Cases [N (%)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Previous CS</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>30 (42.9)</td>
</tr>
<tr>
<td>2</td>
<td>22 (31.4)</td>
</tr>
<tr>
<td>≥3</td>
<td>18 (25.7)</td>
</tr>
<tr>
<td>Intraoperative grading of LUS</td>
<td></td>
</tr>
<tr>
<td>Grade I</td>
<td>35 (50.0)</td>
</tr>
<tr>
<td>Grade II</td>
<td>31 (44.3)</td>
</tr>
<tr>
<td>Grade III</td>
<td>4 (5.7)</td>
</tr>
</tbody>
</table>

CS, cesarean section; LUS, lower uterine segment.

(Fig. 1). The best cut-off value was more than or equal to 2.75 mm and this yielded the highest diagnostic accuracy with sensitivity 25%, specificity 100%, positive predictive value (PPV) 100%, and negative predictive value (NPV) 95%. The area under the curve (AUC) was 51.1%.

Figure 1

Receiver–operator characteristics (ROC) curve for three-dimensional ultrasonography in the prediction of intraoperative grade III of lower uterine segment.
shown that the risk of uterine rupture in the presence of a defective scar is directly related to the degree of thinning of the LUS [17]. Several studies using various methods have been carried out to evaluate the correlation of LUS measurement with the risk of uterine rupture or dehiscence with relative success. In some studies, the sonographers measured the entire LUS by transabdominal US, whereas in others, only the middle muscle layer was assessed using transvaginal US and some studies used both approaches [11]. To assess the risk of uterine rupture in a subsequent pregnancy, researchers have used 2D US in the evaluation of the uterine scar in the third trimester [5]. However, it remains insufficient because the portion observed by 2D US is actually 1–2 cm caudal to the scar tissue [6]. Among the newest technological advances in the evaluation of cesarean scar defect is the ability to use 3D US, which can show more precisely the location, shape, and size of a defective scar [7]. It is possible that 3D US could improve the reliability of LUS measurement as its reliability and validity for the measurement of in-vitro models have proved to be excellent. This might be because of the use of the multiplanar display of 3D US, which enables simultaneous longitudinal, transverse, and coronal views and their surface reconstruction, which provides new image features that are not possible to obtain with conventional 2D US [11]. A number of objective methods have been used to evaluate the cesarean scar defects. These include hysterosalpingograms such as anterior out-pouching [3]. As noninvasive alternative procedures, MRI and computed tomography can also be diagnostic [4].

The aim of the current study was to assess the efficacy of the 3D US in the prediction of cesarean scar dehiscence in pregnant patients at term and compare the outcome of measurement with the intraoperative visual assessment of the scar. This study showed that the mean maternal age was 26.34 ± 5.1 years, the mean parity was 2.33 ± 1.22, the mean GA at delivery was 37.77 ± 1.14 weeks, the mean LUS thickness was 4.78 ± 0.82 mm, and the mean maternal weight was 87.46 ± 7.81 kg; the mean duration of last previous CS was 3.65 ± 3.05 years, as Akamura et al. [5] studied 186 pregnant women with previous CS at 37–40 weeks’ gestation. In the uterine dehiscence group, the mean age of the women was 29.0 ± 3.5 years, mean parity was 1.0 ± 0, and the mean GA at delivery was 40.5 ± 0.7 weeks, whereas in the group with no uterine dehiscence, the mean age was 30.2 ± 3.5 years, mean parity was 1.1 ± 0.4, and the mean GA at delivery was 39.9 ± 1.7 weeks. Scar dehiscence was reported in 9/186 (4.84%) cases; six of these were found accidentally at emergency CS, two at planned repeat CS, and one after VBAC. The mean LUS thickness was significantly lower in women who had scar dehiscence compared with women with an intact scar (1.7 ± 0.7 vs. 2.6 ± 0.8 mm, respectively, P = 0.001); the sensitivity was 77.8% and specificity was 88.6% [5]. This is obviously lower than that of our study. This may be because they measured only the muscle layer at its thinnest portion by TVS [5]. In a study by Sen et al. [18], 71 pregnant women with previous CS were included as a study group. In the study group, mean ± SD age was 25 ± 3 years, mean parity was 1.3 ± 0.5, and the mean pregnancy duration was 39.5 ± 0.9 weeks. Sen et al. [18] reported that the thickness of the LUS ranged between 1.7 and 7.3 mm (mean: 3.29 ± 1.09 mm) in the study group, whereas the mean lower segment thickness was 3.63 ± 0.64 mm in the control group. Comparing the transabdominal and transvaginal US findings in the study and the control groups, P values were 0.002 and 0.007, respectively, hence statistically significant. Thus, lower segment thickness in the study group was significantly less than that in the control group. Sensitivity, specificity, PPV, and NPV were 90.9, 84, 71.4, and 95.5% for transabdominal sonography and 81.8, 84, 69.2, and 91.3% for transvaginal sonography, respectively. Both transabdominal and transvaginal sonography were performed for all included women. The lower segment thickness was measured from the muscularis and mucosa of the bladder on the outer side to the chorioamnionitic membrane inside. This study showed that, even if transvaginal sonography was not available or experience with it was lacking, transabdominal sonography with magnification can comparably visualize the LUS thickness [18].

In a prospective study by Cheung [19], the mean age of the women in the cesarean group maternal was 30.5 ± 4.2 years and the mean maternal weight was 66.5 ± 5.2 kg; the mean LUS thickness in the cesarean group was 1.9 ± 1.4 mm. Although the difference between the

### Table 4 Comparison between different grades of cesarean section scars

<table>
<thead>
<tr>
<th>Obstetric characteristics</th>
<th>Grade I (n = 35)</th>
<th>Grade II (n = 31)</th>
<th>Grade III (n = 4)</th>
<th>F</th>
<th>P</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal age (years)</td>
<td>25.69 ± 4.78</td>
<td>27.19 ± 5.09</td>
<td>25.5 ± 8.27</td>
<td>0.77</td>
<td>0.47</td>
<td>NS</td>
</tr>
<tr>
<td>Previous CS (n)</td>
<td>1.66 ± 0.91</td>
<td>2.1 ± 0.91</td>
<td>2.5 ± 1.29</td>
<td>2.74</td>
<td>0.072</td>
<td>NS</td>
</tr>
<tr>
<td>Gestational age (weeks)</td>
<td>38.06 ± 1.3</td>
<td>37.5 ± 0.89</td>
<td>37.25 ± 0.96</td>
<td>2.37</td>
<td>0.101</td>
<td>NS</td>
</tr>
<tr>
<td>LUS thickness by 3D US (mm)</td>
<td>4.78 ± 0.82</td>
<td>4.5 ± 0.84</td>
<td>4.38 ± 1.25</td>
<td>1.05</td>
<td>0.357</td>
<td>NS</td>
</tr>
<tr>
<td>Maternal weight (kg)</td>
<td>87.46 ± 7.81</td>
<td>88.97 ± 7.5</td>
<td>87.5 ± 7.55</td>
<td>0.334</td>
<td>0.717</td>
<td>NS</td>
</tr>
<tr>
<td>Duration since last previous CS (years)</td>
<td>3.08 ± 2.54</td>
<td>4.33 ± 3.42</td>
<td>3.23 ± 3.87</td>
<td>1.41</td>
<td>0.251</td>
<td>NS</td>
</tr>
</tbody>
</table>

CS, cesarean section; 3D US, three-dimensional ultrasonography; LUS, lower uterine segment.
cesarean and nullipara control LUS thickness failed to reach statistical significance, it achieved significance in patients with more than one previous delivery (both vaginal and cesarean) [19]. Cheung [19] reported 100% sensitivity and 90% specificity. The difference in the results between the Cheung and the current study is because Cheung measured only the myometrial layer thickness, whereas in this study, the full LUS thickness was measured. In the current study, 3D US scans (sagittal view) were performed on all included women to measure the thickness of the LUS at its thinnest portion. The measurement was recorded and a mean was obtained. The mean LUS thickness was 4.63 ± 0.85 mm. Then, 3D US scans (coronal view) were performed on all included women with descriptive dehiscence at each point of the scar through progressive electronic dissection of the whole wall starting from the posterior urinary bladder until it reached the anterior uterine wall, detecting areas of dehiscence. In the current study, the LUS was inspected intraoperatively during the CS to note the grade according to the Qureshi et al. [10] classification. The intraoperative grading showed that 35 patients were grade I, 31 patients were grade II, and four patients were grade III. In the current study, there was no statistically significant difference between normal and abnormal CS scars in the number of previous CS sections, maternal age, BMI, GA, and birth weight (P > 0.05). 3D was unreliable for the prediction of uterine scar defects AUC 51.1%. A cut-off value with 3D less than or equal to 2.75 had 25% sensitivity, 100% specificity, 100% PPV, and 95.7% NPV, with 95.7% accuracy proved by the ROC curve.

In the Bujold et al.’s [20] study, follow-up data after delivery were obtained in 236 (94%) patients. Among these, 125 (53%) women underwent a trial of labor (TOL), with 90 (72%) women experiencing successful vaginal birth after cesarean delivery. Three (2.4%) cases of complete uterine rupture during a TOL and six (2.5%) cases of uterine scar dehiscence were reported, for a total of nine uterine scar defects. ROC curve analysis showed that full LUS thickness was evaluated to complete uterine rupture during a TOL with an AUC of 88% (95% confidence interval: 79–98%) [20]. In the Bujold et al.’s [20] study for the full LUS thickness, sensitivity was 100% and specificity was 75% for complete uterine rupture and sensitivity was 67% and specificity was 72% for scar dehiscence. The difference between Bujold et al. [20] and the current study was the large number of women studied, whereas our sample size was lower. In the Mansour et al.’s [21] study, the validity of 3D US versus operative findings indicated a sensitivity of 83.3%, a specificity of 100%, a PPV of 100%, and a NPV of 99%, and accuracy of 99%.

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Conflicts of interest
There are no conflicts of interest.

References

