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RELIABILITY OF ULTRASONOGRAPHIC DIAGNOSTIC MODALITIES OF PLACENTA ACCRETA

G.A.El-Kholey, M.A.Mohamed, K.M.Salama, I.I.Sewidan and O.K.Naser
Obstetrics and Gynecology Dept., Faculty of Medicine, Benha Univ., Benha, Egypt
E-Mail:Omar.Ali21@fmed.bu.edu.eg

Abstract

Aim: TO determine the reliability of trans-abdominal and color Doppler ultrasound as diagnostic modalities in diagnosing placental invasion in patients with placenta previa with prior uterine surgery compared to those with no uterine surgery and correlation with intra operative finding.

Methods: 150 pregnant women more than 28 weeks' gestation with placenta previa (75 patients with scarred uterus versus 75 patients with non-scarred uterus) were included. Routine ultrasound scan was done for evaluation of placental invasion including loss of retroplacental clear zone, abnormal placental lacunae, bladder wall interruption, myometrial thinning, placental bulge, focal exophytic mass followed by color Doppler scan to assess Doppler markers of placental invasion including uterovesical hypervascularity, subplacental hypervascularity, bridging vessels and placental lacunae feeder vessels. The results of different ultrasound and color Doppler criteria were correlated with the clinical confirmed placenta accreta or non-accreta in both groups (scarred versus non-scarred uteri).

Results: There was a significant significant higher incidence of placenta accreta in scarred uterus as compared to very low incidence in non-scarred uterus. The highest sensitivities, NPVs of ultrasound markers were abnormal placenta lacunae and loss of retroplacental clear zone while the highest specificities and PPVs were myometrial thinning and bladder wall interruption as predictor of placental invasion. Bridging vessels had the highest sensitivity, specificity, PPV, NPVs and accuracy of color Doppler markers in predicting placental invasion. There was statistically significant higher incidence of ultrasound and color Doppler markers suggestive of placental invasion in scarred uterus group as compared to non-scarred group ($P < 0.001$)

Conclusion: It could be concluded that gray scale and color Doppler ultrasound have good performance in the diagnosis of AIP and that prenatal diagnosis improves maternal outcome.

Keywords: Cesarean section, Scarred uterus, Unscarred uterus, Ultrasound, Placenta accreta, Doppler.

1. Introduction

Placenta accreta spectrum (PAS) disorders is a spectrum of conditions characterized by an abnormal adhesion to, and invasion of trophoblastic tissue through the myometrium and uterine serosa [1].

According to the depth of invasion, abnormally invasive placenta refers to the entire spectrum of conditions including placenta accreta (PA), placenta increta (PI), and placenta percreta (PP) [2].

It is strongly associated with the combination of prior uterine surgery and placenta Previa. Today, the main cause of placenta accreta spectrum is increased rate of uterine surgery, in particular, cesarean section, myomectomy, dilatation and curettage, endometrial ablation and invitro fertilization (IVF). In the absence of endometrial reepithelialization of the scar area the trophoblast and villous tissue can invade deeply within the myometrium, including its circulation, and reach the surrounding pelvic organs [3].

The worldwide incidence of placenta accreta spectrum (PAS) is rapidly increasing, following the trend of rising cesarean delivery. PAS is a heterogeneous condition associated with a high maternal morbidity and mortality rate, presenting unique challenges in its diagnosis and management [4].

Usually, the first clinical presentation for PAS is massive obstetric hemorrhage occurring during delivery, when attempting to remove the placenta manually. Notably, antenatal bleeding may be observed among those women with placenta previa. Besides, presenting with abdominal pain is sometimes a warning of uterine rupture, probably as a consequence of placenta percreta [5].

Antenatal diagnosis of placenta accreta spectrum (PAS) disorders allows planned management by a multidisciplinary team in a tertiary center, and thus can reduce hemorrhagic morbidity, compared with intrapartum diagnosis [6].

Prenatal ultrasound is a promising diagnostic tool for PAS in the second or third trimester. Recent evidence shows sonographic markers of PAS can be present in the first trimester. Prenatal ultrasound may help predict the depth and topography of placental invasion which are the major determinants of maternal morbidity [7].

The antenatal diagnosis of placenta accreta depends on 2D grey scale imaging and color Doppler Imaging. The 2D Sonographic parameters include, location of placenta, loss of retroplacental clear zone, irregularity and thickness of the uterine bladder interface, the smallest myometrial thickness in the sagittal plane, presence of lacunar spaces, placental bulge and focal exophytic mass. Doppler markers of placental invasion including uterovesical hypervascularity, subplacental hypervascularity, bridging vessels and placental lacunae feeder vessels hypervascularity, bridging vessels and placental lacunae feeder vessels [8].

Management by a multidisciplinary team is of great importance for obtaining better outcomes of PAS patients. Immediately after delivery, the most used procedure in the nonconservative management of PAS is hysterectomy. Conservative management may be considered among those women with fertility need. Notably, expectant management should not be routinely recommended, while Triple P procedure is a promising technique which has the potential to achieve the maximum preservation of uterine and its physiologic function [9].

2. Material and methods

A Prospective observational case control study was conducted at the Obstetrics and Gynecology department of Benha University Hospitals from September 2018 to June 2021.

This Study was approved by the ethics committee of Benha Faculty of Medicine and The review board in OB/GYN. Department. Written Informed consent was obtained from all participants prior to commencing the study.

2.1. Patients and methods

This study enrolled 150 pregnant women more than 28 weeks' gestation attended Benha University Hospitals with placenta previa. All patients included in the study underwent operative abdominal delivery at our hospital.

Inclusion criteria were gestational age more than 28 weeks' gestation determined by first day of last menstrual period and confirmed by ultrasound, placenta previa anterior or central or posterior and singleton pregnancies. Exclusion criteria were Multifetal pregnancies, Premature rupture of membrane, History of previous placenta previa and Medical conditions as Heart diseases, Hypertensive Disorders, etc.

Patients included in this study were divided into 2 groups:

- **Study group:** included 75 pregnant women with history of prior uterine surgery (cesarean section, myomectomy, dilatation and curettage, endometrial ablation, etc.) (group of **scarred uterus**).
- **Control group:** included 75 pregnant women with no history of prior uterine surgery (group of **non-scarred uterus**).

All patients in both groups were submitted to thorough history taking, general examination, abdominal examination, obstetric examination and Investigations in form of complete blood count, blood group and Rh typing, Random blood sugar, coagulation profile, renal and liver function tests and cross matched blood to be available.

Routine ultrasound scan was done at weekly interval for evaluation of placental invasion in addition to the standard fetal assessment (viability, fetal lie, fetal weight, Amniotic Fluid Index) using 3.5 MHZ abdominal probe (Voluson 730 PRO V, GE Healthcare, USA). Partial bladder filling was considered for evaluating the uterine-serosa interface and the bladder wall.

Gray-scale B-mode sonography was first used to screen the placental tissue in a systematic fashion. Careful attention was paid to homogeneity and echogenicity patterns of the placenta especially those with suspicion of having abnormal placenta. Then, patients were referred to color Doppler ultrasound for further evaluation of the uteroplacental vascular morphological manifestation for possibility of placenta accreta.

The following ultrasound criteria of placental invasion was evaluated according to FIGO consensus guidelines on placenta accreta spectrum disorders proposed by Jauniaux et al., 2018[10]: loss of retroplacental clear zone, abnormal placental lacunae, bladder wall interruption, myometrial thinning, placental bulge, focal exophytic mass followed by color Doppler scan to assess uterovesical hypervascularity, subplacental hypervascularity, bridging vessels and placental lacunae feeder vessels.

All deliveries were performed by expert obstetricians who have the ability to handle cesarean hysterectomy, pelvic devascularization and hypogastric artery ligation and in presence of expert anesthesiologist, neonatologist and on-call vascular surgeon and urologist. The uterine incision was performed avoiding the lower uterine segment to prevent excessive bleeding. Following delivery of the fetus and clamping of the cord, an attempt was made to expel the placenta aided by administration of uterotonics and application of controlled cord traction. There was be no attempt to remove the placenta manually when it evident that the placenta had reached the uterine serosa. Cases of placenta accreta were managed by caesarean hysterectomy and/or other alternative procedures (pelvic devascularization, placental extirpation, compression sutures, triple P procedure and internal iliac artery ligation) as appropriate.

Placenta accreta was confirmed at caesarean section on clinical basis (difficult removal of the placenta or presence of visual invasion of the placenta into the uterine wall, serosa or adjacent tissues).

The results of different ultrasound and color Doppler criteria in both groups were correlated with the clinical confirmed placenta accreta or non-accreta. In addition, other outcomes measures including operative data and Maternal and fetal outcomes.

2.2. Statistical analysis

Recorded data were tabulated and analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp) Qualitative data were described using number and percent. The Kolmogorov-Smirnov test was used to verify the normality of distribution Quantitative data were described using range (minimum and maximum), mean, standard deviation, median and interquartile range (IQR). Significance of the obtained results was judged at the 5% level.

The used tests were

Chi-square test

For categorical variables, to compare between different groups

Fisher's Exact or Monte Carlo correction

Student t-test

For normally distributed quantitative variables, to compare between two studied groups

Mann Whitney test

For abnormally distributed quantitative variables, to compare between two studied groups

Confidence interval

Was set to 95% and the margin of error accepted was set to 5%.

P-value

Was considered statistically significant at $p \leq 0.05$

Correction for chi-square when more than 20% of the cells have expected count less than 5

3. Results

To evaluate the accuracy of grayscale and color Doppler ultrasound criteria in the diagnosis of MAP; this study enrolled 195 patients with placenta previa (major and minor). Out of these 33 women didn't meet the inclusion criteria, 12 refused admission and 150 included in the study in which there were divided into 2 groups; 75 cases with scarred uterus and 75 cases with non-scarred uterus. Among the 150 women with placenta previa, placenta accreta was diagnosed intraoperatively Figure (1).

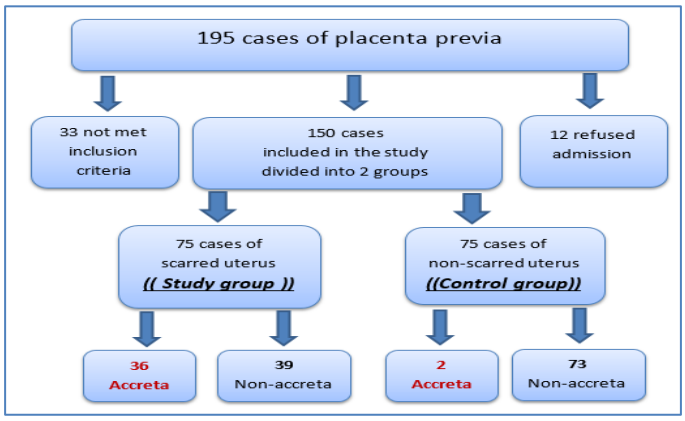

Fig. (1) Flow chart of the study.

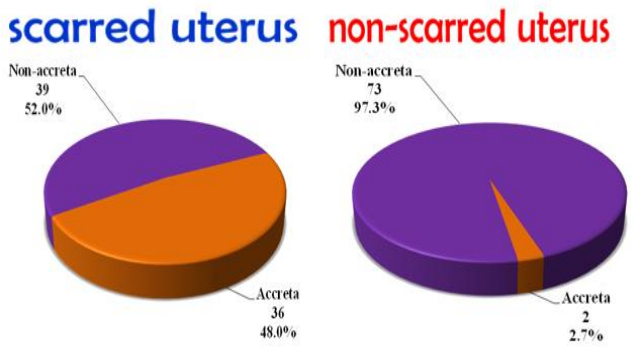

Fig. (2) Incidence of placenta accreta in scarred and non-scarred uteri.

Table (1) Comparison between scarred uterus and non-scarred uterus group according to maternal clinical characteristics, incidence of accrete and ultrasonic placental location in each group (values are given as n, % and mean ± SD)

		Scarred uterus (n = 75)	Non-scarred uterus (n = 75)	χ^2p	95%C.I
Incidence of accreta	**Non-accreta**	39 (52.0%)	73 (97.3%)	<0.001*	32.552 – 56.596
	Accreta	36 (48.0%)	2 (2.7%)		
Degree	**Minor**	28 (37.3%)	47 (62.7%)	0.002*	9.403 – 39.647
	Major	47 (62.7%)	28 (37.3%)		
Location	**Anterior**	39 (52.0%)	21 (28.0%)	0.003*	8.326 – 38.094
	Posterior	7 (9.3%)	28 (37.3%)	<0.001*	14.694 – 40.260
Central		29 (38.7%)	26 (34.7%)	0.611	-11.217 – 18.962

χ^2: Chi square test SD: Standard deviation C.I: Confidence interval

p: p value for comparing between the studied groups *: Statistically significant at $p \leq 0.05$

In our study, there was statistically significant higher incidence of placenta accreta in scarred uterus (36 accreta vs 39 none accrete) as compared to non-scarred uterus (2 accreta vs 73 non accrete) (P <0.001) Figure (2), Table (1).

As regard degree of placenta, 62.7% of scarred group were major compared to 37.3% of non-scarred group. This association was statistically significant (P value = 0.002) Table (2).

Pairwise analysis showed that anterior location of placenta was higher in scarred uteri compared to non-scarred uteri (P <0.003), while posterior location of placenta was higher in non-scarred uteri compared to scarred uteri (P <0.001). There was no statistical difference in central location between the two groups (P value = 0.611) Figure (3), Table (2).

In our study, there was statistically significant higher incidence of ultrasound markers suggestive of placental invasion in scarred uterus group as compared to non-scarred group (P < 0.001) (Table 3).

Table (2) Incidence of placenta accreta and non-accreta with repeated cesarean section in group of scarred uterus (n = 75) (values are given as n and %)

Number of previous caesarean section	Accreta (n = 36)	Non-accreta (n = 39)
Non Previous	1ϕ (16.7%)	5 (83.3%)
Previous 1	3 (21.4%)	11 (78.6%)
Previous 2	12 (46.2%)	14 (53.8%)
Previous 3	14 (66.7%)	7 (33.3%)
Previous ≥4	6 (75.0%)	2 (25.0%)

ϕ A case of placenta accreta with previous myomectomy.

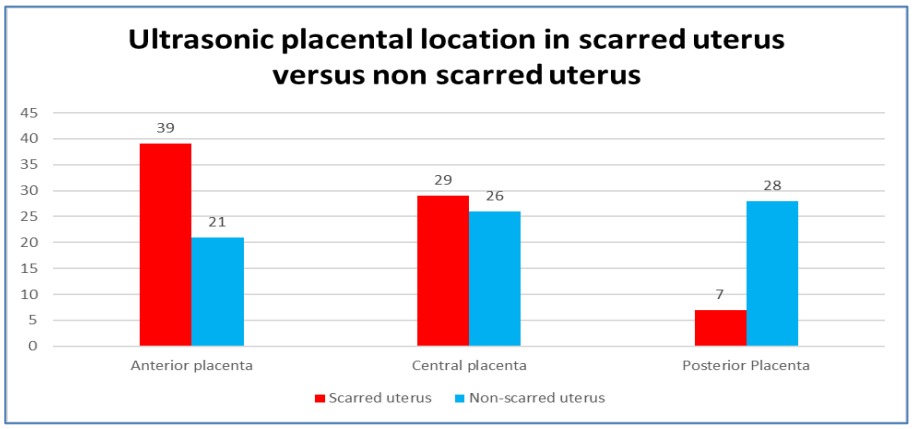

Fig. (3) Ultrasonic placental location in scarred and non-scarred uteri.

Table (3) Comparison between scarred uterus and non-scarred uterus group according to prevalence of different ultrasound markers in each group (values are given as n and %)

	Scarred (n = 75)	Non-scarred (n = 75)	χ^2p	95%C.I	Sensitivity	Specificity	PPV	NPP	Accuracy
Loss of clear zone	39 (52.0%)	11 (14.7%)	<0.001*	22.524–49.908	52.0	85.33	78.0	64.0	68.67
Abnormal placenta lacunae	41 (54.7%)	13 (17.3%)	<0.001*	22.309–50.187	54.67	82.67	75.93	64.58	68.67
Bladder wall interpretation	32 (42.7%)	0 (0.0%)	<0.001*	31.062–53.980	42.67	100.0	100.0	63.56	71.33
Myometrial thining	29 (38.7%)	8 (10.7%)	<0.001*	14.385–40.442	38.67	89.33	78.38	59.29	64.0
Placental bulge	36 (48.0%)	10 (13.3%)	<0.001*	20.222–47.302	48.0	86.67	78.26	62.50	67.33
Exophytic mass	3 (4.0%)	0 (0.0%)	FE0.245	-1.537–11.113	4.0	100.0	100.0	51.02	52.0

χ^2: Chi square test
C.I: Confidence interval
p: p value for comparing between the studied groups
*: Statistically significant at p ≤ 0.05

Table (4) Comparison between scarred uterus and non-scarred uterus group according to prevalence of different color Doppler markers in each group (values are given as n and %)

	Scarred (n = 75)	Non-scarred (n = 75)	χ^2 p	95%C.I	Sensitivity	Specificity	PPV	NPP	Accuracy
Uterovesical hyper vascularity	38 (50.7%)	7 (9.3%)	<0.001*	27.325–53.374	50.67	90.67	84.44	64.76	70.67
Sub placental hyper vascularity	34 (45.3%)	6 (8.0%)	<0.001*	23.664–49.309	45.33	92.0	85.0	62.73	68.67
Bridging vessel	33 (44.0%)	0 (0.0%)	<0.001*	32.272–55.253	44.0	100.0	100.0	64.10	72.0
Lacunar feeding vessel	35 (46.7%)	0 (0.0%)	<0.001*	34.803–57.875	46.67	100.0	100.0	65.22	73.33

χ^2: Chi square test C.I: Confidence interval
p: p value for comparing between the studied groups *: Statistically significant at p ≤ 0.05

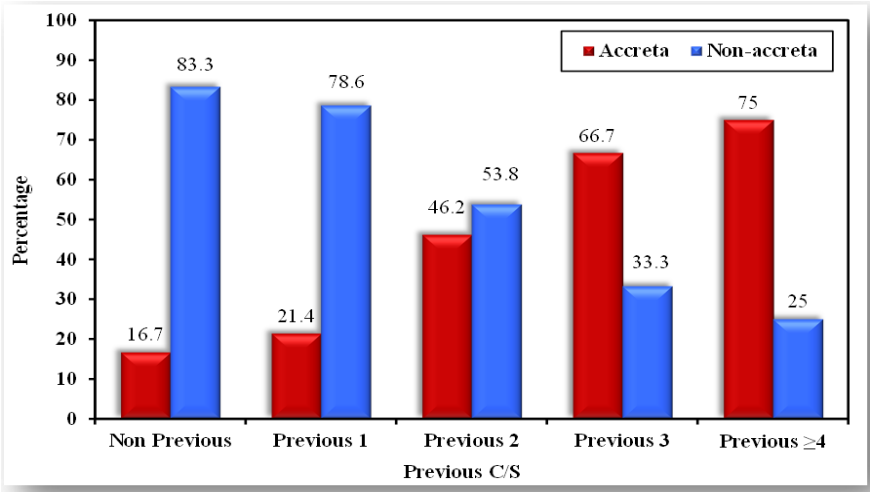

Fig. (4) Incidence of placenta accreta and non-accreta with repeated cesarean section in group of scarred uteri.

In this study the incidence of placenta accreta with repeated 1, 2, 3, or ≥4 prior cesarean deliveries were 21.4%, 46.2%, 66.7%, and 75%, respectively. (Table 2 - Figure 4)

Five patients had previous myomectomy (3 in accreta and 2 in non accreta group) but unfortunately it was not possible to know the exact site and size of removed myomas. There was no significant difference between accreta and non accreta group regarding curettage or myomectomy as risk factors (P = 0.949 and 0.666 respectively). However, there was one case of placenta accreta in patient with no prior history of cesarean section but with prior history of myomectomy.

Also there was statistically significant higher incidence of color Doppler markers suggestive of placental invasion in scarred uterus group as compared to non-scarred group (P < 0.001) (Table 4).

There were no cases of maternal mortality reported in our study.

Thirty-three patients (44.0%) of scarred group underwent hysterectomy while five patients (6.7%) of non-scarred group had hysterectomy due to uncontrollable bleeding from placental site (P<0.001, 95% CI 23.954 – 49.177).

Triple-P procedure was performed in sex cases (8.0%) of scarred uterus. Placental extirpation was only done in only one case (1.3%) of scarred uterus. Bilateral internal iliac artery ligation performed in 7 cases of unscarred uterus for uncontrollable bleeding. None of these 3 procedures was done in non-scarred uterus.

There is statistically significant higher incidence of blood loss, units of blood transfused, FFP transfusion and longer duration of hospital stay after surgery in scarred group as compared to non-scarred group.

The mean gestational age at delivery was 36.33 ± 1.81 weeks for scarred group and 36.35±1.58 weeks for non-scarred group (P = 0.962). The average neonatal birth weight in scarred group was 2.7 ± 0.4 Kg with no statistically significant difference with non accreta group (P = 0.6). Eighteen of the neonates (ten in scarred and eight in non-scarred group) required admission to NICU for low birth weight or respiratory distress syndrome.

Table (5) Sensitivity, specificity, accuracy, positive and negative predictive values of ultrasonic markers of placental invasion in group of scarred uterus (n=75) (values are given as number and %)

	Accreta (n = 36)	Non-accreta (n = 39)	χ^2 p	95%C.I	Sensitivity	Specificity	PPV	NPV	Accuracy
Loss of clear zone	32 (88.9%)	7 (17.9%)	<0.001*	50.551–82.185	88.89	82.05	82.05	88.89	85.33
Abnormal placenta lacunae	33 (91.7%)	8 (20.5%)	<0.001*	51.016–82.348	91.67	79.49	80.49	91.18	85.33
Bladder wall interruption	28 (77.8%)	4 (10.3%)	<0.001*	46.780–79.700	77.78	89.74	87.50	81.40	84.0
Myometrial thining	26 (72.2%)	3 (7.7%)	<0.001*	43.945–77.457	72.22	92.31	89.66	78.26	82.67
Placental bulge	21 (58.3%)	15 (38.5%)	0.085	-2.667–39.686	58.33	61.54	58.33	61.54	60.0
Exophytic massΦ	3 (8.3%)	0 (0.0%)	FE0.106	-2.189–21.784	8.33	100.0	100.0	54.17	56.0

χ^2: Chi square test C.I: Confidence interval
p: p value for comparing between the studied groups *: Statistically significant at $p \leq 0.05$

Table (6) Sensitivity, specificity, accuracy, positive and negative predictive values of Doppler markers of placental invasion in group of scarred uterus (N=75) (values are given as number and %)

	Accreta (n = 36)	Non-accreta (n = 39)	χ^2 p	95%C.I	Sensitivity	Specificity	PPV	NPV	Accuracy
Uterovesical hyper vascularity	29 (80.6%)	9 (23.1%)	<0.001*	35.692–71.734	80.56	76.92	76.32	81.08	78.67
Sub placental hyper vascularity	26 (72.2%)	8 (20.5%)	<0.001*	29.597–67.098	72.22	79.49	76.47	75.61	76.0
Bridging vessel	30 (83.3%)	3 (7.7%)	<0.001*	55.815–85.750	83.33	92.31	90.91	85.71	88.0
Lacunar feeding vessel	19 (52.8%)	16 (41.0%)	0.308	-10.355–32.451	52.78	58.97	54.29	57.50	56.0

χ^2: Chi square test C.I: Confidence interval
p: p value for comparing between the studied groups *: Statistically significant at $p \leq 0.05$

In our study, the highest sensitivities, NPVs of ultrasound markers were abnormal placenta lacunae and loss of retroplacental clear zone. The highest specificities and PPVs were myometrial thinning and bladder wall interruption as predictor of placental invasion in scarred uterus group while Bridging vessels had the highest sensitivity, specificity, PPV, NPVs and accuracy of color Doppler markers in predicting placental invasion (Table 5,6)

Twenty-nine patients (80.6%) of accreta patients in scarred uterus group underwent hysterectomy for morbidly adherent placenta while four patients (10.3%) of non accreta patient had hysterectomy due to uncontrollable bleeding from placental site (P<0.001, 95% CI 49.795 – 81.801).

In our study, only two cases (2.7%) out of 75 case of non-scarred uterus were reported to be accreta and the other 73 case in this group (97.3%) were non accreta.

4. Discussion

This study was aimed to evaluate the reliability of trans-abdominal and color Doppler ultrasound as diagnostic modalities in diagnosing placental invasion in patients with placenta previa with prior uterine surgery compared to those with no uterine surgery.

In our study, there was statistically significant higher incidence of placenta accreta in scarred uterus compared to non-scarred uterus. The frequency of placenta accreta in scared uterus in this study was 48% and 2.7% in unscarred uterus whereas in the study by Chattopadhyay et al. (1993) [11] the frequency of placenta accreta in previously scarred uterus was 38.29% and non-scarred uterus was 4.75%. The frequency of placenta accreta in previously scarred uterus was 6.06% and non-scarred uterus was 2.9% in a study by Shrigiriwar et al. (2019) [12] whereas in the study by Upreti et al. (2020) [13] the frequency of placenta accreta in previously scarred uterus was 13.04% and non-scarred uterus was 2.9%.

In our study, there was statistically significant higher incidence of major placenta in scarred uterus (47 major vs 28 minor) as compared to non-scarred uterus (28 major vs 47 minor) (P 0.002). This agreed with Upreti et al. (2020) [13] who reported the presence of major placenta in scarred uterus (27 major vs 19 minor) as compared to non-scarred uterus (21 major vs 18 minor) (P 0.4)

In our study, anterior location of placenta was higher in scarred uteri compared to non-scarred uteri (P <0.003), while posterior location of placenta was higher in non-scarred uteri compared to scarred uteri (P <0.001). This agreed with Upreti et al. (2020) [13] reported higher incidence of anterior placenta in scarred uterus (37 anterior vs 9 posterior) as compared to non-scarred uterus (21 anterior vs 18 posterior) (P 0.009). Also Katke (2016) [14] reported higher incidence of anterior placenta in scarred uterus (10 anterior vs 5 posterior) as compared to non-scarred uterus (17 anterior vs 8 posterior) (P 0.03). Shrigiriwar et al. (2019) [12] reported that anterior placenta was more common in our study scarred uterus (P = 0.048)

In this study, there was statistically significant higher incidence of ultrasound and color Doppler markers suggestive of placental invasion in scarred uterus group as compared to non-scarred group (P < 0.001). These previous finding as regard ultrasound and Doppler marker in both group can be explained by the fact of higher incidence (48%) of placenta accreta in scarred uterus group (36 out of 75) and the very low incidence of accreta (2.7) in non-scarred uterus group (2 out of 75) as there was higher incidence of ultrasound and color Doppler markers of placental invasion in placenta accreta versus non accreta.

Thirty-three patients (44.0%) of scarred group underwent hysterectomy while five patients (6.7%) of non-scarred group had hysterectomy due to uncontrollable bleeding from placental site. Shrigiriwar et al. (2019) [12] reported that Cesarean hysterectomy was required in 11 cases out of 66 cases in scarred uterus and 1 case out of 34 in non-scarred uterus group. Results were statistically significant (P = 0.045), and similar results were found in the studies of Kaur et al. (2017) [15] and Parikh et al. (2016) [16].

The average intrapartum blood loss (mL) in patients with scarred uterus group was 1254.0 ± 476.7 compared to patients with non-scarred uterus 1054.7±288.3 (P < 0.025, 95% CI 71.978 – 326.689) (table 5). These results agree with Shrigiriwar et al. (2019) [12] who reported More than 1000 ml blood loss was found in 53% of the patients in scarred uterus. P = 0.018 was considered to be statistically significant, and hence, it was found that the amount of blood loss increases as the number of previous cesarean section increases. This was also found in the studies of Kaur et al. (2017) [15] and Parikh et al. (2016) [16].

Eighty-four percent of patients with scarred had blood transfusion and the median value of blood transfusion units was 3 with interquartile range 2 – 4 (table 5). Katke et al. (2016) [14] reported that 33.3% of patients with scarred had blood transfusion while 24% of non-scarred uterus had blood transfusion.

Four of our patients i.e. 5.3% of scarred uterus (three in accreta subgroup and one in non accreta subgroup) had accidental bladder injury while no bladder injury was reported in non-scarred uterus group. These results consistent with Shrigiriwar et al. (2019) [12] who reported bladder injury four cases in scarred uterus.

There was no statically significant difference as regard fetal birth weight, Apgar score at 1 minute, Apgar score at 5 minutes, respiratory distress syndrome and admission to NICU. These results are consistent with that of Chaudhari et al. (2017) [17] that mean birth weight is 2.3-2.6 Kg, but 27% of babies in this study required NICU admission. Thus, fetal outcome did not differ much with the presence of scarred uterus. This was similar to the results of Shrigiriwar et al. (2019) [12] Kaur et al. (2017) [15], Pravin et al. (2017) [18], Katke et al. (2016) [14] and Parikh et al., (2016) [16].

Ultrasonic and color Doppler markers in predicting placenta placental invasion in scarred uterus were evaluated

- Regarding Loss of retroplacental clear space:

In our study, the loss of retroplacental clear zone had a sensitivity of 88.89%, a specificity of 82.05% with PPV 82.05% and NPV 88.89% (P < 0.001, 95% CI 50.551–82.185). The overall accuracy for this ultrasound finding was 85.33%.

Our findings to some extend agree with Maged et al. (2017) [19] who reported sensitivity 87.3%, specificity 89.2%, PPV 93.2% and NPV 80.5% with an overall accuracy of 88% with this ultrasonic marker and with Pilloni et al. (2016) [20] who found sensitivity 81.1% specificity 97.8, PPV 83.7 % and NPV 97.5%.

Our results are not consistent with Cali et al. (2013) [21] who reported sensitivity 90%, specificity 81% and NPV 97% but with low PPV 57% and with Wong et al. (2008) [22] who found sensitivity and NPV 100% and low specificity 35% and PPV 20%. Also, it disagrees with the results of Rezk and Shawky (2014) [23] who reported sensitivity 92.6%, PPV 89.3% with low specificity 25% and NPV 33.3%.

- Regarding Abnormal placenta lacunae:

In this study, intraplacental lacunae had high sensitivity 91.67% with specificity 79.49%, PPV 80.49%, NPV 91.18% (P < 0.001, 95% CI 51.016–82.348). The overall accuracy of intraplacental lacunae was 85.33%.

The diagnostic accuracy of lacunae shows more variation from author to author than other signs of PAD. Maged et al. (2017) [19] reported sensitivity 93.65%, specificity 62.16%, PPV 80.8%, NPV 85.2% with an overall accuracy of 82%. Comstock et al. (2004) [24] reported sensitivity of 93% of intraplacental lacunae after 20 weeks of GA. Rezk and Shawky (2014) [23] found that lacunae had a sensitivity of 84.9%, specificity 72.5%, PPV 80.4% and NPV 78.4%.

Pilloni et al. (2016) [20] reported that lacunae had low sensitivity and low PPV with sensitivity 48.6%, specificity 94.6%, PPV 54.5% and NPV 93.2%.

- Regarding Bladder wall interpretation:

In our study, interruption of this line had a relatively low sensitivity 77.78% with specificity 89.74%, PPV 87.5% and NPV 81.4% (P < 0.001, 95%

CI 46.78–79.70). The overall accuracy for finding of uterine-bladder line interruption is 84.0%.

Our data to some extend agree with Cali et al. (2013) [21] who reported that uterine-bladder line interruption/thinning has sensitivity of 70%, specificity 99%, PPV 96% and NPV 92%.

Our data are inconsistent with Rezk and Shawky (2014) [23] who reported that bladder line interruption had not only low sensitivity of 71.01%, but also low specificity 56.3%, PPV 77.8% and NPV 47.4%. Pilloni et al. (2016) [20] found that thinning/interruption of uterine serosa-bladder interface had sensitivity of 40.5% with specificity 97.8%, PPV 71.4% and NPV 92.5%. Wong et al. (2008) [22] reported very low sensitivity of interrupted bladder line in diagnosis of MAP 11% with specificity 100%, PPV 100% and NPV 88%.

- Regarding Myometrial thining:

In our study, myometrial thining had sensitivity 72.22%, specificity 92.31%, PPV 89.66%, NPV 78.26% (P < 0.001, 95% CI 0.52 ─ 0.80). The overall accuracy for finding of less than 1 mm myometrial thickness was 82.67%.

Twickler et al. (2000) [25] found a sensitivity 100%, specificity 72%, PPV 72%, and NPV 100%.

Inconsistent to the above results, Wong et al. (2007) [22] reported low sensitivity 22% with specificity of 100%, PPV of 100% and NPV of 89% and Pilloni et al. (2016) [20] found that myometrial thickness < 1 mm had a low sensitivity 18.9% with specificity 99.3%, PPV 77.8% and NPV 90.2%.

- Regarding Placental bulge:

In our study, placental bulge had sensitivity 58.33%, specificity 61.54%, PPV 85.33%, NPV 61.54% (P < 0.001, 95% CI -2.667–39.686). The overall accuracy for finding of placental bulge was 60.0%.

Our study agreed with Comstock et al. (2004) [24] who stated that placental bulge isn't sensitive but didn't agree him in being specific where he found it a specific sign.

- Regarding Exophytic mass into the bladder:

In our study, we reported exophytic mass into the bladder in 3 cases with placenta percreta that was confirmed by intraoperative finding. Although the specificity and PPV was 100%, the sensitivity was only 8.33% and NPV 54.17% because it was rare ultrasonic finding (P = 0.106, 95% CI -2.189–21.784).

- Regarding Uterovesical hypervascularity:

In this study, uterovesical hypervascularity had high sensitivity 80.56% with specificity 76.92%, PPV 76.32%, NPV 81.08% (P < 0.001, 95% CI 35.692–71.734). The overall accuracy of Uterovesical hypervascularity was 78.67%.

Our data are consistent with that of Cali et al. (2013) [22] who reported that hypervascularity of uterine serosa – bladder wall interface had a sensitivity of 90%, specificity 100%, PPV 100% and NPV 97%.

Our results disagree with that of Pilloni et al. (2016) [20] who found that increased vascularity of uterine serosa – bladder wall interface had low sensitivity 10.8% with specificity 100%, PPV 100% and NPV 89.4%.

- Regarding Subplacental hypervascularity:

In this study, subplacental hypervascularity had high sensitivity 72.22% with specificity 79.49%, PPV 76.47%, NPV 75.61% (P < 0.001, 95% CI 29.597–67.098). The overall accuracy of subplacental hypervascularity was 76%.

- Regarding Bridging vessels

In our study, bridging vessels had sensitivity 83.33%, specificity 92.31%, PPV 90.91%, NPV 85.71% (P < 0.001, 95% CI 0.67 ─ 0.91). The overall accuracy for finding of bridging vessels is 88% which was the highest accuracy among the other ultrasound and color Doppler markers.

Our data are consistent with that of Shih et al. (2009) [26] who found that bridging vessels is the best single diagnostic sign of placenta accreta, with 97% sensitivity. Our results disagree with that of Maged et al. (2017) [19] who reported sensitivity 47.2%, specificity 94.6%, PPV 93.8%, NPV 51.5% with an overall accuracy of 65%.

- Regarding Lacunar feeding vessels:

In this study, Lacunar feeding vessels had high sensitivity 52.78% with specificity 58.97%, PPV 54.29%, NPV 57.50% (P 0.308, 95% CI -10.355–32.451). The overall accuracy of Lacunar feeding vessels was 56%.

In our study, only two cases (2.7%) out of 75 case of non-scarred uterus were reported to be accreta and the other 73 case in this group (97.3%) were non accrete. These findings were parallel to study by Shrigiriwar et al. (2019) [12] who found one case (2.9%) of invasive placenta out of 34 case of unscarred uterus. Upreti et al. (2020) [13] reported the finding of 2 cases of placenta accreta in a group of 39 cases of unscarred uterus. Chattopadhyay et al. (1993) [11] reported the finding of 8 cases (4.75%) of placenta accreta in a group of 175 cases of unscarred uterus. Katke (2016) [14] reported no cases of placenta accreta in a series of 25 cases of unscarred uterus.

This was very low incidence of accreta in non-scarred uterus (only 2 cases = 2.7%) while incidence of non-accreta was 73 cases (97.3%) in non-scarred uterus. This high discrepancy in number of cases in subgroups (2 accreta subgroup versus 73 non-accreta subgroups) make comparison between these subgroups in non-scarred uterus statically non-significant (P: not significant). This value in this study was not statistically significant probably due to smaller sample size.

4. Conclusion

Ultrasound and color Doppler markers had reliable accuracy in detection of MAP. Abnormal placental lacunae and loss of retroplacental clear zone had the highest sensitivities and NPVs of ultrasound

markers while myometrial thinning and bladder wall interruption had the highest specificities and PPVs in predicting placental invasion. Bridging vessels had the highest sensitivity, specificity, PPV, NPVs and accuracy of color Doppler markers in predicting placental invasion.

Thus, it is recommended to use the following ultrasonic markers (loss of clear zone, abnormal placental lacunae, myometrial thinning, bladder wall interruption and bridging vessels) as good diagnostic predictor for MAP in scarred uterus.

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