INTRODUCTION

Transabdominal obstetric ultrasound is routinely performed during mid-pregnancy to determine placenta localization, including placenta previa, a condition defined as placenta overlying the internal os. Placenta previa is found in up to 2% of pregnancies at the early second-trimester transvaginal scan.¹ The incidence of placenta previa decreases to 0.3%–0.9% in the third trimester because of placental migration, growth towards better blood flow together with the development of the lower uterine segment.¹² Placenta accreta spectrum (PAS) is a complex obstetric condition in which placental villi attach directly to the superficial myometrium or invade pelvic tissue and organs.³ According to a retrospective survey, only 29% of women in the Nordic countries are diagnosed prenatally. An
improved screening in women with increased risk for PAS would enable a scheduled delivery at specialist centers with reduced morbidity.5–7

As a consequence of the low detection rate of PAS, a new routine that is not yet nationally implemented has been worked out in Sweden. In the new routine, a wider group of women are offered a follow-up vaginal ultrasound as a complement to the routine mid-pregnancy obstetric ultrasound, which also takes into account the risk factors for placenta previa and/or PAS. However, no published data evaluating the efficacy of the existing routine in assessing the placenta localization at the routine mid-pregnancy obstetric ultrasound within a large Nordic cohort has been identified. The aim of this study was to examine the detection rate of placenta previa and PAS within the existing routines for placenta assessment by a routine mid-pregnancy obstetric ultrasound within a Swedish cohort. Furthermore, we aimed to estimate risk factors and the prevalence of placenta previa and PAS within this cohort.

2 MATERIALS AND METHODS

This was an observational prospective cohort study with data collected from women attending routine mid-pregnancy obstetric ultrasound, between January 1, 2013 and December 31, 2017, at Sahlgrenska University Hospital. This is the largest tertiary center in Sweden with approximately 10 000 deliveries per year, and performing a routine mid-pregnancy obstetric ultrasound on pregnant women in the Gothenburg area; <3% of pregnant women attend in a private setting (local quality control, data not published).

The routine mid-pregnancy obstetric ultrasound is often performed between 18 and 20 weeks of pregnancy and is attended by 97% of pregnant women in Sweden.8,9 It is performed by specially trained midwives and obstetricians according to the International Society of Ultrasound in Obstetrics and Gynecology guidelines with some modifications as follows. The placenta location was only evaluated at the routine mid-pregnancy ultrasound by abdominal approach. If the placenta was reaching both the anterior and posterior uterine walls, and so covering the internal os (named cup-shaped), or if the midwife had a high suspicion of such a location, then a follow-up examination was deemed necessary. This follow-up examination included abdominal and vaginal ultrasound performed in weeks 30–32 of pregnancy by an obstetrician.10 Cohort 1 consisted of women with (or suspected of having) a cup-shaped placenta localization at the routine mid-pregnancy obstetric ultrasound. Data were noted and collected prospectively by the midwives when performing the routine mid-pregnancy obstetric ultrasound in weeks 18–20 of pregnancy. All women in cohort 1 were followed until delivery. The diagnosis of placenta previa or PAS was set at the delivery by the attending obstetrician and was a clinical diagnosis. During this period, 48 378 routine mid-pregnancy obstetric ultrasounds were performed, and 49 917 women were delivered at the hospital. In order to make sure that all women with the clinical diagnosis of placenta previa or PAS were identified, cohort 2 was created. Cohort 2 consisted of women diagnosed with placenta previa or PAS at delivery by the clinician and registered with the corresponding International Classification of Diseases, 10th revision code (O44.0, O44.1, O43.2, O43.2x, O43.2A, O43.2B) in the Hospital Discharge Register at Sahlgrenska University Hospital during the same period. Hence women in cohort 1 with a diagnosis of placenta previa and PAS were also included in cohort 2. The reference group consisted of women with singleton pregnancies (multiple pregnancies were excluded), delivered at Sahlgrenska University Hospital from January 1, 2015 to December 31, 2015, extracted from the Swedish Pregnancy Register. Data on covariates were retrieved from the medical records for cohorts 1 and 2 and from the Swedish Pregnancy Register for the reference group.

No power calculation was performed. The size of the data set determined the sample size. Analyses of associations between covariates were performed using logistic regression, and interactions between covariates were tested. All tests were two-sided, and P

| TABLE 1 Characteristics of cohort 1, including women with a placenta previa, detected at the routine mid-pregnancy obstetric ultrasounda |
|---------------------------------------------------------------|
| **Maternal age, year**                                      | Cohort 1 (n = 339) | Reference group (n = 9872) |
| ≤24                                                          | 14 (4.1)           | 877 (8.9)                 |
| 25–34                                                        | 209 (61.7)         | 7119 (72.1)               |
| ≥35                                                          | 116 (34.2)         | 1874 (19.0)               |
| Missing                                                      | 0                  | 2                         |
| **Smoking in early pregnancy**                               |                    |                           |
| Smoking in early pregnancy                                   | 23 (7)             | 387 (4.1)                 |
| Missing                                                      | 10                 | 516                       |
| **Body mass indexa**                                        |                    |                           |
| ≤24                                                          | 229 (70)           | 5520 (60.7)               |
| 25–29                                                        | 82 (25.1)          | 2484 (27.3)               |
| ≥30                                                          | 28 (8.6)           | 1087 (12)                 |
| Missing                                                      | 12                 | 781                       |
| **In vitro fertilization**                                  |                    |                           |
| In vitro fertilization                                      | 54 (16.4)          | 347 (3.7)                 |
| Missing                                                      | 9                  | 516                       |
| **Previous pregnancies**                                    |                    |                           |
| 0                                                            | 82 (24.5)          | 2847 (30.4)               |
| 1                                                            | 114 (34)           | 2941 (31.4)               |
| 2                                                            | 70 (20.9)          | 1840 (19.7)               |
| ≥3                                                           | 103 (30.7)         | 2530 (27.1)               |
| Missing                                                      | 4                  | 516                       |
| **Cesarean deliveries**                                     |                    |                           |
| 0                                                            | 297 (87.9)         | 8970 (90.9)               |
| ≥1                                                           | 41 (12.1)          | 902 (9.1)                 |
| Missing                                                      | 1                  | 0                         |

aValues are presented as number (percentage).

aBody mass index is calculated as weight in kilograms divided by the square of height in meters.
values below 0.05 were considered statistically significant. Analyses were performed using SAS software, version 9.4 of the SAS system for Windows (SAS Institute Inc., Cary, NC, USA).

The study was approved by the Regional Ethics Board in Gothenburg 180219 (Registration number 042-18, amendment registration number 2020-00147). Informed consent was not required by the ethics board. The study was registered according to the Personal Data Act and was approved by the Data Protection Officer at Sahlgrenska University (Registration number 2017-00505). The work described in the article has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki).

3 | RESULTS

Cohort 1 consisted of 339 women; 17 (5%) women had missing data on placenta previa and PAS, leaving 85 (26%) women diagnosed with placenta previa, 13 (4%) women diagnosed with placenta previa and PAS in combination, and 2 (0.6%) women diagnosed with PAS without placenta previa at delivery. Compared with the reference group, including 9872 women, cohort 1 had a higher proportion of women aged ≥35 years, in vitro fertilization (IVF), and three or more previous pregnancies (Table 1).

Cohort 2 consisted of 227 women; 219 (96%) were diagnosed with placenta previa, 28 (12%) were diagnosed with PAS, and 20 (9%) were diagnosed with a combination of these at delivery. Placenta previa was detected among 98 (49%) women with the existing mid-pregnancy screening routines (Figure 1). In total, 216 (99%) of all placenta previa were diagnosed before delivery, mainly as the result of bleeding complications. Among the patients considered to have a normal placentation at the routine mid-pregnancy obstetric ultrasound but diagnosed with placenta previa later in pregnancy or at the time of delivery, a majority of cases, 61 (73%), had risk factors for abnormal placentation (Figure 1). Compared with the reference group, including 9821 women, among the women in cohort 2 with placenta previa and without PAS, a larger proportion were ≥35 years of age, smoked, had an IVF pregnancy or had three or more previous pregnancies (Table 2). Multivariable analysis showed that increased maternal age, smoking in early pregnancy, IVF, and previous cesarean delivery were independent risk factors for placenta previa (Table 3). For body mass index (BMI, calculated as weight in kilograms divided by the square of height in meters), there was a significant interaction with previous cesarean delivery. Decreasing BMI was associated with a higher risk for placenta previa in patients with no previous cesarean delivery, whereas no such association was found for those with previous cesarean delivery (see Table S1). The prevalence of placenta previa was 44/10 000 during the study period.

FIGURE 1 Patients with placenta previa in cohort 2 were divided into two groups depending on whether the placenta location at the routine mid-pregnancy ultrasound qualified the patient for a planned placenta control or if the placenta previa was detected later in pregnancy. The patients were further divided into groups depending on the presence of the selected risk factors: maternal age at least 35 years, smoking in early pregnancy, number of previous pregnancies more than four, previous cesarean section, previous uterine surgery. Any patients with any of the risk factor variables missing were excluded. Women with any of the risk factors variables lacking are referred to as missing in the figure and are not included in the calculations in the figure.
In cohort 2, PAS was detected at the routine mid-pregnancy obstetric ultrasound in 7 (25%) women, although 14 (50%) of the women diagnosed with PAS were prenatally suspected (Figure 2) due to checks performed because of risk factors such as previous cesarean sections. Risk factors were present in all women in cohort 2 regardless of placenta location at the routine mid-pregnancy obstetric ultrasound (Figure 2). Of women diagnosed with PAS without any prenatal suspicion, 8 (57%) had an overlying placenta at routine

| TABLE 2 | Characteristics of cohort 2, including women diagnosed with placenta previa or placenta accreta spectrum at delivery<sup>a</sup> |
|-----------------|-----------------|-----------------|-----------------|
| Maternal age, year | Placenta previa (n = 219) | Reference (n = 9821) | PAS (n = 28) | Reference (n = 9866) |
| ≤24 | 8 (3.7) | 962 (9.8) | 0 | 965 (9.8) |
| 25–34 | 108 (49.3) | 6475 (65.9) | 10 (35.7) | 6500 (65.9) |
| ≥35 | 103 (47) | 2382 (24.3) | 18 (64.3) | 2399 (24.3) |
| Missing | 0 | 2 | 0 | 2 |
| Smoking in early pregnancy | 19 (9.3) | 385 (4.1) | 4 (1.6) | 386 (4.1) |
| Missing | 15 | 514 | 3 | 515 |
| Body mass index<sup>b</sup> | | | | |
| ≤24 | 126 (63.6) | 5493 (60.7) | 9 (37.5) | 5519 (60.7) |
| 25–29 | 52 (26.3) | 2469 (27.3) | 9 (37.5) | 2481 (27.3) |
| ≥30 | 20 (10.1) | 1082 (12) | 6 (25) | 1086 (12) |
| Missing | 21 | 777 | 4 | 780 |
| In vitro fertilization | 49 (23.9) | 338 (3.6) | 2 (7.7) | 347 (3.7) |
| Missing | 14 | 514 | 2 | 515 |
| Previous pregnancies | | | | |
| 0 | 52 (24) | 2837 (30.5) | 1 (4) | 2847 (30.4) |
| 1 | 64 (29.5) | 2932 (31.5) | 5 (20) | 2939 (31.4) |
| 2 | 47 (21.7) | 1826 (19.6) | 5 (20) | 1839 (19.7) |
| ≥3 | 54 (24.9) | 1712 (18.4) | 14 (56) | 1726 (18.5) |
| Missing | 2 | 514 | 3 | 515 |
| Cesarean deliveries | | | | |
| 0 | 173 (79) | 8915 (90.8) | 10 (35.7) | 8966 (90.9) |
| ≥1 | 46 (21) | 906 (9.2) | 18 (64.3) | 914 (9.3) |
| Missing | 0 | 0 | 0 | 0 |

Abbreviation: PAS, placenta accreta spectrum.

<sup>a</sup>Values are presented as number (percentage).

<sup>b</sup>Body mass index is calculated as weight in kilograms divided by the square of height in meters.

| TABLE 3 | Univariable and multivariable analyses of risk factors for placenta previa (n = 197)<sup>a</sup> |
|-----------------|-----------------|-----------------|
| Variables | Univariable | Multivariable | |
| | OR | 95% CI | P value | OR | 95% CI | P value |
| Maternal age (per year) | 1.13 | 1.10–1.16 | <0.001 | 1.09 | 1.06–1.13 | <0.001 |
| Smoking in early pregnancy | 2.34 | 1.43–3.85 | 0.001 | 3.05 | 1.79–5.17 | <0.001 |
| BMI (per unit) | 0.97 | 0.94–1.01 | 0.13 | 0.95 | 0.92–0.99 | 0.01 |
| IVF | 7.94 | 5.61–11.24 | <0.001 | 6.96 | 4.77–10.16 | <0.001 |
| Previous pregnancies (per no.) | 1.15 | 1.06–1.25 | 0.001 | 1.06 | 0.96–1.17 | 0.22 |
| Previous cesarean delivery | 2.68 | 1.89–3.81 | <0.001 | 2.48 | 1.70–3.61 | <0.001 |

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by the square of height in meters); CI, confidence intervals; IVF, in vitro fertilization; OR, odds ratio.

<sup>a</sup>Complete data patients, reference group n = 9042.
mid-pregnancy obstetric ultrasound (Figure 2). A higher proportion of women with PAS had a maternal age ≥35 years, smoked, had a BMI ≥30, three or more previous pregnancies and were delivered by cesarean section, compared with the reference group (Table 2). The prevalence of PAS was 5.6/10,000 deliveries during the study period. Isolated PAS, eg without placenta previa, occurred in 1.6/10,000 deliveries.

4 | DISCUSSION

For women with placenta previa, 98 (49%) were detected with the existing routines for placenta assessment at the routine mid-pregnancy obstetric ultrasound, but only 7 (25%) of women with PAS were detected. However, 216 (99%) of all placenta previa was diagnosed prenatally because of bleeding complications during pregnancy, and the prenatal suspicion rate of PAS was 14 (50%) because of an additional routine in which women with a history of repeated cesarean sections or uterine surgery were planned for a follow-up ultrasound to study the signs of PAS.

With the current guidelines, half of the placenta previa cases were detected within the screening program. However, using only the transabdominal approach has its drawbacks. Transvaginal ultrasound is superior to a transabdominal approach in accurately predicting placental location at delivery, especially when the placenta appears to be low. Adding a vaginal approach to the routine mid-pregnancy obstetric ultrasound would set a much higher demand on the time spent for the scan and on educating the staff. The prenatal suspicion rate of PAS was considerably higher than in the NOSS study, but was still low. At the routine mid-pregnancy obstetric ultrasound, a cup-shaped placenta was present in 57% of women with PAS that was not prenatally suspected, which underlines the importance of identifying ultrasound criteria for PAS.

In this study, the known risk factors for placenta previa were all confirmed as independent risk factors. The odds ratio for placenta previa was almost seven times higher for IVF pregnancies than spontaneous pregnancies, which could be due to the interaction between embryo and endometrium. We found an interaction between BMI and previous cesarean delivery with decreased risk of placenta previa in those without previous cesarean delivery, an association that needs further evaluation.

A meta-analysis demonstrated a prevalence of placenta previa in hospital-based studies varying from 2.8 to 19.7 per 1000 pregnancies and a derived prevalence rate of 4.4 per 1000 pregnancies, which are in line with our values. The wide range in prevalence could be a result of the timing of diagnosis, definition of placenta previa, diagnostic tools, and the varying occurrence of risk factors. The prevalence of PAS in our single-center study was higher than that demonstrated in the NOSS study, 5.6 versus 3.4 per 10,000 deliveries. However, the Swedish prevalence was estimated to be 2 per 10,000 deliveries. Our study included all women diagnosed with PAS, unlike the NOSS study, which only included women who underwent laparotomy.

The strength of this study was the prospectively collected data, validated registry data for the reference group, and the large, non-selected population of pregnant women bound to one obstetric department that was conducting the ultrasound scans. Approximately 99% of all the women included in the study gave birth at the hospital, enabling optimal coordination and cooperation between specialties regarding the delivery and possible postpartum
care. Furthermore, the large population bound to one department enables consistency in assessments regarding ultrasonography. The ultrasound scans were performed by skilled midwives and obstetricians specialized in ultrasound, with a great experience of diagnosing placenta previa and PAS.

This was an observational prospective cohort study and compared with randomized studies; it suffered from confounding, due to unknown confounders not included in the regression analyses, selection bias because of missing data for women in cohort 1, who were manually collected by midwives and by clinicians who failed to register diagnoses of placenta previa and PAS at delivery. Also, PAS could be misclassified as retained placenta when vaginally delivered, leading to an underestimated prevalence of PAS.

To increase the detection rate of overlying placentas at the routine mid-pregnancy obstetric ultrasound, a transvaginal approach might be better. Despite the additional examination time, the transvaginal approach could identify false-positive cases, preventing unnecessary concern and follow ups. However; this demands a huge training effort among the screening staff in Sweden. A high IVF rate among women with placenta previa might be considered in the screening procedure, together with risk factors for PAS, to increase the rate of prenatal suspicion of these conditions in the future. Further, we will not find cases of isolated PAS, 0.6% in our study, with a screening based on low placenta location combined with risk factors, and here, future research concerning biomarkers might be of help.

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CONFLICTS OF INTEREST

The authors have no conflicts of interest.

AUTHOR CONTRIBUTIONS

The International Committee of Medical Journal Editors criteria for authorship have been met. TS took part in planning, data analysis, and manuscript writing. A-KJ collected data, took part in analysis, and approved the manuscript. YC designed and planned the study, and took part in the data analysis and manuscript writing.

ORCID

Ylva Carlsson https://orcid.org/0000-0002-1414-7279

REFERENCES

1. Reddy UM, Abuhamad AZ, Levine D, Saade GR. Fetal imaging: executive summary of a joint Eunice Kennedy Shriver National Institute of Child Health and Human Development, Society for Maternal-Fetal Medicine, American Institute of Ultrasound in Medicine, American College of Obstetricians and Gynecologists, American College of Radiology, Society for Pediatric Radiology, and Society of Radiologists in Ultrasound Fetal Imaging workshop. Obstet Gynecol. 2014;123(5):1070-1082.

2. Paniotova J, Tokunaka M, Krajewska K, Zosmer N, Nicolaides KH. Screening for morbidity adherent placenta in early pregnancy. Ultrasound Obstet Gynecol. 2019;53(1):101-106.

3. Jauniaux E, Ayres-de-Campos D, Langhoff-Roos J, Fox KA, Collins S. FIGO classification for the clinical diagnosis of placenta accreta spectrum disorders. Int J Gynecol Obstet. 2019;146(1):20-24.

4. Thurn L, Lindqvist PG, Jakobsson M, et al. Abnormally invasive placenta-prevalence, risk factors and antenatal suspicion: results from a large population-based pregnancy cohort study in the Nordic countries. BJOG. 2016;123(8):1348-1355.

5. Shamshirsaz AA, Fox KA, Salamanian B, et al. Maternal morbidity in patients with morbidly adherent placenta treated with and without a standardized multidisciplinary approach. Am J Obstet Gynecol. 2015;212(2):218.e211-218.e219.

6. Tikkanen M, Paavonen J, Loukovaara M, Stefanovic V. Antenatal diagnosis of placenta accreta leads to reduced blood loss. Acta Obstet Gynecol Scand. 2011;90(10):1140-1146.

7. Chantraine F, Braun T, Gonser M, Henrich W, Tutschek B. Prenatal diagnosis of abnormally invasive placenta reduces maternal peripartum hemorrhage and morbidity. Acta Obstet Gynecol Scand. 2013;92(4):439-444.

8. Reports from the Swedish Council on Technology Assessment in Health Care (SBU). Int J Technol Assess Health Care. 1999;15(2):424-436.

9. The Swedish Pregnancy Register. Register TSP: Graviditetsregistrets årsrapport 2017 (yearly report from the Swedish Pregnancy Register 2017). 2017. https://www.medsciinet.com/gr/uploads/hemsida/dokumentarkiv/GR_Årsrapport_2017.4.0.pdf.

10. Carvalho JS, Allan LD, Chaoui R, et al. ISUOG Practice Guidelines (updated): sonographic screening examination of the fetal heart. Ultrasound Obstet Gynecol. 2013;41(3):348-359.

11. Smith RS, Lauria MR, Comstock CH, et al. Transvaginal ultrasonography for all placentas that appear to be low-lying or over the internal cervical os. Ultrasound Obstet Gynecol. 1997;9(1):22-24.

12. Dashe JS. Toward consistent terminology of placental location. Semin Perinatol. 2013;37(5):375-379.

13. Klar M, Michels KB. Cesarean section and placental disorders in subsequent pregnancies—a meta-analysis. J Perinat Med. 2014;42(5):571-583.

14. Karami M, Jenabi E, Fereidooni B. The association of placenta previa and assisted reproductive techniques: a meta-analysis. J Matern Fetal Neonatal Med. 2018;31(14):1940-1947.

15. Shobeiri F, Jenabi E. Smoking and placenta previa: a meta-analysis. J Matern Fetal Neonatal Med. 2017;30(24):2985-2990.

16. Rosenberg T, Pariente G, Sergienko R, Wiznitzer A, Sheiner E. Critical analysis of risk factors and outcome of placenta previa. Arch Gynecol Obstet. 2011;284(1):47-51.

17. Spangmose AL, Ginstrom Ernstad E, Malchaus S, et al. Obstetric and perinatal risks in 4601 singletons and 884 twins conceived after fresh blastocyst transfers: a Nordic study from the CoNARTaS group. Hum Reprod. 2020;35(4):805-815.

18. St-Germain LE, Castellana B, Baltayeva J, Beristain AG. Maternal obesity and the uterine immune cell landscape: the shaping role of inflammation. Int J Mol Sci. 2020;21(11):3776.

19. Faiz AS, Ananth CV. Etiology and risk factors for placenta previa: an overview and meta-analysis of observational studies. J Matern Fetal Neonatal Med. 2003;13(4):175-190.

20. Jauniaux E, Granbeck L, Bunce C, Langhoff-Roos J, Collins SL. Epidemiology of placenta previa accreta: a systematic review and meta-analysis. BMJ Open. 2019;9(11):e023193.
21. National quality registers. Accessed May 25, 2021. https://www.kvalitetsregister.se/kvalitetsregister/drivaregister/valideringshandbok.54585.html

SUPPORTING INFORMATION
Additional supporting information may be found online in the Supporting Information section.

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