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# Maternal and Fetal Outcomes in Placenta Accreta After Institution of Team-Managed Care

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**Abstract**

**Introduction:** Placenta accreta significantly contributes to maternal morbidity and mortality. We evaluated whether planned delivery and experienced, team-managed surgical intervention results in improved outcomes. We also examined whether risk factors differed for accreta, increta, and percreta and evaluated whether excess lower segment uterine vascularity correlates with disease severity. **Methods:** We retrospectively analyzed patients before versus after institution of a management protocol. Of the 58 044 deliveries over 10 years, there were 67 women whose pregnancies were histopathologically confirmed as placenta accreta, increta, or percreta (1/866). Clinical outcome measures were estimated blood loss (EBL), packed red blood cells (pRBCs) transfused, maternal and fetal complications, intensive care unit admission, and length of stay. **Results:** There were no maternal or infant deaths. In the managed cohort, EBL was reduced by 48% ($P < .001$), intraoperative pRBCs transfused by 40% ($P < .01$), total transfused pRBCs per case by 50% ($P < .01$), and surgical intensive care unit admissions by >50% ($P < .01$). Assessment of maternal risk factors by diagnosis revealed marked differences between accreta versus increta and percreta. Clinically assessed excess vascularity of the lower uterine segment correlated with disease severity. The incidence of neonatal complications was similar in both cohorts. **Conclusions:** Targeted delivery at 34 weeks and team-managed diagnosis, treatment, and care of patients with placenta accreta were associated with improved maternal, but not neonatal outcomes.

**Keywords**

peripartum hemorrhage, increta, percreta, transfusion, surgical management

## Introduction

Hemorrhage now exceeds thromboembolism as the leading cause of maternal death in the United States and equals hypertensive disorders as a primary cause of maternal mortality in the developed world. Placenta accreta-related pathologies are an increasing contributor to maternal death from hemorrhage.[1,2] In some centers, accreta-related pathologies have become the leading reason for cesarean hysterectomy.[3-5]

Placenta accreta and its more extreme variants, increta and percreta, occur when the normal decidual/trophoblast interaction is disrupted such that trophoblast invade deeply into the myometrium or, in the case of placenta percreta, up to and through the uterine serosa. Uterine perforation and rupture into the urinary bladder are potential complications.[6,7] As a consequence of placental invasion into adjacent organs, reconstructive surgery of the bladder or bowel may be necessary. In the more severe cases (increta and percreta), trophoblast-induced vascular remodeling of blood vessels occurs deep in the myometrium.[8] Thus, when removal of the adherent placenta is attempted, significant hemorrhage results because these vessels are of a larger diameter and are conducting a greater blood volume than the smaller diameter spiral arteries that are the normal target of trophoblast invasion and remodeling.

The primary risk factor for placenta accreta-related pathologies is lower uterine segment implantation, especially placenta previa, in association with damage and/or scarring from

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procedures such as dilatation and curettage (D&C), myomectomy, or cesarean section. Rising rates of cesarean delivery are considered the main factor contributing to a 10-fold increase in accreta incidence since the 1950s.[6] Current rates range from 1/533 to 1/7000 live births in developed countries.[5,9-12] However, this rapid rise is not solely due to an increase in cesarean delivery, as incidence has risen without change in the rates of cesarean delivery.[4] Assisted reproductive technology (ART) and older maternal age are contributory.[9,13]

There is no standardization or consensus on the care of these patients nor have the underlying pathological mechanisms been systematically addressed. It is widely believed that the disease undergoes a continuing progression; and hence, early delivery is often performed as a means both to prevent further pathology of the uterus and to avoid labor occurring under conditions that might present significant risk to mother and fetus.[14,15] Most patients require uterine surgery that can compromise future fertility, while the more severe cases frequently necessitate hysterectomy.

The present study was undertaken to evaluate maternal and neonatal outcomes prior to versus after the formation of a specialized team to diagnose, advise, treat, and care for these complicated cases. Neonatal outcomes beyond survival have rarely been detailed in the prior literature. We therefore compared patients who were treated from 2001 to 2006 (early cohort) with those treated 2007 to 2011 (late cohort) when the standardization of care was instituted. We hypothesized that the later cohort would have improved outcomes. The large sample size of the rarer increatas and percretas also permitted a closer examination of maternal risk factors for accreta-related pathologies stratified by disease severity and to examine the relationship between ultrasound and intraoperative assessment of excess lower segment vascularity in relation to disease severity.

## Methods

### Patients

Following protocol approval by the institutional review board, we identified all cases of accreta, increta, and percreta from January 2001 through December 2011 using the keywords accreta, increta, percreta, or cesarean hysterectomy from the Pathology Department's computerized records. From the 58 044 deliveries, 67 patients were identified over this time period (1/866). We included only 3 clinically diagnosed cases of accreta (small portions of adherent placenta left in situ). Two pathologists reviewed the reports and histology slides, confirmed the diagnoses, and measured the depth of invasion into the myometrium. Placenta accreta was diagnosed if there was adherence of placental villi to the myometrium without intervening decidua basalis. Placenta increta was diagnosed if there was placental invasion to >50% of the myometrial depth, while placenta percreta was diagnosed where the villi penetrated the uterine serosa. Charts were obtained; the diagnostic, surgical, and pathology reports were reviewed; and the hospital course and maternal/neonatal outcomes were abstracted. Ultrasound findings deemed diagnostic included the loss of the echogenic zone adjacent to the bladder, placental hypervascularity, disordered (tornado) blood flow, and abnormal lacunae. Key features for a positive magnetic resonance imaging include confirmation and extent of placenta previa, loss of the normal 3-layer myometrium, myometrial thinning, heterogeneous placental signal with hypointense T2 bands, focal myometrial interruptions, bladder wall irregularity, and tenting and frank placental invasion of surrounding structures. In the later cohort, documentation of excess vascularity was by ultrasound, intraoperative photos, and by detailed description in the operative note. Both ultrasound evidence and intraoperative observation in the operative report such as ''increased vasculature,'' ''engorged vessels,'' ''aberrant placental vasculature,'' ''ballooning of the lower uterine segment,'' and ''extensive neovascularization'' were required to document excess vascularity in this series.

### Management and Surgical Procedure

In the early cohort, timing of the surgery was left to the patients' physician. A gynecologic oncologist was called in to assist surgical cases at times. Following institution of the team-managed approach in 2007 by the Center for Abnormal Placentation (CAP), 1 maternal–fetal medicine (MFM) surgeon evaluates all suspected cases of accreta. Patients are counseled on the risks and benefits of surgical intervention. Deliveries are planned for 34 weeks with appropriate antenatal management for prematurity using steroids and magnesium sulfate for fetal neuroprotection. The surgical team includes an MFM surgeon, a vascular surgeon, an anesthesiologist, a urologist, a neonatologist, and an extensive operating room staff. The surgery is performed in the main operating room with advance preparation. Currently the team consists of 6 urologists, 4 vascular/trauma surgeons, 3 MFM surgeons, and 2 plastic surgeons, ensuring that at least 1 physician from each specialty is available at all times. Anesthesiology and neonatology are covered by the attending on call. A team urologist, vascular/trauma surgeon, and plastic surgeon are on standby for all scheduled cases.

The patients receive regional anesthesia that is converted to general, if indicated, after delivery of the fetus. Patients are placed in a lithotomy position using Allen stirrups with padding and venodynes. Cystoscopy is then performed by placing bilateral ureteral stents, previously shown to reduce morbidity.[16] The bladder cavity is carefully inspected for evidence of erosion or neovascularization. A 3-way Foley catheter is then inserted upon completion of the cystoscopy. Midline vertical abdominal incisions are made on all patients. The extent of the incision is determined intraoperatively based on the location of the margin of the placenta. Examination of the pelvis and abdomen is methodically performed to assess the clinical severity of the disease. This includes visualization of the vascularity over the lower uterine segment, on the bladder dome, and lateral pelvic wall. In our experience, extensive vascularity over the lower uterine segment is accompanied by dilatation (or neovascularization) of vessels in the bladder wall, seen as pulsing

vessels across the surface of the bladder dome and within the bladder on cystoscopy. These signs are recorded by the urologist and surgeon as present or absent. Vascularity is photodocumented. When these signs are present, no attempt is made to remove the placenta, as in our experience, these cases are invariably increta or percreta, for which efforts at manual removal are contraindicated.[16]

Intraoperative sonography is performed to demarcate the placental edge. A uterine incision is made avoiding the placenta. The uterine cavity is entered, membranes are ruptured, and amniotic fluid is assessed for meconium. After delivery of the baby, the cord is clamped, cut, and drained completely. The edges of the uterine incision are grasped with clamps to achieve hemostasis. Uterotonics are then administered, and the placenta is allowed to separate spontaneously. If spontaneous separation occurs in the absence of placental bed bleed, the hysterotomy is then repaired. In cases of partial separation with focal accreta, the placental bed is oversewn, and if hemostasis is achieved, hysterectomy is avoided. A large amount of neovascularization of the anterior uterine segment and nonseparation of the placenta is highly suggestive of placenta increta/percreta, in which case a hysterectomy is performed. Prophylactic hypogastric artery ligation is used to decrease blood loss if the arteries are easily identifiable. Innovations developed by the team include targeted intraoperative hypothermia of engorged blood vessels to promote vasoconstriction (with careful monitoring of core body temperature), and intraoperative ultrasound mapping of the location of the placenta prior to uterine incision.

In the most severe cases, when there is a consensus that the risk of life-threatening hemorrhage is high, staged surgery is performed by leaving the placenta in situ and performing the hysterectomy at a later date (n = 4 in this series). Serial measurements of human chorionic gonadotropin track the cessation of active placental function prior to hysterectomy. In 2 additional cases, the patients' strong desire to preserve fertility led to conservative therapy, that is, leaving the placenta in situ following cesarean delivery of the baby. In these cases, pelvic embolization is performed on postoperative days 2 to 4 if hypogastric artery ligation was not performed during the initial surgery.

### Statistical Analyses

Normally distributed variables were analyzed using 1-way analysis of variance with the Bonferroni multiple comparison test to compare diagnostic groups within and between cohorts. Data that were not normally distributed (estimated blood loss [EBL], packed red blood cells [pRBCs] administered, maternal length of stay [LOS], and neonatal intensive care unit [NICU] LOS were compared within cohorts using the Kruskal-Wallis test with Dunn multiple comparison posttest. Proportions for categorical variables were analyzed using chi-square test. Comparison of data between cohorts by diagnostic category was by Mann-Whitney *U* test. All analyses were conducted using GraphPad Prism 5 (v5.0c). Data are reported as median and interquartile range, mean $\pm$ standard deviation, or proportions. Data were considered significant, where the *P* value was <.025 (Bonferroni correction). Birth weight centile for gestational age at delivery was calculated based on national sex-specific intrauterine growth curves.[17]

## Results

### Team-Based Care

Our ability to schedule Center for Abnormal Placentation CAP-team delivery in the later cohort varied by diagnosis. Antenatal suspicion/diagnosis permitted scheduled delivery in 31% of accretas, 69% of increatas, and 85% of percretas. The primary MFM surgeon (A.A.K.) was involved in antenatal management and performed the surgeries in 71% of all cases in the later cohort. The presence of additional team specialists varied by case severity. All percreta cases had an MFM surgeon and urologist present, and, in half, a vascular/trauma surgeon was called in to assist. Among all patients in the later cohort, a urologist was present or called in to surgery for 57%, a vascular/trauma surgeon for 29%, and a plastic surgeon for abdominal wall reconstruction for 14% of the cohort.

### Demographic Data

The demographic characteristics of the women did not differ between the early (n = 25) and late cohorts (n = 42), nor did they differ between diagnostic groups (Table 1).

### Maternal Risk Factors

The presence of risk factors for accreta-related pathologies differed significantly between accreta and increta/percreta (Table 1). Placenta previa (or low-lying placenta covering the cesarean scar) occurred in only 12% of the accreta cases but 90% of increta/percreta ($P < .0001$). Twice as many patients with increta/percreta had prior cesarean deliveries (81% vs 40% in accreta; $P < .005$). In all, 28% of the accreta patients had no history of uterine instrumentation of any kind versus only 10% of increta/percreta ($P = .08$). However, all patients in this 10% had placenta previa. The combination of placenta previa with prior cesarean section, considered the greatest risk factor for morbidly adherent placenta, was less common in accreta (44%) than in the more severe pathologies (81%, $P < .005$). On the other hand, 76% of women with accreta were $\geq$35 years old ($P < .01$), which is more than the patients with increta (59%) and percreta (45%), and while the overall incidence of ART/in vitro fertilization (IVF) was only 15%, 70% of these were accretas ($P < .01$).

### Maternal Outcomes

There were no maternal deaths in our series. All patients with increta or percreta required hysterectomy; while in 6 cases of accreta, the uterus was saved (Table 2). In these patients, the diagnosis was based on an adherent placenta with some tissue

**Table 1.** Mean ± SD (Range) of Maternal/Neonatal Characteristics of the Early and Late Cohorts.[a]

| Variable | Early Cohort, 2001-2006 | | | *P* Value by Diagnosis | Late Cohort, 2007-2011 | | | *P* Value by Diagnosis | *P* Value Both Cohorts Between Diagnostic Groups |
|---|---|---|---|---|---|---|---|---|---|
| | Accreta (n = 9) | Increta (n = 8) | Percreta (n = 8) | | Accreta (n = 16) | Increta (n = 13) | Percreta (n = 13) | | |
| Age, yrs | 37.6 ± 5.7 (31-51) | 34.2 ± 9.0 (23-51) | 38.7 ± 5.5 (31-46) | NS | 36.7 ± 5.4 (29-46) | 36.9 ± 4.0 (31-42) | 33.5 ± 5.8 (25-45) | NS | |
| Gravidity | 4.1 ± 1.7 (2-7) | 4.3 ± 1.8 (1-6) | 3.3 ± 2.0 (1-6) | NS | 3.4 ± 1.7 (1-7) | 4.8 ± 2.7 (1-10) | 5.2 ± 2.5 (2-11) | NS | |
| Parity | 1.7 ± 1.3 (1-3) | 1.8 ± 1.2 (0-3) | 1.7 ± 1.4 (0-4) | NS | 1.1 ± 1.3 (0-4) | 2.2 ± 1.3 (0-4) | 2.5 ± 0.8 (1-4) | NS | |
| Prior cesarean | 66% (1-2) | 88% (0-3) | 62% (0-3) | NS | 31% (0-4) | 92% (0-4) | 92% (0-3) | <.005 | <.005 |
| Placenta previa | 11% | 75% | 88% | <0.005 | 12% | 92% | 92% | <.0001 | <.0001 |
| Ethnicity | | | | | | | | | |
| White | 67% | 62% | 62% | | 57% | 31% | 54% | NS | |
| Hispanic | 33% | 25% | 25% | | 12% | 38% | 23% | NS | |
| Asian | 0 | 0 | 12% | | 6% | 8% | 15% | NS | |
| African American/Black | 0 | 12% | 0 | | 25% | 15% | 15% | NS | |
| Prenatal care first trimester | 88% | 88% | 62% | NS | 81% | 100% | 85% | NS | |
| Height, cm | 162 ± 7 (152-175) | 164 ± 4 (158-170) | 158 ± 5 (152-163) | NS | 162 ± 7 (150-175) | 161 ± 8 (150-173) | 158 ± 5 (152-175) | NS | |
| Prepregnant BMI | 25 ± 5 (18-34) | 25 ± 4 (20-29) | 25 ± 4 (20-31) | NS | 26 ± 4 (20-37) | 27 ± 5 (20-37) | 23 ± 4 (18-29) | NS | |
| Gestational age at birth | 34.7 ± 5.5 (25.0-40.0) | 33.5 ± 2.6 (31.0-38.2) | 34.3 ± 2.0 (30.3-37.2) | NS | 34.6 ± 4.3 (24.6-40.0) | 34.8 ± 2.9 (30.0-38.2) | 34.3 ± 2.6 (29.0-37.4) | NS | |
| Birth weight percentile | 70 ± 29 (25-99) | 52 ± 22 (25-80) | 50 ± 23 (125-90) | NS | 51 ± 27 (18-99) | 51 ± 26 (7-95) | 58 ± 17 (25-93) | NS | |
| APGAR 1 | 8 ± 2 (3-9) | 9 ± 1 (8-9) | 8 ± 1 (6-9) | NS | 8 ± 2 (3-9) | 8 ± 1 (5-9) | 6 ± 2 (1-9) | NS | |
| APGAR 5 | 9 ± 1 (8-9) | 9 ± 1 (8-9) | 9 ± 1 (7-10) | NS | 9 ± 1 (7-9) | 9 ± 1 (7-9) | | NS | |

Abbreviations: BMI, body mass index; SD, standard deviation; APGAR, appearance, pulse, grimace, activity, respiration.

[a] The *P* values for each cohort reflect differences between diagnostic groups within cohorts. The final column indicates the *P* value between diagnostic groups for both cohorts combined, as there was no difference in demographic variables between cohorts by diagnosis.

**Table 2.** Outcomes Between the Early Versus Late Patient Cohorts.[a]

| | 2001-06 | | | | 2007-11 | | | |
|---|---|---|---|---|---|---|---|---|
| | Accreta (n = 9) | Increta (n = 8) | Percreta (n = 8) | *P* | Accreta (n = 16) | Increta (n = 13) | Percreta (n = 7) | *P* |
| Cesarean hysterectomy | 77% | 100%[b] | 100% | NS | 81% | 100% | 100% | NS |
| Pelvic occlusion[b] | 1 (11%) | 1 (14%) | 3 (37%) | NS | 3 (19%) | 1 (8%) | 3 (43%) | NS |
| Estimated intraoperative blood loss, L | 2.0 [1.4-2.6] (0.6-7.5) | 2.2 [1.7-3.6] (0.6-4.5) | 2.0 [1.3-4.0] (0.5-6.5) | NS | 0.8 [0.6-0.8][c] (0.2-1.8) | 1.50 [1.1-2.8] (0.4-5.0) | 0.90 [0.4-1.6][c] (0.3-5.2) | <.025 |
| Preop Hgb, g/dL | 11.1 ± 2.0 (6.7-13.6) | 11.0 ± 0.6 (10.1-11.9) | 11.9 ± 1.6 (9.7-14.2) | NS | 11.4 ± 1.2 (9.5-14.1) | 11.5 ± 1.0 (9.9-13.7) | 11.1 ± 0.9 (9.6-12.0) | NS |
| Postop Hgb, g/dL | 9.6 ± 1.5[d] (6.8-12.5) | 10.7 ± 1.8 (7.4-13.7) | 11.2 ± 2.3 (7.9-14.1) | NS | 9.7 ± 1.6[d] (5.1-11.6) | 10.4 ± 1.9 (6.8-14.3) | 11.4 ± 0.8 (10.0-12.3) | NS |
| [e,f]Administration of blood products, total per case (before, during, and after surgical intervention and subsequent hospitalization). Median [interquartile range] (range), % of patients who received blood product | | | | | | | | |
| pRBCs | 2.0 [1.0-4.0] (0-12) | 3.5 [2.0-8.0] (0-13) | 8.5[g] (7.5-13.3] (3-14) | <.025 | 0.0[c] [0.0-2.0] (0-9) | 4.0[h] [2.5-7.0] (1-12) | 1.0[c] [0.0-2.0] (0-4) | <.01 |
| FFP | 0.0 [0.0-2.0] (0-8), 33% | 2.0 [1.0-2.8] (0-6) ,62% | 4.0 [0.0-4.0] (0-10), 86% | | 0.0 [0.0-0.0] (0-2), 6% | 0.5 [0.0-2.0] (0-4), 54% | 0.0 [0.0-1.0] (0-2), 29% | |
| Platelets | 0.0 [0.0-0.0] (0-2), 11% | 0.0 [0.0-1.8] (0-12), 38% | 1.0 [0.0-2.0] (0-2), 57% | | 0.0 [0.0-0.0] (0-6), 8% | 0.0 [0.0-0.2] (0-1), 23% | 0 | |
| Cryoprecipitate | 0.0 [0.0-0.5] (0-2), 22% | 0 | 0.0 [0.0-1.0] (0-2), 28% | | 0 | 0.0 [0.0-0.0] (0-2), 15% | 0 | |

Abbreviations: FFP, fresh frozen plasma; Hgb, hemoglobin; NS, not significant; preop, preoperative; postop, postoperative; pRBC, packed red blood cell; SD, standard deviation.

[a] Values are mean ± SD (range of values), medians [interquartile range], and proportions, as appropriate).

[b] Embolization or hypogastric artery ligation.

[c] $P < .01$ early versus late cohort, within each diagnostic group.

[d] $P < .025$ paired comparison of pre- and postop hemoglobin (Hgb) concentration.

[e] Blood products other than pRBCs were not statistically tested, due to low numbers and autocorrelation with pRBCs.

[f] Albumin supplemented other blood products in 2 cases, 1 early cohort increta (500 mL), and 1 late cohort increta (250 mL).

[g] $P < .025$, percreta versus accreta, early cohort.

[h] $P < .025$, increta versus accreta and percreta, late cohort.

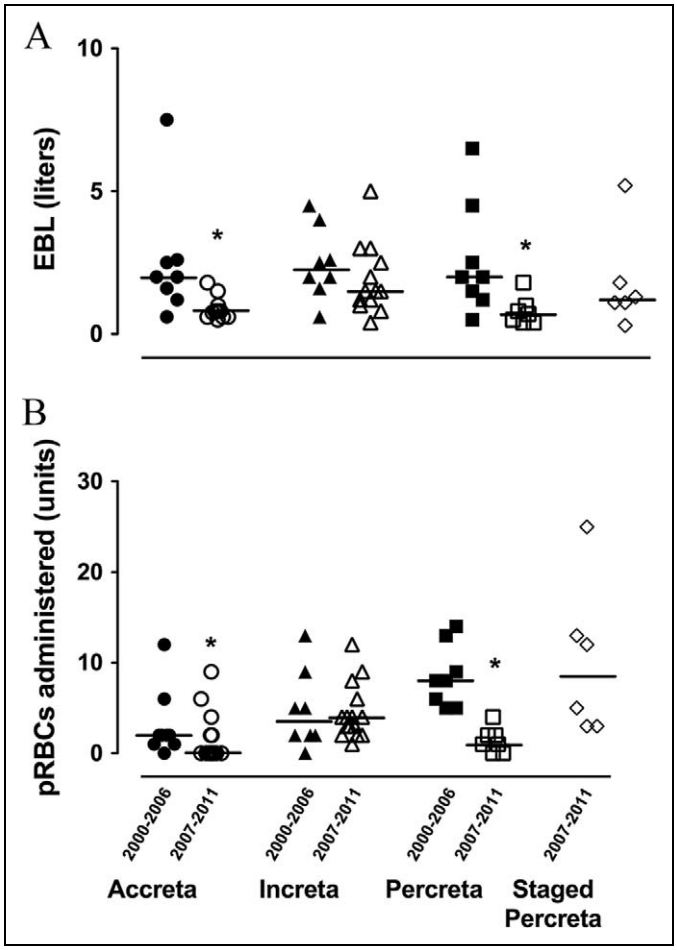


**Figure 1.** A, Estimated intraoperative blood loss in the early (solid symbols) versus late cohort (open symbols) is shown in the upper panel by diagnostic category. Estimated blood loss across all disease severities in the nonstaged cases was a median of 2.0 L (1.5-2.6) in the early cohort, versus 0.8 L (0.6-1.5) in the later cohort ($P < .0001$), a more than 50% reduction. B, The total units of pRBCs administered per case (preoperatively, during surgery, and postoperatively) are shown in the lower panel. Transfusion of pRBCs declined from 5.0 (2.0-8.5) units (early cohort) to 2.0 (0.0-4.0) units (later cohort, $P < .01$). In the later cohort, women with accreta and percreta had less EBL and fewer units of pRBCs transfused, while increta did not differ between the cohorts. Note that staged surgeries had greater units transfused than EBL would indicate, due to the extended postpartum course and hemorrhage in the 2 patients who sought to preserve fertility. EBL indicates estimated blood loss; pRBC, packed red blood cell.

left in situ (n = 3) or manual extraction with pathologically confirmed presence of myometrium on suspicious areas of the maternal basal plate (n = 2). Magnetic resonance imaging of 1 accreta at 14 weeks showed the gestational sac bulging into the bladder. At surgery, it was clear that implantation had been in the cesarean scar, causing partial dehiscence. This was repaired and the uterus left intact.

In the 1-step surgeries (cesarean–hysterectomy), EBL was lowered by 48% ($P < .001$), and the total pRBC transfused by 50% ($P < .01$) in the later compared with the earlier cohort (Table 2; Figure 1). Estimated blood loss is subjective and often does not correlate well with blood product transfusion. However, pre- and postoperative hemoglobin (Hgb) concentrations (Tables 2 and 3) support that blood loss during surgery was adequately replaced.

Among women undergoing staged surgeries (Table 3), EBL at the initial surgery (cesarean) was similar to those who underwent a single surgery. Estimated blood loss at hysterectomy $\leq$21 days later was 2.0 L (0.8-3.5) with transfusion of 2.5 (0.0-4.8) units pRBCs. However, in both patients who sought to preserve fertility, massive hemorrhage occurred 66 and 71 days later, despite uneventful recovery up until that point, requiring hysterectomy and transfusion of 10 and 23 units, respectively.

Maternal admission to the SICU decreased from 48% in the early cohort to 21% in the later cohort ($P < .01$; Figure 2A). Hospital LOS did not differ between diagnostic groups in the early versus late cohort nor between cohorts (median 6 [4-10] in the early cohort and 5 [4-13] in the late cohort).

None of the patients required cystectomy, although 85% of increta and all percreta patients required careful dissection of the bladder from the uterine serosa. Surgical complications occurred in 6 (24%) of the women in the early cohort and 9 (21%) in the later cohort. The most common complication was perforation of the bladder, which occurred in 1 accreta, 1 increta, and 2 percretas in the early cohort. Other complications in this group were a uterine perforation and bowel injury in 1 accreta during D&C, and reoperation for hemorrhage in 1 percreta. Bladder perforation occurred in 4 incretas and 3 percretas in the later cohort. Other complications included reoperation for hemorrhage postpartum with subsequent disseminated intravascular coagulation (DIC; accreta) and DIC following massive hemorrhage in 1-staged surgery (uterine preservation attempted).

## Excess Vascularity

The occurrence of excess vascularity was not systematically documented in the early cohort; and therefore, we only examined differences between diagnostic groups in the later cohort. Excess vascularity correlated with disease severity, being noted on ultrasound and during surgery in all patients with percreta, most with increta and significantly fewer with accreta ($P < .001$; Figure 3).

## Fetal Outcomes

There were no viable fetal or neonatal deaths. The neonates were all well grown; there were no IUGR or SGA infants in the cohort, even among the 5 twin pregnancies (Table 1). There were 4 nonviable fetal demises, 2 at 15 weeks of pregnancy, where spontaneous abortion occurred in 1 patient with accreta and inevitable abortion in another with increta. One pregnancy (increta) was terminated in the second trimester due to congenital birth defects and another at 14 weeks due to implantation in the uterine scar with dehiscence.

The NICU admission rates were similar in the early and late cohorts (Figure 2B), as was the overall incidence of

**Table 3.** Staged Surgery Outcomes.

| Staged Surgery (All Percreta) | 2007-2011 (n = 6) |
|---|---|
| Pelvic occlusion (y/n) | 100% |
| Embolization | 67% |
| Hypogastric ligation | 33% |
| Estimated blood loss (liter) at initial surgery (delivery) | 1.2 [0.9-2.7] (0.3 to 5.2) |
| SICU admission | 50% |
| SICU LOS, days | 2 [0.5-2.2] (1 to 3) |
| NICU admission | 6 (100%) |
| NICU LOS, days | 23 ± 15 |
| Interval first surgery to hysterectomy, days | 32 ± 29 (7 to 77) |
| Estimated blood loss at hysterectomy | 1.2 (0.9-2.6) (0.3 to 5.2) |
| # units pRBC (hysterectomy) | 2.5 [0.0-4.8] (0 to 10) |
| Preop Hgb, g/dL | 11.6 ± 0.9 (10.1 to 12.6) |
| Postop Hgb, g/dL | 11.1 ± 1.8 (9.5 to 12.3) |
| Delta Hgb, g/dL | 0.5 ± 1.9 (−2.7 to +2.2) |
| SICU admission | 3 (50%) |
| SICU LOS, days | 2 ± 1 (1 to 3) |
| Hospital LOS, days | 31 ± 18 (8 to 56) |
| [a]Total blood products administered in both surgeries (prior to, during, and after surgery). Median [interquartile range] (range) | |
| pRBCs (100% of pts) | 8.5 [3-16] (3 to 25) |
| FFP (57% of pts) | 1.0 [0-4] (0 to 13) |
| Platelets (57% of pts) | 1.0 [0-8] (0 to 12) |
| Cryoprecipitate (57% of pts) | 1.0 [0-2] (0 to 4) |

Abbreviations: FFP, fresh frozen plasma; Hgb, hemoglobin; LOS, length of stay; n, no; NICU, neonatal intensive care unit; preop, preoperative; postop, postoperative; pRBC, packed red blood cell; y, yes; pts, patients.
[a] Two cases received albumin (8000 and 500 mL).

complications related to prematurity, shown by gestational age in Figure 4. The NICU LOS ranged from 1 to 148 days in the early cohort and from 5 to 108 days in the later cohort. Neonatal intensive care unit LOS was tightly correlated with gestational age ($r^2 = .96$, $P < .0001$) when 1 outlier of 148 days of NICU stay was excluded. This baby, the product of IVF with donor eggs and sperm, had Vacterl syndrome and was 1 of the 5 birth defects in the series (the others were atrial–septal defect, tetralogy of Fallot, transposition of the great vessels, and Cong foot defect). Newborn complications related to prematurity include respiratory distress syndrome (23%), hyperbilirubinema (41%), anemia of prematurity (14%), transient tachypnea of the newborn (19%), and hypoglycemia (8%). More severe complications such as pneumothorax (3%) and intracranial hemorrhage (4%) were less common, and all babies were discharged healthy and without neurological sequelae from the NICU.

## Discussion

Team management and advance planning for delivery at 34 weeks in patients with placenta accreta is associated with lower blood loss and transfusion and fewer SICU admissions. However, despite advance planning and prophylaxis for prematurity, the incidence of neonatal complications was unchanged. We found that the combination of the 2 primary risk factors, placenta previa and cesarean section, is more prevalent among women with increta and percreta than those with accreta. In contrast, older maternal age and IVF/ART were more prevalent in accreta. Clinical indicators of excess vascularity in the lower uterine segment correlate with disease severity.

A strength of this study is the histopathological diagnosis of all increta and percreta and most accreta. Despite the importance of clear definition of the pathology, most reports do not use this "gold-standard" diagnostic tool.[18] Another strength is the relatively large sample size of the more severe pathologies. However, sample size was still not sufficient to statistically confirm several observations that may be relevant to the pathophysiology. None of our patients were morbidly obese (body mass index [BMI] $\geq 40$). Obesity (BMI $> 29.9$) is present in 20% of New Jersey women of reproductive age,[19] but only 9% of our patients were obese. This may be because as BMI increases, women have a progressively reduced risk of placenta previa.[20] Fifteen percent of our patients had undergone IVF/ART, supporting the association of IVF/ART with placenta accreta.[13] However, since we do not know the background rate of IVF/ART at our institution over the 10-year study period, we cannot test the strength of the relationship. We further cannot dissociate the effects of the more careful monitoring of patients that occurred with the team approach, from the cumulative experience of the team and/or changes in surgical procedures that evolved with time to improve outcomes.

An additional weakness is that the team-based care was not available to all patients due to either no antenatal suspicion of

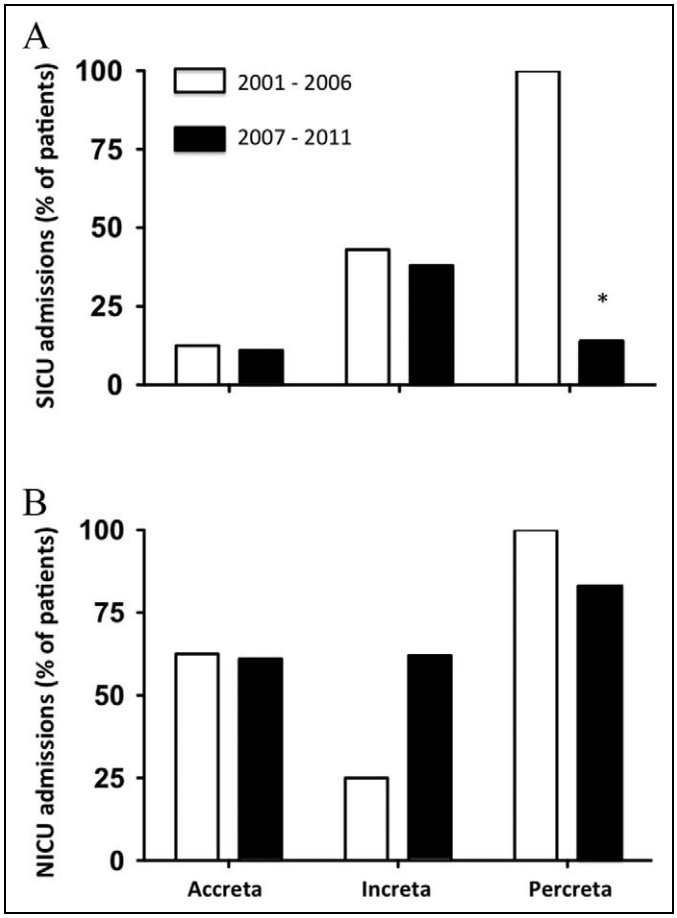


**Figure 2.** A, Maternal admissions to the surgical intensive care unit declined in the later cohort ($P < .01$). The decrease was most pronounced in percreta cases. B, The percentage of neonates admitted to the neonatal intensive care unit (NICU) did not differ between cohorts.

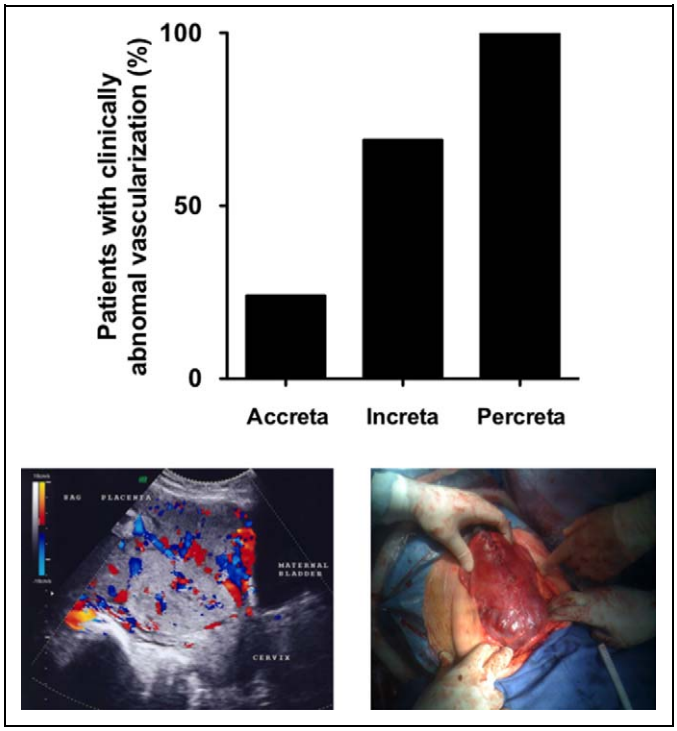


**Figure 3.** Doppler ultrasound and intraoperative photos/annotation were used as clinical evidence of excess vascularity (insets). Excess vascularity correlates with disease severity, being present in 16% of accreta, 69% of increta, and 100% of percreta ($P < .0001$).

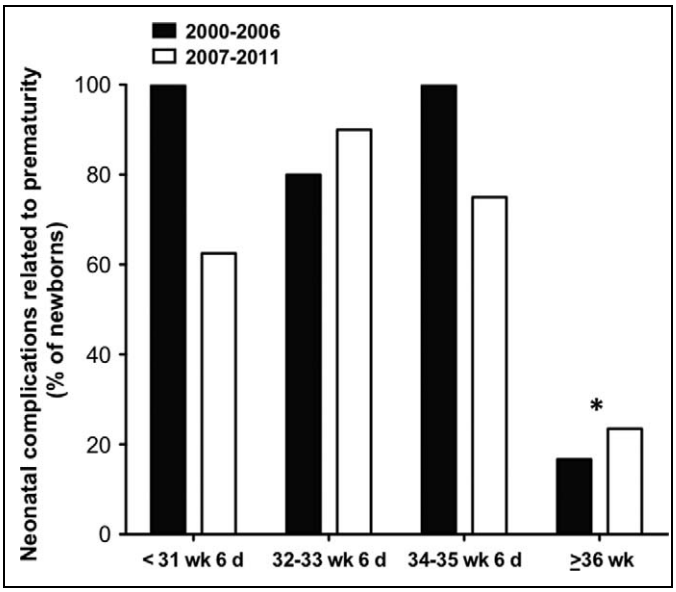


**Figure 4.** Any one of the following is considered a complication related to prematurity: respiratory distress syndrome, anemia of prematurity, transient tachypnea of the newborn, cerebral hemorrhage, hypoglycemia, and apnea. The percentage of neonates with complications related to prematurity did not differ between cohorts at any gestational age. The incidence of complications was similar at each of the gestational age groups shown; the rate of complications declined only at ≥36 weeks ($P < .0001$).

an accreta or emergent delivery ahead of scheduled cesarean. This may have contributed to the similarity in EBL between increatas in the early versus late cohort. CAP was not involved in 5 of the 13 increta cases in the late cohort. In 3, no pathology was suspected (eg, 1 was a primipara with no history of uterine instrumentation). In one case, CAP was called in to assist when invasive placenta was observed. In the other 2, delivery was emergent, ahead of the scheduled C section for placenta previa, and a gyn-concologist was called in to assist. In the final 2 cases, accreta-related pathology was suspected, but private obstetricians did the delivery without consulting CAP. This group of 5 patients tended to have greater intraoperative EBL ($2.6 \pm 1.4$ L) than those in which the CAP specialists were present at the start of the case ($1.5 \pm 1.6$ L, $P = .08$). It is noteworthy that all 5 cases were in 2007 to 2008, prior to CAP becoming well known in the external obstetrics practices.

Our cases represent the more severe end of the abnormally invasive placental spectrum, as reflected in the greater numbers of increta and percreta cases than in other recent case series.[21] Generally accreta accounts for 75%, increta <20%, and percreta <10% of all cases. Nonetheless, the outcomes we report for the

1-step surgeries are consistent with or better than other large academic centers. Approximately 40% of women with accreta will require more than 10 units of pRBCs[22]; in our series, <5% of patients required ≥10 units. A nearby institution, similar to ours and encompassing the same time period, reported a mean of 10 units (median 6.5) of pRBCs administered per patient.[21] This is 3-fold greater than our mean of 2.7 (median 2.0) in the later cohort. Warshak et al[15] and Stotler et al[21] in centers similar to ours, reported ICU admission rates of 35% and 66%, respectively, while ours fell to 21% in the later cohort, largely due to lower blood loss and transfusion.

Our data on the staged surgeries support that efforts to preserve fertility by leaving the increta or percreta placenta in situ substantially increase the risks for the mother and should be discouraged. Both patients wishing to preserve fertility had onset of hemorrhage requiring hysterectomy within months of the initial surgery. Conservative management with attempted preservation of the uterus is successful in 40% to 80% of cases.[23-25] Unfortunately, success by disease severity has not been reported. Unsuccessful conservative management is associated with severe morbidities such as massive hemorrhage, sepsis, DIC, and maternal death.[23-25]

To our knowledge, it has not been reported previously that risk factors for accreta-related pathologies may differ according to the disease severity. The potential for risk factors to vary by disease severity has been obscured by small sample sizes, the tendency to aggregate all accreta subtypes together for analyses and the relative rarity of the more severe forms. In contrast to a recent assertion that accreta is completely iatrogenic,[26] previa alone, absent any history of uterine instrumentation, is associated with a 10% rate of accreta, and is independent of the history of uterine instrumentation.[11,27] This clinical correlation was known more than 100 years ago, when cesarean delivery was virtually nonexistent.[28] We suggest that previa may be the most potent risk factor and that the association with cesarean scar is in part due to the near 3-fold greater incidence of placenta previa in women with prior low transverse cesarean deliveries.[29,30] In addition to excessively high rates of cesarean in the United States, we can expect an increase in the incidence of accreta due to the migration of women from countries where cesarean rates are high, especially East Asia and Latin America.[31] In our series, 24% of the women had been born outside of the United States, and in half of these, prior cesareans were performed in their country of origin. Careful epidemiologic analysis of multiple data sets is required to learn whether or not regional variation in surgical techniques or materials contributes to risk of accreta and whether differences in risk factors between diagnostic categories may provide clues as to pathophysiology.

We found that clinical indicators of excess vascularity in the lower uterine segment correlate with the severity of the accreta, being present in 100% of percreta but in only 16% of accreta. It is not known to what extent this hypervascularity is related to direct remodeling by trophoblast, versus recruitment, neovascularization, and/or paracrine effects. Our findings are consistent with trophoblast remodeling of large, deep myometrial vessels in increta and percreta but not accreta.[8] They are also consistent with several reports indicating that the invasive, extravillous trophoblast is abnormal in accreta-related pathologies.[8,32-36] This is further supported by recent work showing a parallel phenotype between accreta and epithelial cancers in that the extravillous trophoblast in accreta shows evidence of an epithelial-to-mesenchymal transition.[35]

There is now considerable evidence that fetal sex alters placental function,[37] and a high female–male fetal ratio in accreta has been reported.[38] However, our results did not show differences in outcomes by fetal sex, nor was there an excess of female babies in the series (63% male and 37% female).

Timing of delivery in these cases is controversial. It is commonly assumed that the disease progresses with longer duration of pregnancy. There is little evidence for this in the literature as there are no serial diagnostic data or quantification of longitudinal changes in vascularity of the lower uterine segment. Cases with a high index of suspicion for accreta have been identified in the first trimester prospectively[39] and retrospectively.[40] The latter study reexamined early (<10 weeks) ultrasound scans in patients but did not report on whether there was disease progression in later scans revealing features typical of accreta. Statistical modeling of timing of delivery suggests that 34 weeks is optimal,[41] as do clinical data. Significant bleeding requiring emergent delivery occurs in >90% of cases expectantly managed to ≥35 weeks, and maternal deaths occur more frequently at ≥35 weeks.[22] Nearly half of the patients who waited until >36 weeks to deliver required emergent hysterectomy due to hemorrhage.[15] Since these reports did not stratify by disease severity, it is possible that milder cases will not have significant bleeding, requiring early delivery. However, our data do not support this, as the overall target delivery date of 34 weeks was not attained in 40% of accretas, 27% of increta, and 35% of percreta. The major cause was bleeding (21%), followed by preterm premature rupture of membranes (PPROM, 8%). We suggest that patients antenatally diagnosed with invasive placenta should be referred to tertiary care centers with comprehensive management capability. This has occurred with CAP, which has drawn patients from abroad as well as in the tristate area routinely served by the hospital. Moreover, our experience with emergent cases, even those in which invasive placenta is not suspected, suggests that patients who experience >1 episode of heavy bleeding due to placenta previa should be hospitalized until delivery, which is our current practice.

In conclusion, we have shown that early planned delivery and an experienced team managing these complex cases is associated with improved maternal outcomes as measured by blood loss, transfusion, SICU admission, and complications. However, neonatal complications due to prematurity remain high. Hypervascularity of the lower uterine segment correlates with disease severity. Maternal risk factors differ in accreta versus increta/percreta. Multicenter studies are needed in which the risks to the neonate can be evaluated relative to the risks to the mother with early delivery and to determine whether milder disease can be expectantly managed to 36 weeks or greater to reduce iatrogenic prematurity.

## Declaration of Conflicting Interests

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