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Cesarean hysterectomy for placenta accreta spectrum: Surgeon specialty-specific assessment

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HIGHLIGHTS

- Surgical morbidity at cesarean hysterectomy for PAS was evaluated per surgeon's specialty.
- Gynecologic oncologists appear to manage more severe forms of PAS.
- Regardless of surgeon's specialty, surgical morbidity of cesarean hysterectomy for PAS was significant.

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ABSTRACT

Objective. To assess *(i)* clinical and pregnancy characteristics, *(ii)* patterns of surgical procedures, and *(iii)* surgical morbidity associated with cesarean hysterectomy for placenta accreta spectrum based on the specialty of the attending surgeon.

Methods. The Premier Healthcare Database was queried retrospectively to study patients with placenta accreta spectrum who underwent cesarean delivery and concurrent hysterectomy from 2016 to 2020. Surgical morbidity was assessed with propensity score inverse probability of treatment weighting based on surgeon specialty for hysterectomy: general obstetrician-gynecologists, maternal-fetal medicine specialists, and gynecologic oncologists.

Results. A total of 2240 cesarean hysterectomies were studies. The most common surgeon type was general obstetrician-gynecologist ($n = 1534$, 68.5%), followed by gynecologic oncologist ($n = 532$, 23.8%) and maternal-fetal medicine specialist ($n = 174$, 7.8%). Patients in the gynecologic oncologist group had the highest rate of placenta increta or percreta, followed by the maternal-fetal medicine specialist and general obstetrician-gynecologist groups (43.4%, 39.6%, and 30.6%, $P < .001$). In a propensity score-weighted model, measured surgical morbidity was similar across the three subspecialty groups, including hemorrhage / blood transfusion (59.4–63.7%), bladder injury (18.3–24.0%), ureteral injury (2.2–4.3%), shock (8.6–10.5%), and coagulopathy (3.3–7.4%) (all, $P > .05$). Among the cesarean hysterectomy performed by gynecologic oncologist, hemorrhage / transfusion rates remained substantial despite additional surgical procedures: tranexamic acid / ureteral stent (60.4%), tranexamic acid / endo-arterial procedure (76.2%), ureteral stent / endo-arterial procedure (51.6%), and all three procedures (55.4%). Tranexamic acid administration with ureteral stent placement was associated with decreased bladder injury (12.8% vs 23.8–32.2%, $P < .001$).

Conclusion. These data suggest that patient characteristics and surgical procedures related to cesarean hysterectomy for placenta accreta spectrum differ based on surgeon specialty. Gynecologic oncologists appear to

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manage more severe forms of placenta accreta spectrum. Regardless of surgeon's specialty, surgical morbidity of cesarean hysterectomy for placenta accreta spectrum is significant.

1. Introduction

Placenta accreta spectrum refers to a morbidly adherent placenta to the gravid uterus [1,2]. While optimal treatment is currently under active evaluation, pregnant patients with suspected placenta accreta spectrum frequently undergo hysterectomy for the en-bloc removal of in-situ placenta altogether with the uterus immediately following cesarean delivery of the fetus [1]. This surgical procedure, however, is associated with significant maternal morbidity and mortality [3]. Improving perioperative outcomes of cesarean hysterectomy for placenta accreta spectrum is therefore of utmost importance and an unmet-need for surgeons and patients.

Various approaches and surgical techniques have been proposed previously to minimize surgical morbidity of cesarean hysterectomy for placenta accreta spectrum [4–8]. Focused areas of evaluation include a multidisciplinary team approach [9,10], prophylactic ureteral stent placement [11,12], endo-arterial procedures such as uterine arterial balloon occlusion [13] and resuscitative endovascular balloon occlusion of the aorta [14], and combination of antifibrinolytic agent use with endo-arterial embolization [15]. It is recommended that experienced pelvic surgeons perform cesarean hysterectomy for placenta accreta spectrum [8,16].

The majority of prior studies examining the surgeon's role and outcomes of cesarean hysterectomy for placenta accreta spectrum have focused on gynecologic oncologists [17–20]. In addition, the sample sizes of these past studies were low-to-modest (100–150 cases of cesarean hysterectomy, including 60–70 cases performed by gynecologic oncologists) [18,19]. Studies to assess surgical practice and outcomes among other subspecialities such as maternal-fetal medicine specialists were single center experiences [9,21] and comparison to other surgeon's subspeciality were limited. As there is a wide range of practice variability for placenta accreta spectrum across single centers [22], extrapolating specialty-based outcomes is difficult.

Collectively, there is a scarcity of surgeon subspecialty-type specific data to examine patterns of care and outcomes of cesarean hysterectomy for placenta accreta spectrum. The objective of this study was thus to assess *(i)* clinical and pregnancy characteristics, *(ii)* pattern of surgical procedures, and *(iii)* surgical morbidity associated with cesarean hysterectomy for placenta accreta spectrum based on the subspecialty of the attending surgeon in the United States.

2. Materials and methods

2.1. Database

The Premier Healthcare Database was queried for this retrospective study [23]. This program captures both inpatient and outpatient services across >700 hospitals in the United States. The de-identified information that the program collects include patient clinical characteristics, diagnoses and procedures during the hospital encounter, hospital parameters, and outcome endpoints. The Columbia University Institutional Review Board determined the current study exempt as non-human subject research.

2.2. Cohort selection

Patients with a diagnosis of placenta accreta spectrum who underwent cesarean delivery and concurrent hysterectomy at the time from 2016 to 2020 were evaluated. Planned delayed hysterectomy following cesarean delivery [24] and expectant conservative management without hysterectomy following cesarean delivery [25] were possible alternative treatment approaches for placenta accreta spectrum, but these two options were excluded in this study.

The starting point of year 2016 was chosen due to the introduction of the World Health Organization's International Classification of Disease 10th revision Clinical Modification code for placenta accreta spectrum, including three subtypes (accreta, increta, and percreta) (Supplementary Table S1). Performance of cesarean delivery and hysterectomy followed the International Classification of Disease 10th revision Procedure Classification System and Clinical Modification codes, the American Medical Association's Current Procedural Terminology codes, and Diagnosis-Related Group codes (Supplementary Table S1) [3,26].

2.3. Exposure

All the eligible cases were then assessed for surgeon's specialty type for the cesarean delivery and the hysterectomy components of the procedure, separately; and this study focused on three most frequent surgeon's subspeciality types for hysterectomy (Supplementary Table S1). These included general obstetrician-gynecologists, gynecologic oncologists, and maternal-fetal medicine specialists.

In the United States, subspeciality training for gynecologic oncology (3–4 years) follows the completion of general obstetrician-gynecologist training (4 years) [27]. Likewise, subspeciality training for maternal-fetal medicine (3 years) follows the completion of general obstetrician-gynecologist training (4 years) [28]. Cesarean hysterectomy for placenta accreta spectrum is not specifically described in the current training program requirements for these two subspecialities [27,28].

2.4. Outcome measures

The main outcomes assessed in this study were surgical morbidity associated with cesarean hysterectomy for placenta accreta spectrum. The morbidity indicators followed prior analysis for cesarean hysterectomy for placenta accreta spectrum, including hemorrhage / transfusion, bladder injury, ureteral injury, shock, and coagulopathy (Supplementary Table S1) [3].

The secondary outcomes included three targeted-surgical procedures at the time of cesarean hysterectomy: intravenous administration of tranexamic acid, cystoscopic ureteral stent placement, and arterial embolization or balloon catheter placement. These were pre-selected in a view of relevance to cesarean hysterectomy for placenta accreta spectrum [11,15,29]. Text search in patients' billing file was conducted (screened a total of 2493 terms) in addition to the coding schema (Supplementary Table S1).

Additionally, severe maternal morbidity per the Centers for Disease Control and Prevention definition (a total of 21 indicators) [30], surgical reoperation, and surgical site complication were assessed as the secondary outcome measures (Supplementary Table S1).

2.5. Study variables

Patient demographics, pregnancy characteristics, and hospital parameters pertinent to placenta accreta spectrum were preselected.

Patient demographics and general clinical factors included maternal age at delivery (25–29, 30–34, 35–39, and ≥40 years), year of delivery (2016, 2017, 2018, 2019, and 2020), race (Asian, Black, Other, and White) determined by the program, primary payer (Medicaid or commercial), marital status (married, single, or other), admission via emergent care (yes or no), and medical comorbidity (obesity, pregestational hypertension, and pregestational diabetes mellitus). Race was examined in this study due to possible association for placenta accreta spectrum characteristics and outcomes [31].

Pregnancy characteristics included past history of cesarean delivery, placenta previa, maternal gestational diabetes, gestational hypertension, multi-fetal gestation, and gestational age at delivery (<28, 28–31, 32–36, and ≥37). Hospital parameters included bed capacity (<400, 400–499, or ≥500), location type (urban or rural), teaching status (yes or no), U.S. region (Northeast, Midwest, South, or West), and annualized mean delivery volume (quarterized).

2.6. Statistical analysis

Baseline clinical and demographic data were aggregated and presented as percentage by surgeon's sub-specialty groups, and statistical differences were assessed using chi-square tests. Surgeons' subspecialty distribution and utilization rates of the three targeted procedures (tranexamic acid administration, ureteral stent placement, and endo-arterial embolization / balloon occlusion) were summarized per calendar year and temporal trends assessed with the Cochran-Armitage trend test.

The comparison of surgical morbidities across surgeons' subspecialty groups was assessed using propensity score inverse probability of treatment weighting [32]. A multinomial logistic regression model was fitted to calculate predicted probability of being assigned to each surgeon subspecialty group and the weights were calculated to balance and mitigate the difference in the baseline clinical and demographic data across the three surgeon's subspecialty groups. All the measured study covariates were considered in the multinomial logistic regression model, while hospital location setting and gestational age were excluded due to multicollinearity with other variables. Trimming was used for the extreme weights. In the weighted cohort, surgical morbidity rates were assessed in the three surgeon's subspecialty groups.

In sensitivity analyses, patients who had placenta previa with either increta or percreta were evaluated. This group can be a surrogate of antenatally suspected severe form of placenta accreta spectrum [4,8]. In addition, the measured surgical morbidities were assessed based on the performance of three targeted procedures at cesarean hysterectomy (tranexamic acid administration, ureteral stent placement, and endo-arterial embolization / balloon occlusion), evaluated in each surgeons' subspecialty group (general obstetrician-gynecologists, maternal-fetal medicine specialists, and gynecologic oncologists). This was based on the notion that surgical practice patterns may differ across surgeon's specialty [20,33]. Last, surgery setting was compared for the measured morbidity (emergency vs non-emergency).

A *P*-value of <0.05 was considered statistically significant (2-tailed hypothesis). SAS Software version 9.4 (SAS Institute Inc., Gary, NC, USA) was used for analysis. The results were reported in accord with the STROBE reporting guidelines for observational study [34].

3. Results

3.1. Demographic characteristics

A total of 2240 cesarean hysterectomies met the study inclusion criteria. Hysterectomy following cesarean delivery was most frequently performed by general obstetrician-gynecologists that accounted for nearly two-thirds of the study population ($N = 1534$, 68.5%). This was followed by gynecologic oncologists ($N = 532$, 23.8%). Hysterectomy following cesarean delivery was infrequently performed by maternal-fetal medicine specialists, representing <10% of study population ($N = 174$, 7.8%).

During the study period, the distributions of surgeon's subspecialty were overall unchanged (Fig. 1). These included general obstetrician-gynecologists (66.4% to 70.0%, *P-trend* = 0.097), gynecologic oncologists (22.3% to 22.6%, *P-trend* = 0.465), and maternal-fetal medicine specialist (11.3% to 7.4%, *P-trend* = 0.086).

Patients in the maternal-fetal medicine specialist group were more likely to be obese (28.7% vs 18.3–23.7%), admitted to the hospital through emergent care (56.3% vs 38.0–41.7%), and have had prior cesarean delivery (82.8% vs 74.6–79.1%) compared to the other two subspeciality groups (all, $P < .05$; Table 1).

Patients in the gynecologic oncologist group had the highest rate of placenta increta or percreta (43.4%), followed by maternal-fetal medicine specialists (39.7%) and general obstetrician-gynecologists (30.6%) ($P < .001$). The results were consistent for placenta percreta: 26.5%, 24.1%, and 17.4% for the gynecologic oncologist, maternal-fetal medicine specialist, and general obstetrician-gynecologist groups, respectively (Table 1).

Patients in the gynecologic oncologist and maternal-fetal medicine specialist groups were more likely to have placenta previa (62.4–63.2% vs 49.4%) including placenta previa with either increta or percreta (27.0–27.4% vs 16.2%) (both, $P < .001$; Table 1). Patients in the general obstetrician-gynecologist group were more likely to deliver at term gestation (23.5% vs 10.3%, $P < .001$, Table 1), and this group was also characterized by small bed capacity, rural setting, non-teaching status, and lower delivery volume centers compared to other groups (all, $P < .001$; Table 1).

3.2. Targeted procedures

At the study population-level, the utilization of all three targeted procedures at cesarean hysterectomy increased during the 5-year study period from 2016 to 2020 (Fig. 2). The largest relative-increase was the administration of tranexamic acid from 11.5% to 37.5% (3.3-fold increase; *P-trend* < 0.001). The relative-increase in the remaining two targeted procedures were modest: ureteral stent placement (16.9% to 23.4%, 1.4-fold increase, *P-trend* = 0.014) and endo-arterial embolization / balloon occlusion (15.9% to 20.7%, 1.3-fold increase, *P-trend* = 0.018).

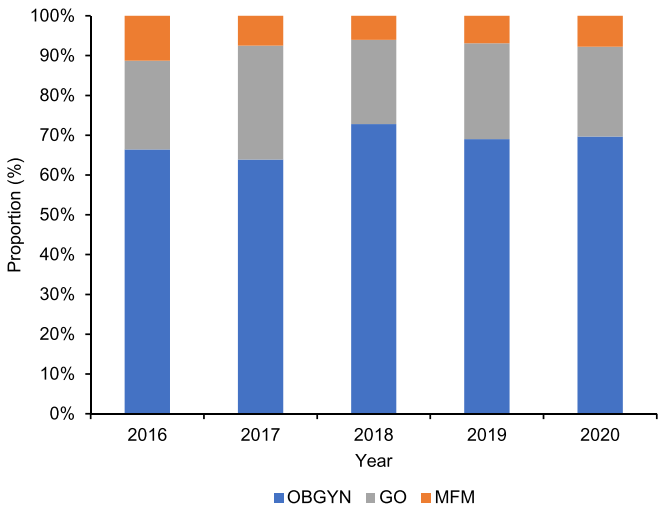

Fig. 1. Distribution of surgeon's subspeciality.
Proportional distributions of three measured surgeon's subspecialities (OBGYN, GO, and MFM) for cesarean hysterectomy performed for placenta accreta spectrum are shown from 2016 to 2020. Abbreviations: OBGYN, general obstetricians and gynecologists; GO, gynecologic oncologists; and MFM, maternal-fetal medicine specialists.

Table 1
Clinico-pregnancy characteristics and hospital parameters by surgeon subspecialty.

Characteristic	OBGYN	GO	MFM	*P*-value
	N (%)	N (%)	N (%)	
Total Number	1534 (100)	532 (100)	174 (100)	
Age (y)				0.266
25–29	340 (22.2)	116 (21.8)	35 (20.1)	
30–34	554 (36.1)	179 (33.7)	70 (40.2)	
35–39	450 (29.3)	173 (32.5)	57 (32.8)	
≥40	190 (12.4)	64 (12.0)	12 (6.9)	
Year				>0.05[§]
2016	259 (16.9)	87 (16.4)	44 (25.3)	
2017	290 (18.9)	130 (24.4)	34 (19.5)	
2018	351 (22.9)	102 (19.2)	29 (16.7)	
2019	301 (19.6)	105 (19.7)	30 (17.2)	
2020	333 (21.7)	108 (20.3)	37 (21.3)	
Race				0.332
Asian	71 (4.6)	21 (4.0)	*	
Black	290 (18.9)	101 (19.0)	34 (19.5)	
Other	233 (15.2)	106 (19.9)	32 (18.4)	
Unknown	59 (3.9)	25 (4.7)	*	
White	881 (57.4)	279 (52.4)	92 (52.9)	
Payer type				0.992
Medicaid	779 (50.8)	267 (50.2)	87 (50.0)	
Commercial	669 (43.6)	233 (43.8)	76 (43.7)	
Unknown	86 (5.6)	32 (6.0)	11 (6.3)	
Marital status				0.021
Married	818 (53.3)	293 (55.1)	95 (54.6)	
Single	549 (35.8)	202 (38.0)	70 (40.2)	
Other[†]	167 (10.9)	37 (7.0)	*	
Emergent care				<0.001
No	822 (53.6)	315 (59.2)	72 (41.4)	
Yes	640 (41.7)	202 (38.0)	98 (56.3)	
Unknown	72 (4.7)	15 (2.8)	*	
Obesity				0.001
No	1253 (81.7)	406 (76.3)	124 (71.3)	
Yes	281 (18.3)	126 (23.7)	50 (28.7)	
Pregestational hypertension				0.827
No	1456 (94.9)	506 (95.1)	167 (96.0)	
Yes	78 (5.1)	26 (4.9)	*	
Pregestational diabetes				0.115
No	1482 (96.6)	508 (95.5)	163 (93.7)	
Yes	52 (3.4)	24 (4.5)	11 (6.3)	
Gestational hypertension				0.165
No	1449 (94.5)	512 (96.2)	162 (93.1)	
Yes	85 (5.5)	20 (3.8)	12 (6.9)	
Gestational diabetes				0.345
No	1327 (86.5)	447 (84.0)	151 (86.8)	
Yes	207 (13.5)	85 (16.0)	23 (13.2)	
Multifetal gestation				0.816
No	1476 (96.2)	509 (95.7)	168 (96.6)	
Yes	58 (3.8)	23 (4.3)	*	
Prior cesarean delivery				0.012
No	390 (25.4)	111 (20.9)	30 (17.2)	
Yes	1144 (74.6)	421 (79.1)	144 (82.8)	
Placenta previa				<0.001
No	777 (50.7)	200 (37.6)	64 (36.8)	
Yes	757 (49.4)	332 (62.4)	110 (63.2)	
Placental accreta subtype				<0.001
Accreta	1064 (69.4)	301 (56.6)	105 (60.3)	
Increta	203 (13.2)	90 (16.9)	27 (15.5)	
Percreta	267 (17.4)	141 (26.5)	42 (24.1)	
Previa with increta / percreta				<0.001
No	1286 (83.8)	386 (72.6)	127 (73.0)	
Yes	248 (16.2)	146 (27.4)	47 (27.0)	
Gestational age (w)				<0.001
≥37	360 (23.5)	55 (10.3)	18 (10.3)	
32–36	921 (60.0)	358 (67.3)	116 (66.7)	
28–31	147 (9.6)	69 (13.0)	28 (16.1)	
<28	96 (6.3)	45 (8.5)	11 (6.3)	
Unknown	*	*	*	
Hosp bed capacity				<0.001
<400	479 (31.2)	60 (11.3)	13 (7.5)	
400–499	171 (11.2)	108 (20.3)	24 (13.8)	
≥500	884 (57.6)	364 (68.4)	137 (78.7)	
Hosp location setting				<0.001
Urban	1422 (92.7)	507 (95.3)	174 (100)	
Rural	112 (7.3)	25 (4.7)	0	

Table 1 (*continued*)

Characteristic	OBGYN	GO	MFM	*P*-value
	N (%)	N (%)	N (%)	
Hosp teaching setting				<0.001
No	466 (30.4)	85 (16.0)	14 (8.1)	
Yes	1068 (69.6)	447 (84.0)	160 (91.9)	
Hosp region				<0.001
Northeastern	259 (16.9)	112 (21.1)	28 (16.1)	
Midwest	307 (20.0)	90 (16.9)	30 (17.2)	
South	718 (46.8)	235 (44.2)	31 (17.8)	
West	250 (16.3)	95 (17.9)	85 (48.9)	
Hosp delivery volume				<0.001
QT1 (lowest)	435 (28.4)	112 (21.1)	15 (8.6)	
QT2	405 (26.4)	104 (19.6)	41 (23.6)	
QT3	413 (26.9)	142 (26.7)	22 (12.6)	
QT4 (highest)	281 (18.3)	174 (32.7)	96 (55.2)	

Number (percentage per column) is shown. * Small number suppressed. † Including unknown. § Cochran-Armitage trend test for all 3 groups. Abbreviations: OBGYN, general obstetricians and gynecologists; GO, gynecologic oncologists; MFM, maternal-fetal medicine specialists; QT, quartile.

When examined the three surgeon's subspeciality groups, the utilization rates of all three targeted procedures at cesarean hysterectomy were higher among the patients in the maternal-fetal medicine specialist group compared to those in the other groups (Table 2). These included administration of tranexamic acid (47.7% vs 22.2–26.5%), ureteral stent placement (44.8% vs 14.8–22.0%), and *endo*-arterial embolization or balloon occlusion (38.5% vs 11.6–19.6%) (all, $P < .001$).

The results were consistent when examined for the patients who had placenta previa either with increta or percreta: administration of tranexamic acid (72.3% vs 24.6–34.3%), ureteral stent placement (59.6% vs 27.4–38.4%), and endo-arterial embolization or balloon occlusion (66.0% vs 18.9–26.0%) (all, $P < .001$).

3.3. Surgical morbidities by surgeons' subspecialty

In the propensity score-weighted cohort, the study covariates were well-balanced across the three surgeons' subspecialty groups (all, $P > .05$; Supplementary Table S2). The measured surgical morbidities were overall similar across the three surgical specialty groups (Table 3). These included the incidence rates of hemorrhage / blood transfusion ranging between 59.4% and 63.7% ($P = .688$), bladder injury ranging between 18.3% and 24.0% ($P = .453$), ureteral injury ranging between 2.2% and 4.3% ($P = .502$), shock ranging between 8.6% and 10.5% ($P = .794$), and coagulopathy ranging between 3.3% and 7.4% ($P = .227$). The results remained consistent for severe maternal morbidity, surgical site complication, and reoperation (Table 3).

Among cesarean hysterectomies performed by general obstetrician-gynecologists, the incidence rates of measured outcomes were overall lowest among those with tranexamic acid administration and ureteral stent placement across the observed targeted procedure patterns (Table 4).

Among cesarean hysterectomies performed by gynecologic oncologists, the incidence of hemorrhage / blood transfusion was overall substantial but was lowest with ureteral stent placement and endo-arterial

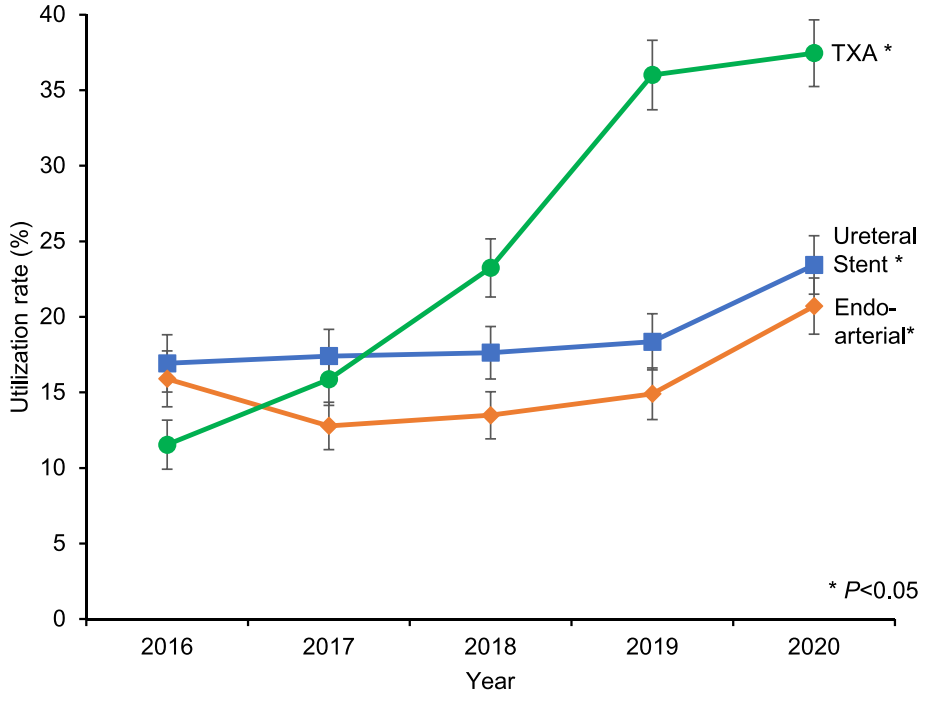

Fig. 2. Temporal trends of utilization of targeted procedures.
Temporal trends of utilization rates of three targeted procedures (TXA use, ureteral stent insertion, and endo-arterial procedure) at cesarean hysterectomy for placenta accreta spectrum are shown from 2016 to 2020. * Cochran-Armitage trend test. Observed value and corresponding standard error are displayed. Abbreviations: TXA, tranexamic acid; and endo-arterial, uterine arterial embolization / balloon occlusion.

Table 2
Targeted procedures at hysterectomy.

		OBGYN	GO	MFM	*P*-value
Entire cases	Tranexamic acid				<0.001
	No	1193 (77.8)	391 (73.5)	91 (52.3)	
	Yes	341 (22.2)	141 (26.5)	83 (47.7)	
	Ureteral stent				<0.001
	No	1307 (85.2)	415 (78.0)	96 (55.2)	
	Yes	227 (14.8)	117 (22.0)	78 (44.8)	
	Arterial occlusion				<0.001
	No	1356 (88.4)	428 (80.5)	107 (61.5)	
	Yes	178 (11.6)	104 (19.6)	67 (38.5)	
Previa (increta / percreta)	Tranexamic acid				<0.001
	No	187 (75.4)	96 (65.8)	13 (27.7)	
	Yes	61 (24.6)	50 (34.3)	34 (72.3)	
	Ureteral stent				<0.001
	No	180 (72.6)	90 (61.6)	19 (40.4)	
	Yes	68 (27.4)	56 (38.4)	28 (59.6)	
	Arterial occlusion				<0.001
	No	201 (81.1)	108 (74.0)	16 (34.0)	
	Yes	47 (18.9)	38 (26.0)	31 (66.0)	
Other Cases*	Tranexamic acid				<0.001
	No	1006 (78.2)	295 (76.4)	78 (61.4)	
	Yes	280 (21.8)	91 (23.6)	49 (38.6)	
	Ureteral stent				<0.001
	No	1127 (87.6)	325 (84.2)	77 (60.6)	
	Yes	159 (12.4)	61 (15.8)	50 (39.4)	
	Arterial occlusion				<0.001
	No	1155 (89.8)	320 (82.9)	91 (71.7)	
	Yes	131 (10.2)	66 (17.1)	36 (28.4)	

Number (percentage per column) is shown. * Other than placenta previa with increta / percreta. Abbreviations: OBGYN, general obstetricians and gynecologists; GO, gynecologic oncologists; MFM, maternal-fetal medicine specialists;.

embolization across the observed targeted procedure patterns although remained considerably high (51.6% vs 55.4–76.2%, $P = .007$; Table 4). The bladder injury rate was 10%-point lower with tranexamic acid administration and ureteral stent placement compared to other procedural patterns (12.8% vs 23.8–32.2%, $P < .001$). Surgery setting was not associated with the measured morbidity (Supplementary Table S3).

4. Discussion

4.1. Principal findings

Key results of this study were as follows: First, maternal-fetal medicine specialists infrequently performed cesarean hysterectomy for placenta accreta spectrum. Second, gynecologic oncologists were more likely to be involved in cesarean hysterectomy for more severe forms of placenta accreta spectrum. Third, maternal-fetal medicine specialists were more likely to perform additional surgical procedures at cesarean hysterectomy for placenta accreta spectrum. Lastly, across the three surgeon's subspecialties, surgical morbidity rates of cesarean hysterectomy for placenta accreta spectrum were substantial.

Table 3
Surgeon type-specific surgical morbidity in PS-IPTW cohort.

	OBGYN	GO	MFM	
	% (SE)	% (SE)	% (SE)	*P*-value
PPH / transfusion	63.7 (1.0)	59.4 (1.1)	60.5 (1.1)	0.688
Bladder injury	18.3 (0.8)	22.3 (0.9)	24.0 (0.9)	0.453
Ureteral injury	2.9 (0.4)	2.2 (0.3)	4.3 (0.4)	0.502
Shock	8.6 (0.6)	9.3 (0.6)	10.5 (0.7)	0.794
Coagulopathy	7.4 (0.6)	6.1 (0.5)	3.3 (0.4)	0.227
Severe maternal morbidity	49.2 (1.1)	49.0 (1.1)	51.0 (1.1)	0.926
Surgical site complication	9.9 (0.6)	10.3 (0.6)	9.9 (0.6)	0.989
Reoperation	2.0 (0.3)	2.5 (0.3)	3.0 (0.4)	0.848

Percentage (standard error) per surgeon subspeciality are shown. Abbreviations: PS-IPTW, propensity score inverse provability of treatment weighting; OBGYN, general obstetricians and gynecologists; GO, gynecologic oncologist; MFM, maternal-fetal medicine specialists; PPH, postpartum hemorrhage.

4.2. Clinical / research implications

Overall, <10% of patients in this study population underwent immediate hysterectomy for placenta accreta spectrum were performed by maternal-fetal medicine specialists. This may in part reflect a 2012 practice survey of maternal-fetal medicine specialists in the United States that reported that they have low-to-modest case-volume for placenta

Table 4
Outcomes stratified by targeted procedures per subspecialty groups.

	Combination of targeted procedures				
Tranexamic acid	(+)	(+)		(+)	
Ureteral stent	(+)		(+)	(+)	
Endo-arterial		(+)	(+)	(+)	
	%	%	%	%	*P*-value
OBGYN					
PPH / transfusion	61.4	73.4	62.6	66.1	0.006
Bladder injury	14.0	16.5	29.3	27.5	<0.001
Ureteral injury	1.5	**	**	7.3	<0.001
Coagulopathy	5.2	9.7	**	12.8	<0.001
Shock	7.1	12.7	**	10.1	0.035
Severe maternal morbidity	46.4	54.4	52.8	49.1	0.116
GO					
PPH / transfusion	60.4	76.2	51.6	55.4	0.007
Bladder injury	12.8	23.8	25.8	32.2	<0.001
Ureteral injury	*	*	*	*	0.010
Coagulopathy	4.9	*	*	*	0.006
Shock	10.2	14.3	*	*	0.054
Severe maternal morbidity	54.0	52.4	45.2	47.1	0.463
MFM					
PPH / transfusion	70.3	*	*	30.4	<0.001
Bladder injury	*	*	*	27.8	<0.001
Ureteral injury	*	0	*	*	0.453
Coagulopathy	*	*	0	*	0.017
Shock	*	*	*	*	0.001
Severe maternal morbidity	57.8	*	*	21.5	<0.001

Percentage per column is shown. * Suppressed small number. Bonferroni correction for the significant level = 0.0006. Abbreviations: OBGYN, general obstetricians and gynecologists; GO, gynecologic oncologists; MFM, maternal-fetal medicine specialists; PPH, postpartum hemorrhage.

accreta spectrum [22]; the majority considered hysterectomy as the mainstay of management for placenta accreta spectrum but nearly one-third of responders experienced conservative management [22].

Moreover, a 2023 survey for maternal-fetal medicine fellows in the United States reported that only 26% were comfortable performing cesarean hysterectomy without gynecologic oncologist assistance [35]. While not examined in the current study, the concept of conservative management without immediate hysterectomy for placenta accreta spectrum is increasing in recent years that may possibly have attributed the statistics of this study [36].

Rates of placenta increta or percreta, severe forms of placenta accreta spectrum, were highest in the gynecologic oncologist group followed by the maternal-fetal medicine specialist group in the current study. This trend was similar to a 2022 retrospective study demonstrating that gynecologic oncologists were more likely to be involved in suspected placenta percreta (37.1% vs 11.7%) [17].

Furthermore, gynecologic oncologist's surgical experiences for placenta accreta spectrum appear significant. A 2022 practice survey for gynecologic oncologists in the United States showed that 71.6% and 36.6% of responders have experienced greater than 5 and 10 liters of blood loss at placenta accreta spectrum surgery, respectively [20]. Cesarean hysterectomy case-volume for placenta accreta spectrum is also modest for gynecologic oncologists in the United States. The aforementioned practice survey suggested that only 35.5% perform 6 or more surgeries a year [20]. Notably, 50.3% of responders expressed interests in placenta accreta spectrum management [20].

Utilization of additional surgical procedures at cesarean hysterectomy for placenta accreta spectrum differed across the surgeon's subspecialities. Of the three groups, maternal-fetal medicine specialists were more likely to administer tranexamic acid, insert ureteral stents, and arrange endo-arterial occlusion or embolization at cesarean hysterectomy for placenta accreta spectrum. Available prior data for surgeon type-specific practice were mainly practice surveys but not patient-level assessment [20,22].

Despite the inter-societal joint consensus between the American College of Obstetricians and Gynecologists and the Society of Maternal-Fetal Medicine, endorsed by the Society of Gynecologic Oncologists for the management of placenta accreta spectrum [7], the current patient-level study of real-world practice demonstrates wide practice variability that needs further evaluation. Rapid uptick in the administration of tranexamic acid at the study cohort-level may be possibly due to the influence of cesarean delivery data rather placenta accreta specific [37].

The most notable results of this study were that across the three surgeon's subspecialities surgical morbidities of immediate hysterectomy for placenta accreta spectrum following cesarean delivery were substantially high. Irrespective to surgeon's subspeciality, more than half of the patients had hemorrhage or received blood transfusion, and nearly one in four to five had urinary tract injury and one tenth had shock. These results echo global view of surgical outcomes of immediate hysterectomy performed for placenta accreta spectrum [3,17,19,24,25,38].

4.3. Strengths and limitations

Inclusion of large sample size, assessment of surgeons' subspecialty, evaluation of detailed surgical procedures, and corroboration of demographic difference to assess surgical morbidity strengthened the interpretation of the study findings.

There were several limitations in the study. First, information on surgeon's details including surgical experience and case-volume regarding cesarean hysterectomy for placenta accreta spectrum was not available in the database. A 2021 multicenter study led by the International Society for Placenta Accreta Spectrum suggested that inexperience in placenta accreta spectrum surgery was associated with large blood loss [38]. Second, measured surgical morbidities were not able to be segregated for the cesarean delivery part and the hysterectomy part, limiting the granularity to interpret the hysterectomy morbidity. Chronology between surgical morbidity and targeted surgical procedures was also not segregated.

Third, despite the inclusion of more than 2000 cases, sample size may not reflect the nationwide statistics of cesarean hysterectomy for placenta accreta spectrum. For example, the estimated annual number of cesarean hysterectomies performed for placenta accreta spectrum was nearly 1900 nationwide in the recent years in the United States [3]. Fourth, center-of-excellence criteria for placenta accreta spectrum was not available in the program but can possibly impact treatment approach and outcomes.

Fifth, preoperative diagnosis, exact surgical blood loss, and operative time were not available in the program but these were important outcome information in this type of study. Sixth, accuracy of data was not assessable due to lack of actual medical record review. Lastly, the program captures only one surgeon's subspecialty per surgical procedure, resulting in possible misclassification if there was a second subspeciality surgeon involved in the hysterectomy part (e.g., gynecologic oncologist participated during the surgery started with general obstetrician-gynecologist and consulted intraoperatively for surgical morbidity).

4.4. Conclusion

This study suggests that patient characteristics and surgical procedures related to cesarean hysterectomy for placenta accreta spectrum differ based on surgeon specialty. Regardless of surgeon's specialty, surgical morbidity of cesarean hysterectomy for placenta accreta spectrum is significant, suggesting the necessity of developing a strategic approach to improve surgical outcomes.

Several expert panels have called for action to fill a gap between decreasing surgical volumes and increasing cases of placenta accreta spectrum for graduating general obstetrician-gynecologists from training programs [39]. While decreasing surgical experience for complex pelvic surgery that can be vital for placental accreta spectrum surgery was noted in gynecologic oncology fellows in the United States [40], management of pregnant patients with suspected placenta accreta spectrum can be a possible future practice for gynecologic oncologists [16,41,42]. Going forward, this may be the opportunity to propose the core surgical training curriculum specific to placenta accreta spectrum across the three societies for general obstetrician-gynecologists, gynecologic oncologists, and maternal-fetal medicine specialists as the next direction.

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Ethical committee review

Columbia University Institutional Review Board (AAAN2900).

Data sharing statement

The data on which this study is based are Premier Healthcare Database (https://premierinc.com/about).

Transparency

The manuscript's corresponding authors (Koji Matsuo, Jason D. Wright) affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained. The Premier Healthcare Database is the source of the de-identified data used; race and ethnicity were grouped by the program; and the program has not verified and is not responsible for the statistical validity of the data analysis or the conclusions derived by the study team.

Meeting presentation

Society of Gynecologic Oncology's 2024 Annual Meeting on Women's Cancer, San Diego, CA, March 16–18, 2024.

Tweetable statement

In this U.S. cohort study, regardless of surgeon's subspecialty type, surgical morbidity of cesarean hysterectomy for placenta accreta spectrum was significant.

CRediT authorship contribution statement

Koji Matsuo: Writing – original draft, Visualization, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Yongmei Huang:** Writing – review & editing, Visualization, Software, Resources, Methodology, Investigation, Formal analysis, Data curation. **Shinya Matsuzaki:** Writing – review & editing, Supervision, Methodology, Investigation, Conceptualization. **Andrew Vallejo:** Writing – review & editing, Investigation. **Joseph G. Ouzounian:** Writing – review & editing, Supervision, Resources, Investigation. **Lynda D. Roman:** Writing – review & editing, Supervision, Investigation, Funding acquisition. **Fady Khoury-Collado:** Writing – review & editing, Supervision, Resources, Investigation. **Alexander M. Friedman:** Writing – review & editing, Supervision, Investigation. **Jason D. Wright:** Writing – review & editing, Supervision, Resources, Project administration, Methodology, Investigation, Formal analysis, Conceptualization.

Declaration of generative AI and AI-assisted technologies in the writing process

Not appliable.

Appendix A. Supplementary data

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References

[1] R.M. Silver, D.W. Branch, Placenta Accreta Spectrum, N. Engl. J. Med. 378 (16) (2018) 1529–1536.
[2] E. Jauniaux, S. Collins, G.J. Burton, Placenta accreta spectrum: pathophysiology and evidence-based anatomy for prenatal ultrasound imaging, Am. J. Obstet. Gynecol. 218 (1) (2018) 75–87.
[3] S. Matsuzaki, R.S. Mandelbaum, R.N. Sangara, et al., Trends, characteristics, and outcomes of placenta accreta spectrum: a national study in the United States, Am. J. Obstet. Gynecol. 225 (5) (2021) 534 e531–534 e538.
[4] J.C. Kingdom, S.R. Hobson, A. Murji, et al., Minimizing surgical blood loss at cesarean hysterectomy for placenta previa with evidence of placenta increta or placenta percreta: the state of play in 2020, Am. J. Obstet. Gynecol. 223 (3) (2020) 322–329.
[5] F. Khoury-Collado, J.M. Newton, O.R. Brook, et al., Surgical techniques for the Management of Placenta Accreta Spectrum, Am. J. Perinatol. 40 (9) (2023) 970–979.
[6] K. Matsuo, R.N. Sangara, S. Matsuzaki, et al., Placenta previa percreta with surrounding organ involvement: a proposal for management, Int. J. Gynecol. Cancer 33 (10) (2023) 1633–1644.
[7] American College of O, Gynecologists, Society for Maternal-Fetal M, Obstetric Care Consensus No. 7: Placenta Accreta Spectrum, Obstet. Gynecol. 132 (6) (2018) e259–e275.
[8] R.M. Silver, K.A. Fox, J.R. Barton, et al., Center of excellence for placenta accreta, Am. J. Obstet. Gynecol. 212 (5) (2015) 561–568.
[9] A.A. Shamshirsaz, K.A. Fox, B. Salmanian, et al., Maternal morbidity in patients with morbidly adherent placenta treated with and without a standardized multidisciplinary approach, Am. J. Obstet. Gynecol. 212(2):218 (2015) e211–e219.
[10] A.G. Eller, M.A. Bennett, M. Sharshiner, et al., Maternal morbidity in cases of placenta accreta managed by a multidisciplinary care team compared with standard obstetric care, Obstet. Gynecol. 117 (2 Pt 1) (2011) 331–337.
[11] R. Horgan, K. Hessami, Y. Hage Diab, et al., Prophylactic ureteral stent placement for the prevention of genitourinary tract injury during hysterectomy for placenta accreta spectrum: systematic review and meta-analysis, Am J Obstet Gynecol MFM. 5 (10) (2023), 101120.
[12] M.A. Scaglione, A.A. Allshouse, D.R. Canfield, et al., Prophylactic ureteral stent placement and urinary injury during hysterectomy for placenta Accreta Spectrum, Obstet. Gynecol. 140 (5) (2022) 806–811.
[13] M. Chen, X. Liu, Y. You, et al., Internal iliac artery balloon occlusion for placenta Previa and suspected placenta Accreta: a randomized controlled trial, Obstet. Gynecol. 135 (5) (2020) 1112–1119.
[14] A.J. Nieto-Calvache, J.M. Palacios-Jaraquemada, R.A. Aryananda, et al., How to identify patients who require aortic vascular control in placenta accreta spectrum disorders? Am J Obstet Gynecol MFM. 4 (1) (2022), 100498.
[15] J.L. Munoz, L.M. Blankenship, P.S. Ramsey, G.A. McCann, Implementation and outcomes of a uterine artery embolization and tranexamic acid protocol for placenta accreta spectrum, Am. J. Obstet. Gynecol. 229 (1) (2023) 61 e61–61 e67.
[16] O. Touhami, L. Allen, H. Flores Mendoza, M.A. Murphy, S.R. Hobson, Placenta accreta spectrum: a non-oncologic challenge for gynecologic oncologists, Int. J. Gynecol. Cancer (2022).
[17] J.L. Munoz, L.M. Blankenship, P.S. Ramsey, G.A. McCann, Importance of the gynecologic oncologist in management of cesarean hysterectomy for placenta Accreta Spectrum (PAS), Gynecol. Oncol. 166 (3) (2022) 460–464.
[18] V.M. Fratto, C.L. Conturie, J. Ballas, et al., Assessing the multidisciplinary team approaches to placenta accreta spectrum across five institutions within the University of California fetal consortium (UCfC), J. Matern. Fetal Neonatal Med. 34 (18) (2021) 2971–2976.
[19] D.J. Brennan, B. Schulze, N. Chetty, et al., Surgical management of abnormally invasive placenta: a retrospective cohort study demonstrating the benefits of a standardized operative approach, Acta Obstet. Gynecol. Scand. 94 (12) (2015) 1380–1386.
[20] K. Matsuo, N.L. Vestal, A.R. Rau, et al., Gynecologic oncologists in surgery for placenta accreta spectrum: a survey for practice, experience, and interest, Int. J. Gynecol. Cancer 32 (11) (2022) 1433–1442.
[21] O.M. Turan, A. Shannon, M.R. Asoglu, K.R. Goetzinger, A novel approach to reduce blood loss in patients with placenta accreta spectrum disorder, J. Matern. Fetal Neonatal Med. 34 (13) (2021) 2061–2070.
[22] T.F. Esakoff, S.J. Handler, J.M. Granados, A.B. Caughey, PAMUS: placenta accreta management across the United States, J. Matern. Fetal Neonatal Med. 25 (6) (2012) 761–765.
[23] Premier Healthcare Database: data that informs and performs, Premier, 2024 https://products.premierinc.com/downloads/PremierHealthcareDatabaseWhitepaper.pdf. (accessed 12/31/2023).
[24] L.C. Zuckerwise, A.M. Craig, J.M. Newton, S. Zhao, K.A. Bennett, M.A. Crispens, Outcomes following a clinical algorithm allowing for delayed hysterectomy in the management of severe placenta accreta spectrum, Am. J. Obstet. Gynecol. 222 (2) (2020) 179 e171–179 e179.
[25] L. Sentilhes, A. Seco, E. Azria, et al., Conservative management or cesarean hysterectomy for placenta accreta spectrum: the PACCRETA prospective study, Am. J. Obstet. Gynecol. 226 (6) (2022) 839 e831-839 e824.
[26] J.D. Wright, Y. Huang, A.H. Li, A. Melamed, D.L. Hershman, Nationwide estimates of annual inpatient and outpatient hysterectomies performed in the United States, Obstet. Gynecol. 139 (3) (2022) 446–448.
[27] ACGME Program requirements for graduate medical education in gynecologic oncology, Accreditation Council for Graduate Medical Education, 2024 https://www.acgme.org/globalassets/pfassets/programrequirements/225_gynecologiconcology_2023.pdf. (accessed 1/14/2024).
[28] ACGME Program requirements for graduate medical education in maternal-fetal medicine, Accreditation Council for Graduate Medical Education (ACGME), 2024. https://www.acgme.org/globalassets/pfassets/programrequirements/230_maternalfetalmedicine_2023.pdf. (accessed 1/14/2024).
[29] K. Matsuo, S. Matsuzaki, N.L. Vestal, et al., Utilizations and outcomes of intra-arterial balloon occlusion at cesarean hysterectomy for placenta accreta spectrum, Acta Obstet. Gynecol. Scand. 100 (12) (2021) 2234–2243.
[30] How Does CDC Identify Severe Maternal Morbidity?, Centers for Disease Control and Prevention, 2024. https://www.cdc.gov/reproductivehealth/maternalinfanthealth/smm/severe-morbidity-ICD.htm. (accesssed 12/22/2022).
[31] N.L. Vestal, R.N. Sangara, R.S. Mandelbaum, et al., Racial and ethnic disparity in characteristics and outcomes of women with placenta accreta spectrum: a comparative study, Reprod. Sci. 29 (7) (2022) 1988–2000.

[32] D.F. McCaffrey, B.A. Griffin, D. Almirall, M.E. Slaughter, R. Ramchand, L.F. Burgette, A tutorial on propensity score estimation for multiple treatments using generalized boosted models, Stat. Med. 32 (19) (2013) 3388–3414.
[33] J.A. Jolley, M.P. Nageotte, D.A. Wing, V.K. Shrivastava, Management of placenta accreta: a survey of maternal-fetal medicine practitioners, J. Matern. Fetal Neonatal Med. 25 (6) (2012) 756–760.
[34] The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE)Statement: guidelines for reporting observational studies. Enhancing the QUAlity and Transparency Of health Research, https://www.equator-network.org/reporting-guidelines/strobe/>; 2024. Accessed January 1, 2024.
[35] M. Kaur, J.M. Phillips, H.K. Ahmadzia, A survey evaluating practice pattern in management of obstetric hemorrhage, J Neonatal Perinatal Med. 16 (3) (2023) 539–545.
[36] K.A. Fox, A.A. Shamshirsaz, D. Carusi, et al., Conservative management of morbidly adherent placenta: expert review, Am. J. Obstet. Gynecol. 213 (6) (2015) 755–760.
[37] L. Sentilhes, M.V. Senat, M. Le Lous, et al., Tranexamic acid for the prevention of blood loss after cesarean delivery, N. Engl. J. Med. 384 (17) (2021) 1623–1634.
[38] A. Schwickert, H.J. van Beekhuizen, C. Bertholdt, et al., Association of peripartum management and high maternal blood loss at cesarean delivery for placenta accreta spectrum (PAS): a multinational database study, Acta Obstet. Gynecol. Scand. 100 (Suppl. 1) (2021) 29–40.
[39] C. Feltmate, S.R. Easter, J.B. Gilner, A.K. Karam, F. Khourry-Callado, K.A. Fox, Graduate and continuing medical education of placenta Accreta Spectrum, Am. J. Perinatol. 40 (9) (2023) 1002–1008.
[40] M.S. Hoffman, Y. Xiong, S. Apte, W. Roberts, R.M. Wenham, Twenty-year surgical trends in a gynecologic oncology fellowship training program: implications for practice, Gynecol. Oncol. 155 (2) (2019) 359–364.
[41] S.V. Blank, W.K. Huh, M. Bell, et al., Doubling down on the future of gynecologic oncology: the SGO future of the profession summit report, Gynecol. Oncol. 171 (2023) 76–82.
[42] M.S. Hoffman, D.S. Chi, D.L. Clarke-Pearson, W. Cliby, W. Creasman, P.B. Underwood Jr., Surgical training in gynecologic oncology: past, present, future, Gynecol. Oncol. 158 (1) (2020) 188–193.