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Original Research

Application of Ligation of Internal Iliac Artery and Uterine Artery in Pernicious Placenta Previa

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Abstract

Backgrounds: To investigate the use of vascular ligation in the treatment of pernicious placenta previa. **Methods**: Clinical data from 199 patients with pernicious placenta previa were collected and divided into groups according to placenta location, placenta accretion and vessel ligation, the pregnancy outcome of each group was compared. **Results**: The unplanned reoperation rate was lower for the internal iliac artery ligation group than the group without internal iliac artery ligation ($p < 0.05$). The intraoperative bleeding volume, blood transfusion volume, and intensive care unit (ICU) admission rate were lower for the prophylactic internal iliac artery ligation group than the therapeutic ligation group ($p < 0.05$), and in the hysterectomy patients, intraoperative bleeding was lower in the prophylactic internal iliac artery ligation group than the therapeutic ligation group ($p < 0.05$). The hysterectomy rate was lower for the uterine artery ligation group than the group without uterine artery ligation ($p < 0.05$); and for superficial and deep placental accreta, the operation time of uterine artery ligation group was shorter than internal iliac artery ligation group, intraoperative bleeding volume, blood transfusion volume, and ICU admission rate have no significant difference, when placental penetrating implantation was performed, patients with internal iliac artery ligation were statistically more severely ill, but there was no difference in prognosis. **Conclusions**: Vascular ligation is an effective means of managing high-risk obstetric bleeding and helps to avoid hysterectomy and unplanned reoperation, but surgeons need to choose the appropriate ligation method to improve patient prognosis, considering the patient's condition and his or her skills.

Keywords: pernicious placenta previa; placenta previa; uterine artery ligation; internal iliac artery ligation

1. Introduction

Pernicious placenta previa (PPP) refers to placenta previa in a pregnancy in which the placenta is attached to the scar from a previous uterine surgery, with the possibility of placental accreta and hemorrhage [1]. According to the study, the prevalence of pernicious placenta previa was 11.25% [2]. The incidence of pernicious placenta previa prenatal hemorrhage was 3.9%, postpartum hemorrhage 1.4%, placenta accretion 3.0%, and hysterectomy 5.3% [3]. With the adjustment of fertility policy and the increase in the cesarean section rate in China, the incidence of pernicious placenta previa has increased significantly [4]. PPP can lead to severe postpartum hemorrhage, which is currently one of the main causes of obstetric hysterectomy [5] and is also an important cause of maternal death [6]. With the opening of the three-child policy, an increasing number of women are becoming pregnant, and how to reduce perioperative bleeding and preserve a patient's uterus has become a major problem in obstetrics.

It has been shown that pelvic artery ligation is an effective surgical procedure for the management of obstetric hemorrhage [7], and pelvic artery ligation includes internal iliac artery ligation and uterine artery ligation. The anterior segment of the internal iliac artery is the main blood supply to the pelvic structures, and ligation of the anterior segment of the internal iliac artery is theoretically effective in controlling hemorrhage caused by pelvic organs. The uterine artery is the anterior branch of the internal iliac artery and provides 90% of the uterine blood supply. Ligation of the uterine artery can rapidly reduce uterine blood flow and control uterine bleeding. It has been shown that uterine artery ligation in patients with pernicious placenta previa can reduce intraoperative bleeding and hysterectomy rates and improve patient prognosis [8,9], but there are few studies on internal iliac artery ligation in these patients. The purpose of this study was to investigate the application of two vascular ligation methods in patients with pernicious placenta previa by retrospectively analyzing the clinical data of patients with pernicious placenta previa in our obstetrics department and to provide a reference for clinical diagnosis and treatment.

2. Materials and Methods

2.1 Clinical Data

Clinical data were collected for 256 patients with pernicious placenta previa admitted to the Department of Obstetrics and Gynecology of the Affiliated Hospital of Southwest Medical University from January 2015 to September 2022. Fifty-seven patients who did not meet the inclusion criteria were excluded, and the remaining 199 patients were included in the study for analysis. The inclusion criteria as follows: ① gestational week >28 weeks; ② singleton

pregnancy; ③ meeting the diagnostic criteria of pernicious placenta previa; ④ history of uterine surgery, including cesarean section and myomectomy; and ⑤ delivery in our hospital with complete and reliable clinical data. The exclusion criteria were as follows: ① gestational week less than 28 weeks; ② abnormal coagulation function before cesarean section; ③ delivery in another hospital with incomplete data; and ④ combined medical, surgical and malignant tumors. The study was approved by the ethics committee of affiliated hospital of Southwest Medical University, China.

2.2 Vascular Ligation

2.2.1 Uterine Artery Ligation

Preoperative assessment of the patients' condition was moderate, after delivery of the fetal placenta during the operation, there was a lot of uterine bleeding, especially in the middle and upper sections of the uterus, but the bleeding was assessed to be controllable, and bilateral uterine artery ligation was performed at the lower sections of the uterus or below the original uterine scar incision with 2-0 Vichio (AOH0028Y, COVIDIEN, Shanghai, China) line through the uterine muscle wall and broad ligament.

2.2.2 Internal Iliac Artery Ligation (Prophylactic Ligation)

According to the preoperative ultrasonography and magnetic resonance examination report of the patient, the patients' condition was dangerous, combined with the observation that the blood supply in the lower segment of the uterus was abundant or even open to the naked eye after opening the abdominal cavity during the operation, the patient was assessed to have the risk of massive bleeding. Immediately after the delivery of the fetus, the plasma drainage tube was temporarily lapped in the lower segment of the uterus to block the uterine blood supply, and then the uterus was pulled out of the incision, reach the bifurcation of the common iliac artery and the initial segment of the internal and external iliac arteries, open the posterior peritoneum about 4–5 cm above it, separate the ureter, open the sheath about 2–3 cm below the start of the internal iliac artery, and separate the internal iliac artery, use the gallbladder forceps to carefully separate the posterior wall of the internal iliac artery from the internal iliac vein. After the forceps tip has passed the internal iliac artery, the prepared 2 No. 7 silk threads were taken out and the interval was 0.5 cm for double ligation. Finally, the peritoneum was sutured with No. 4 silk thread to complete the ligation of the internal iliac artery. Therapeutic ligation was suitable for preoperative assessment of the patients' condition, with a low risk of bleeding. However, due to the turbulent uterine bleeding after delivery of the fetal placenta during the operation, bilateral internal iliac artery ligation was performed immediately same as prophylactic ligation.

2.2.3 Definition of Unplanned Reoperation

Patients with uncontrollable massive bleeding after cesarean section who need to be sent to the operating room again for laparotomy exploration and hemostasis or interventional therapy such as vascular embolization and vascular balloon occlusion are defined as unplanned reoperation.

2.2.4 Definition of Placental Accretion

Placental adhesion and placental accretion with an area less than 3 cm were defined as shallow placental accretion. The placental accreta area $\geq$3 cm was defined as deep placental accreta; penetrative placental accretion is defined when the placental villi penetrate the uterine wall to reach the serous layer of the uterus and even invade the adjacent organs of the uterus.

2.3 Observation Indicators

General information data: location of placental attachment, degree of placental accreta, and mode of vascular ligation; surgery-related indicators: patients' operation time, intraoperative bleeding, intraoperative blood transfusion, postoperative bleeding, postoperative blood transfusion, the number of hysterectomy patients, the number of intensive care unit (ICU) admissions, and the number of unplanned reoperations.

2.4 Statistical Methods

SPSS 26.0 software (SPSS; Chicago, IL, USA) was used for data analysis, with skewed continuous variables expressed as the median (range) and categorical variables expressed as several cases (percentage), using the Mann–Whitney U test. The Kruskal–Wallis H test was used for comparisons between multiple groups, and Kruskal–Wallis H one-way ANOVA (k samples) was used for multiple comparisons. Qualitative data are expressed as several cases (%) and the χ^2 test or Fisher exact probability method were used. Two comparisons were performed using the Bonferroni correction method. Differences were considered statistically significant at $p < 0.05$.

3. Results

Clinical data and different parameters are mentioned in Table 1.

Comparison of uterine artery ligation and internal iliac artery ligation with and without vascular ligation: the operation time of internal iliac artery ligation was longer than that of uterine artery ligation and no ligation; the bleeding was more than that of no ligation, and the difference was significant ($p < 0.05$). The internal iliac artery ligation group had a larger placental accreta area and higher bladder implantation rate than the uterine artery ligation and nonligation groups ($p < 0.05$), and the penetrating implantation rate was higher in the internal iliac artery ligation group than in the uterine artery ligation group ($p < 0.05$), while there was no difference compared with the nonligation group.

Table 1. Clinical general data.

	Placental position		Implantation status			Vascular ligation		Hysterectomy
Category	The placenta is mainly attached to the anterior wall and the incision	Mainly attached to the posterior and lateral walls	Shallow implant	Deep implantation	Penetrating implant	Simple uterine artery ligation	Internal iliac artery ligation alone	Hysterectomy
Number of cases (n)	92	107	55	39	35	60	56	32
Proportion (%)	46.2	53.8	42.7	30.2	27.1	30.1	28.1	16

Table 2. Comparison of vascular ligation and nonligation in pernicious placenta previa M (P_{25}–P_{75}) patients (%).

Category	Surgery time (min)	Intraoperative bleeding volume (mL)	Intraoperative blood transfusion volume (u)	Postoperative bleeding volume (mL)	Postoperative blood transfusion volume (u)	Implantation area (cm)	Hysterectomy	Penetrating implantation	Bladder implantation
Uterine artery ligation (I) n = 60	80.5 (61–81)	1000 (500–1700)	2 (0–3.5)	0 (0–0)	0 (0–2)	4 (3–5)	0 (0%)	5 (12.2%)	0 (0%)
Internal iliac artery ligation (II) n = 56	125 (95–140)	1200 (700–2000)	2 (0–4)	0 (0–20)	1.5 (0–2.7)	7 (5–9)	12 (21.4%)	17 (42.5%)	9 (25.7%)
Untied (III) n = 83	80 (65–105)	800 (500–1500)	1.5 (0–2)	0 (0–0)	0 (0–3)	2 (2–3)	20 (24.1%)	13 (27.1%)	1 (2.3%)
H/χ^2 value	43.968	6.413	5.097	5.100	3.947	70.180	16.636	9.405	12.908
p value	0.000	0.041	0.078	0.078	0.139	0.000	0.000	0.009	0.002
I *vs*. II	61.935 (0.000)	19.457 (0.204)				26.578 (0.003)	14.341 (0.000)	9.399 (0.002)	4.410 (0.045)
I *vs*. III	3.247 (1.000)	5.096 (1.000)				38.601 (0.000)	16.809 (0.000)	3.038 (0.081)	0.330 (1.000)
II *vs*. III	58.688 (0.000)	24.553 (0.040)				65.179 (0.000)	0.134 (0.714)	2.308 (0.129)	9.444 (0.004)

M, Medine.

Table 3. Comparison of the two types of vascular ligation in patients with pernicious placenta previa combined with placental accreta M (P_{25}–P_{75}).

Degree of implantation	Ligation method	Number of patients	Surgery time (min)	Intraoperative bleeding volume (mL)	Intraoperative blood transfusion volume (U)	Postoperative bleeding volume (mL)	Postoperative blood transfusion volume (u)
Shallow implantation	Simple uterine artery ligation	22 (53.7%)	75 (60–91.25)	600 (500–925)	0 (0–2.63)	0 (0–0)	0 (0–0)
	Internal iliac artery ligation alone	14 (35%)	96.5 (80–120)	750 (575–925)	0 (0–2)	0 (0–5)	0 (0–1.63)
	z/χ^2 value	2.855	2.871	0.705	0.359	1.517	1.651
	p value	0.091	0.004	0.490	0.761	0.413	0.296
Deep implantation	Simple uterine artery ligation	14 (34.1%)	107.5 (87.3–125)	1800 (1600–2500)	4 (3–4.5)	0 (0–0)	2 (0–3.25)
	Internal iliac artery ligation alone	9 (22.5%)	135 (112.5–140)	2000 (1850–2250)	3.5 (2.5–4)	0 (0–35)	2 (0–4)
	z/χ^2 value	0.868	1.893	0.446	1.221	0.873	0.131
	p value	0.352	0.062	0.688	0.250	0.557	0.926
Penetrating implantation	Simple uterine artery ligation	5 (12.2%)	95 (75–125)	2000 (1500–2750)	3 (1.75–4)	0 (0–1400)	2 (0–5.25)
	Internal iliac artery ligation alone	17 (42.5%)	140 (120–178.5)	2000 (1050–2750)	4 (2.5–8)	0 (0–50)	2 (0.25–4)
	z/χ^2 value	9.399	2.359	0.079	1.425	0.957	0.24
	p value	0.002	0.015	0.940	0.164	0.053	0.820

M, Medine.

Table 4. Comparison of therapeutic versus prophylactic internal iliac artery ligation in pernicious placenta previa M (P_{25}–P_{75}) patients (%).

Category	Number of patients	Surgery time (min)	Intraoperative bleeding volume (mL)	Intraoperative blood transfusion volume (u)	Postoperative bleeding volume (mL)	Postoperative blood transfusion volume (u)	Hysterectomy rate	ICU admission
Therapeutic	29	130 (95–145)	2000 (1200–2100)	3 (1.75–4)	0 (0–87.5)	2 (1.5–4)	7 (25%)	7 (46.7%)
Preventive	27	120 (95–135)	700 (500–1100)	1.5 (0–3)	0 (0–0)	0 (0–1.5)	5 (17.9%)	2 (10%)
z/χ^2 value		1.389	4.232	2.086	1.653	3.898	1.355	6.033
p value		0.165	0.000	0.037	0.098	0.000	0.244	0.022

ICU, Intensive Care Unit; M, Medine.

Table 5. Comparison between therapeutic and prophylactic internal iliac artery ligation in patients undergoing hysterectomy M (P_{25}–P_{75}).

Category	Number of patients	Surgery time (min)	Intraoperative bleeding volume (mL)	Intraoperative blood transfusion volume (u)	Postoperative bleeding volume (mL)	Postoperative blood transfusion volume (u)
Therapeutic	7	192 (120–215)	3000 (2500–4000)	6 (2–11)	0 (0–0)	3 (2–4.5)
Preventive	5	140 (107.5–156.5)	2000 (950–2000)	4 (4–7)	0 (0–150)	4 (0.25–7.75)
z/χ^2 value		1.218	2.888	0.082	1.748	0.164
p value		0.268	0.003	0.934	0.268	0.876

M, Medine.

The rate of hysterectomy was lower for the uterine artery ligation group than for the internal iliac artery ligation and nonligation groups ($p < 0.05$), while the area of placental accreta was wider for the uterine artery ligation group than for the nonligation group ($p < 0.05$) (see Table 2) .There was no unplanned reoperation after internal iliac artery ligation in 1 patient, whereas in 10 patients (7%), unplanned reoperation was performed in those who did not undergo internal iliac artery ligation, including 4 patients who underwent uterine artery ligation and 6 patients who did not undergo ligation, with statistically significant differences ($p < 0.05$). One patient underwent subtotal hysterectomy, 1 underwent dissection + pelvic gauze tamponade, and intermuscular vein thrombosis occurred in 2 of 8 patients after interventional therapy.

Comparison of uterine artery ligation and internal iliac artery ligation in patients with pernicious placenta previa combined with placental accreta: in patients with pernicious placenta previa combined with superficial implantation, the operative time of uterine artery ligation was less than that of internal iliac artery ligation, and the difference was statistically significant ($p < 0.05$). The differences in intraoperative and postoperative bleeding and blood transfusion were not statistically significant ($p > 0.05$). In patients with pernicious placenta previa combined with deep placental accreta, the differences in the operative time and intraoperative bleeding volume between the two vascular ligation methods were not statistically significant ($p > 0.05$). In patients with pernicious placenta previa combined with penetrating implantation, the operative time for internal iliac artery ligation was longer than that for uterine artery ligation, and the difference was statistically significant ($p < 0.05$). However, there were more ligation cases of internal iliac artery than uterine artery in patients with penetrating implantation with a significant difference ($p < 0.05$) (see Table 3).

Comparison of different internal iliac artery ligations in pernicious placenta previa patients: the intraoperative bleeding and transfusion volumes and postoperative transfusion volume were less in the prophylactic internal iliac artery ligation group than in the therapeutic ligation group; the ICU admission rate was lower in the prophylactic internal iliac artery ligation group than in the therapeutic ligation group, and the difference was statistically significant ($p < 0.05$) (Table 4). There was no difference in the comparison of the hysterectomy rate between the prophylactic and therapeutic internal iliac artery ligation groups ($p > 0.05$), but the prophylactic iliac internal artery ligation group had less intraoperative bleeding than the therapeutic ligation group, and the difference was statistically significant ($p < 0.05$) (Table 5).

4. Discussion

4.1 Vascular Ligation in Pernicious Placenta Previa

To prevent severe postpartum hemorrhage in patients with pernicious placenta previa, in addition to cervical lift-off sutures, uterine tamponades, uterine sutures, vascular ligation and balloon blocks, or even hysterectomy, have been used to manage refractory postpartum hemorrhage [10,11]. Prophylactic balloon blocks have been reported to be effective in controlling postpartum hemorrhage but do not reduce the incidence of hysterectomy in patients with pernicious placenta previa with implantation [12]. Some studies have reported that prophylactic balloon blocks have no significant effect on intraoperative bleeding or the hysterectomy rate in placenta previa patients with implantation and significantly increase the financial burden on patients [13]. The efficacy of balloon blocks has not been unanimously accepted, and there are complications such as coagulation dysfunction [14], fever, lower abdominal pain, thrombosis [10], and lumbosacral pain [15]. In contrast, some studies have shown that arterial ligation can circumvent the complications associated with cannulation and balloon placement while achieving the same efficacy [16,17]. A randomized controlled study concluded that uterine artery ligation reduced intraoperative bleeding and transfusion volumes during cesarean delivery [18]. It has also been suggested that uterine artery ligation is effective in reducing the rate of hysterectomy for placenta previa patients [19,20]. Additionally, Camuzcuoglu *et al*. [21] concluded that internal iliac artery ligation is a safe and effective method for the treatment of severe postpartum hemorrhage.

The statistical results of this study showed that the operative time for the intraoperative internal iliac artery ligation group was longer than that of the uterine artery ligation and nonligation groups, and these patients had more

bleeding than nonligation patients; however, the patients in the internal iliac artery ligation group had extensive placenta implantation and more patients had bladder implantation, and there was a significant difference ($p < 0.05$). This difference may be due to the poor condition of patients in the internal iliac artery ligation group, who underwent intraoperative uterine resection and bladder repair, thus leading to a longer operation time and more bleeding and may also be related to the technical level of the surgeon. Some studies have shown that the bleeding and blood transfusion volumes in patients is directly proportional to the operative time of internal iliac artery ligation [22]. Therefore, in clinical work, surgeons should refine their operational skills for internal iliac artery ligation to minimize the operative time and improve patient prognosis. The results of this study also showed that the 60 patients who underwent uterine artery ligation had a wider placental accreta surface than those who did not undergo vascular ligation ($p < 0.05$), but none of them underwent intraoperative hysterectomy; there were 4 cases of unplanned reoperation after surgery, including 1 case of open hysterectomy. In the 83 patients who did not undergo vascular ligation, there were 20 who underwent hysterectomy and 6 who underwent unplanned reoperation; none of the 56 patients who underwent internal iliac artery ligation had unplanned reoperation. Because vascular embolization is expensive, it is difficult to perform in primary hospitals, and there is a risk of complications such as thrombosis. Therefore, for pernicious placenta previa, intraoperative vascular ligation is chosen to reduce bleeding and hysterectomy rates, which can prevent unplanned reoperation, but the surgical skills of surgeons need to be improved.

4.2 Selection of Different Vascular Ligatures during Surgery for Pernicious Placenta Previa

A stratified analysis of the degree of placental accreta showed that in superficial placental accreta patients, internal iliac artery ligation had no advantage over uterine artery ligation except for a longer operative time; in deep placental accreta patients, there was no significant difference between internal iliac artery ligation and uterine artery ligation in terms of operative time, intraoperative bleeding or blood transfusion volume ($p > 0.05$); in penetrating placental accreta patients, although there was no difference between the two types of artery ligation in terms of bleeding or transfusion volumes ($p > 0.05$), the number of patients who underwent internal iliac artery ligation was much greater than that who underwent uterine artery ligation ($p < 0.05$). Thus, we conclude that in the absence of penetrating implantation, uterine artery ligation can be preferred in cases of pernicious placenta previa, which requires little surgical technique and a short operative time, whereas in the presence of penetrating implantation or even bladder implantation, internal iliac artery ligation should be preferred.

The statistical results of this study also showed that prophylactic internal iliac artery ligation was associated with lower intraoperative bleeding, transfusion and postoperative transfusion volumes and lower ICU admission rates compared with therapeutic ligation, and prophylactic ligation was also associated with less intraoperative bleeding than therapeutic ligation in patients who underwent hysterectomy ($p < 0.05$). Less intraoperative bleeding may help to clear the surgical field, avoid blind clamping of peripheral vessels, nerves, and connective tissues, and reduce complications. It has been suggested that performing uterine artery ligation before delivery of the placenta may reduce intraoperative bleeding and transfusion volumes in patients with pernicious placenta previa [23]. Sanad *et al*. [24] concluded that performing uterine artery ligation before delivery of the fetus in central placenta previa patients may reduce intraoperative bleeding and transfusion volumes. However, in the case of pernicious placenta previa, when the bladder is adherent to the lower segment of the uterus, the surface vessels of the uterus and bladder are irritated, and performing uterine artery ligation without pushing the bladder open is likely to damage the ureter and bladder, making the procedure is risky. Therefore, performing prophylactic internal iliac artery ligation or uterine artery ligation before delivery of the placenta is worth considering when a pernicious placenta previa patient is evaluated for risk of hemorrhage and hysterectomy, especially when penetrating placenta implantation, bladder implantation, and extensive implantation are involved.

It is worth noting that a recent study reported that [25] placental accreta is a risk factor for amniotic fluid embolism (AFE), and when stratified by placental accreta spectrum subtypes, more severe forms of placental accreta spectrum had a greater association with AFE. AFE is a rare complication of childbirth, its clinical characteristics are sudden onset, dangerous and unpredictable, which can lead to severe adverse outcomes such as disability and death of maternal and fetal. The incidence of AFE is very low, with clinical reports of (1.7–7.7) per 100,000, but the mortality rate is as high as 19–86% [26–28]. The study found that failure to rescue after AFE exceeded 30% when AFE occurred in the setting of placental pathology: 42.9% for AFE and placenta accreta spectrum (PAS) [25]. Although none of the 199 patients in this study developed AFE, AFE may be a complication of placenta previa, placenta accreta, postpartum hemorrhage and so on. Once it occurs, it will cause great harm. Therefore, in clinical work, we should pay special attention to and prevent AFE in advance, because appropriate prevention and treatment can avoid the tragedy of maternal death.

5. Conclusions

In conclusion, vascular ligation is an effective means of managing high-risk obstetric hemorrhage, helping to avoid hysterectomy and unplanned reoperation and improving patient prognosis, although, of course, the surgeon needs to choose a suitable hemostatic modality according to

the patients' condition and his or her skills. This study was a retrospective analysis, and the choice of intraoperative hemostatic modality is biased. Prospective studies on the choice and timing of vascular ligation are needed to identify better treatment options for pernicious placenta previa patients.

Availability of Data and Materials

The datasets that support the findings of this study are available from the corresponding author upon reasonable written request.

Author Contributions

XDF, LJB designed the research study. LJB, JL, QNS collected data. JL, QNS analyzed the data. LJB drafted the manuscript. XDF, LJB revised it. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work to take public responsibility for appropriate portions of the content and agreed to be accountable for all aspects of the work in ensuring that questions related to its accuracy or integrity.

Ethics Approval and Consent to Participate

This study has been approved by the Clinical Trial Ethics Committee, Affiliated Hospital of Southwest Medical University, and the ethical approval number is KY2022237. This study was approved by the Ethical Committee of our hospital. Written informed consent was signed from all participants. The study was carried out under senior surgeons following standard techniques and regulations.

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Conflict of Interest

The authors declare no conflict of interest.

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