



The Analysis Study of High-intensity Focused Ultrasound in Management of Placenta Accreta Spectrum: A Comprehensive Systematic Review

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ABSTRACT

Background: Placenta Accreta Spectrum (PAS) refers to a group of abnormal placental invasion disorders involving the uterine wall. High-Intensity Focused Ultrasound (HIFU) has emerged as a promising non-invasive treatment modality for PAS. This systematic review aims to evaluate the clinical outcomes associated with HIFU in the management of PAS. **Methods:** The study followed PRISMA 2020 guidelines, reviewing English-language publications from 2014 to 2024. Editorials, duplicate reviews from the same journal, and papers lacking a DOI were excluded. The literature search was conducted using PubMed, SagePub, SpringerLink, and Google Scholar. **Result:** A total of 2,172 articles were initially identified through online databases (PubMed, SagePub, SpringerLink, and Google Scholar). After three rounds of screening, eight relevant studies were selected for full-text analysis. **Conclusion:** HIFU offers a promising, non-invasive alternative for managing Placenta Accreta Spectrum (PAS), preserving fertility, minimizing complications, and ensuring positive outcomes. While further research is needed, it could become a standard treatment option in obstetrics and gynecology.

Keywords: ultrasound, HIFU, placenta accreta syndrome

INTRODUCTION

Placenta Accreta Spectrum (PAS) refers to a group of abnormal placental invasion disorders involving the uterine wall, categorized by the depth of invasion. These include placenta accreta, where the placenta attaches to the myometrium; placenta increta, where it invades the myometrium; and placenta percreta, where the invasion extends beyond the myometrium.^{1,2} PAS poses a significant obstetric emergency, often leading to severe complications such as emergency hysterectomy, massive transfusion, hemorrhagic shock, and even maternal death if not managed effectively.³⁻⁵

The incidence of PAS has risen significantly over the decades, reflecting changes in maternal demographics and obstetric practices. Key risk factors include prior cesarean deliveries, placenta previa, and advanced maternal age—all of which have become increasingly prevalent in modern populations. While PAS was once considered rare,

occurring in approximately 1 in 30,000 deliveries before 1950, its incidence has now increased to 3 in 1,000 deliveries in the current decade.⁶⁻⁸

The current standard management for PAS is cesarean hysterectomy, which allows for controlled intervention to minimize blood loss. However, this approach is associated with significant surgical risks, the loss of uterine function, and psychological consequences for patients. Efforts to explore uterus-preserving alternatives have led to the evaluation of procedures such as preoperative uterine artery embolization, open surgical devascularization, and hysteroscopic resection of residual placental tissue, sometimes supplemented with methotrexate or by leaving the placenta in situ. Despite these options these techniques often result in complications, including infection, bleeding, and the need for secondary hysterectomy.⁹⁻¹¹

High-Intensity Focused Ultrasound (HIFU) has emerged as a promising non-invasive treatment

modality for PAS. This technology uses ultrasound waves to generate thermal damage selectively in targeted tissues without affecting surrounding structures.^{12,13} Initially developed in the 1950s for treating benign and malignant tumors, HIFU has since been successfully applied in managing uterine fibroids, cesarean scar pregnancies, and adenomyosis. Recently, its potential to preserve the uterus while minimizing surgical morbidity and blood loss in PAS cases has garnered significant attention.¹⁴⁻¹⁶

Given the rising prevalence of PAS and the significant maternal morbidity associated with its management, exploring innovative and effective treatments is crucial. HIFU, with its non-invasive nature and potential to reduce complications, represents a pivotal step in advancing care for PAS.^{17,18} This systematic review aims to evaluate the clinical outcomes associated with HIFU in the management of PAS. This review seeks to provide insights into whether HIFU can serve as a viable alternative for women seeking uterus-preserving options for this high-risk condition.

METHODS

Protocol

The study strictly adhered to the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) 2020 guidelines to ensure methodological rigor and accuracy. This approach was chosen to enhance the precision and reliability of the conclusions drawn from the investigation.

Criteria for Eligibility

This systematic review aims to evaluate the clinical outcomes associated with HIFU in the management of PAS based on literature from the past decade. The review aimed to provide insights to improve patient treatment strategies, with an emphasis on the significance of key findings in the reviewed studies. Inclusion criteria for the study included: 1) Papers published in English, and 2) Papers published between 2014 and 2024. Exclusion criteria were: 1) Editorials, 2) Papers without a DOI, 3) Previously published review articles, and 4) Duplicate entries in journals..

Search Strategy

The keywords used for this research are ultrasound, hifu, placenta accreta syndrome. The Boolean MeSH keywords inputted on databases for this research are:

("diagnostic imaging"[MeSH Subheading] OR ("diagnostic"[All Fields] AND "imaging"[All Fields]) OR "diagnostic imaging"[All Fields] OR "ultrasound"[All Fields] OR "ultrasonography"[MeSH Terms] OR "ultrasonography"[All Fields] OR "ultrasonics"[MeSH Terms] OR "ultrasonics"[All Fields] OR "ultrasounds"[All Fields] OR "ultrasound s"[All Fields] OR ("high intensity focused ultrasound ablation"[MeSH Terms] OR ("high intensity"[All Fields] AND "focused"[All Fields] AND "ultrasound"[All Fields] AND "ablation"[All Fields]) OR "high intensity focused ultrasound ablation"[All Fields] OR "hifu"[All Fields])) AND (("placenta accreta"[MeSH Terms] OR ("placenta"[All Fields] AND "accreta"[All Fields]) OR "placenta accreta"[All Fields]) AND

("syndrom"[All Fields] OR "syndromal"[All Fields] OR "syndromally"[All Fields] OR "syndrome"[MeSH Terms] OR "syndrome"[All Fields] OR "syndromes"[All Fields] OR "syndrome s"[All Fields] OR "syndromic"[All Fields] OR "syndroms"[All Fields]))).

Data retrieval

Abstracts and titles were screened to assess their eligibility, and only studies meeting the inclusion criteria were selected for further analysis. Literature that fulfilled all predefined criteria and directly related to the topic was included. Studies that did not meet these criteria were excluded. Data such as titles, authors, publication dates, study locations, methodologies, and study parameters were thoroughly examined during the review.

Quality Assessment and Data Synthesis

Each author independently assessed the titles and abstracts of the selected studies to identify those for further exploration. Articles that met

the inclusion criteria underwent further evaluation. Final decisions on

inclusion were based on the findings from this review process.

Table 1. Article Search Strategy

Database	Keywords	Hits
Pubmed	("diagnostic imaging"[MeSH Subheading] OR ("diagnostic"[All Fields] AND "imaging"[All Fields]) OR "diagnostic imaging"[All Fields] OR "ultrasound"[All Fields] OR "ultrasonography"[MeSH Terms] OR "ultrasonography"[All Fields] OR "ultrasonics"[MeSH Terms] OR "ultrasonics"[All Fields] OR "ultrasounds"[All Fields] OR "ultrasound s"[All Fields] OR ("high intensity focused ultrasound ablation"[MeSH Terms] OR ("high intensity"[All Fields] AND "focused"[All Fields] AND "ultrasound"[All Fields] AND "ablation"[All Fields]) OR "high intensity focused ultrasound ablation"[All Fields] OR "hifu"[All Fields])) AND (("placenta accreta"[MeSH Terms] OR ("placenta"[All Fields] AND "accreta"[All Fields]) OR "placenta accreta"[All Fields]) AND ("syndrom"[All Fields] OR "syndromal"[All Fields] OR "syndromally"[All Fields] OR "syndrome"[MeSH Terms] OR "syndrome"[All Fields] OR "syndromes"[All Fields] OR "syndrome s"[All Fields] OR "syndromic"[All Fields] OR "syndroms"[All Fields]))	466
Springer Link	((ultrasound) OR (hifu)) AND (placenta accreta syndrome)	402
Sagepub	((ultrasound) OR (hifu)) AND (placenta accreta syndrome)	500
Google Scholar	((ultrasound) OR (hifu)) AND (placenta accreta syndrome)	804

Table 2. JBI *Critical appraisal of Study*

Parameters	Yuan (2023)	Lin (2021)	Jiang (2020)	Guan (2022)	He (2021)	Caloone (2019)	Xu (2024)	Shazly (2021)
1. Bias related to temporal precedence								
Is it clear in the study what is the “cause” and what is the “effect” (ie, there is no confusion about which variable comes first)?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2. Bias related to selection and allocation								
Was there a control group?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3. Bias related to confounding factors								
Were participants included in any comparisons similar?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
4. Bias related to administration of intervention/exposure								
Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	No.	No.	No.	No.	No.	No.	No.	No.
5. Bias related to assessment, detection, and measurement of the outcome								
Were there multiple measurements of the outcome, both pre and post the intervention/exposure?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Were the outcomes of participants included in any comparisons measured in the same way?	No.	No.	No.	No.	No.	No.	No.	No.
Were outcomes measured in a reliable way?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
6. Bias related to participant retention								
Was follow-up complete and, if not, were differences between groups in terms of their follow-up adequately described and analyzed?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
7. Statistical conclusion validity								
Was appropriate statistical analysis used?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

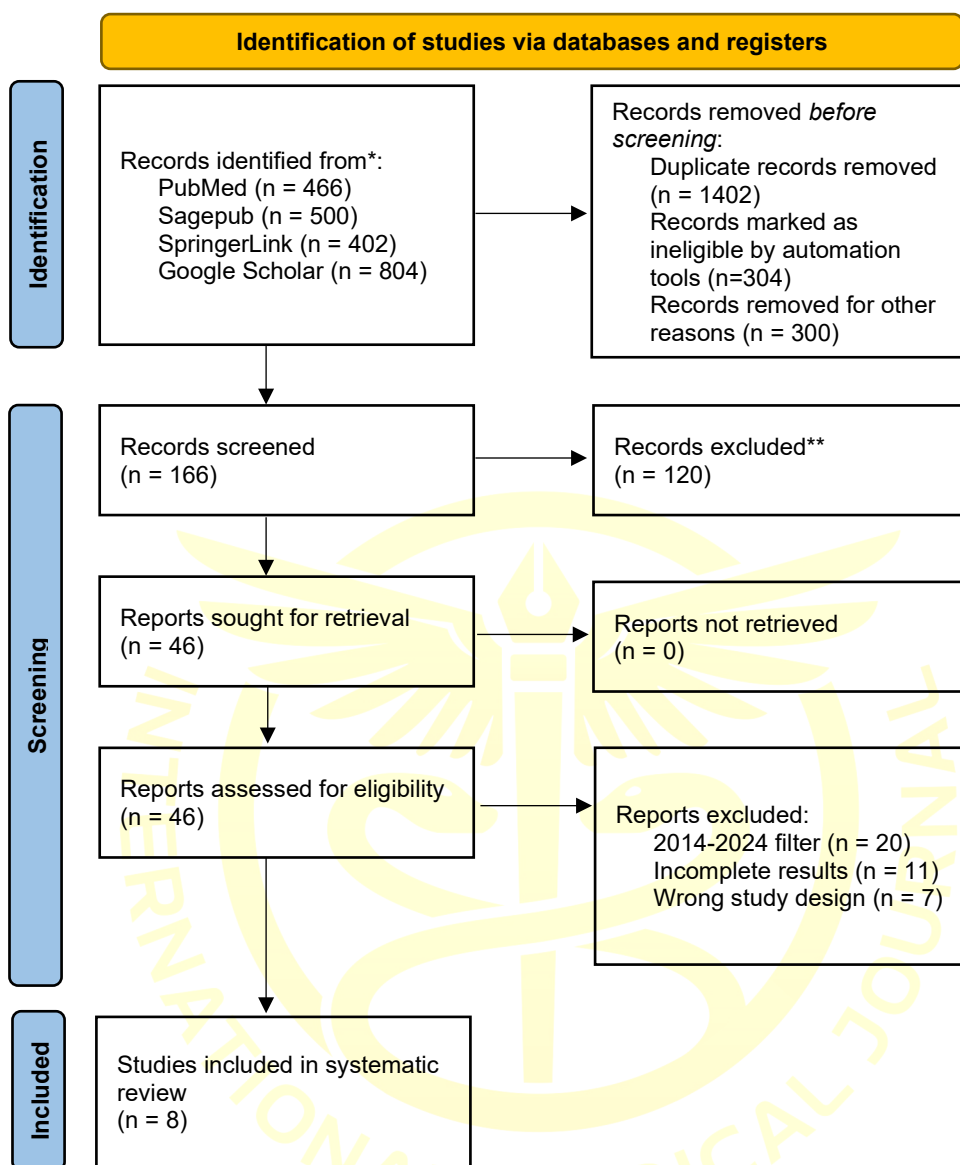


Figure 1. Article search flowchart

RESULT

The initial number of articles retrieved from online databases (PubMed, SagePub, SpringerLink, and Google Scholar) is 2,172 articles. After conducting three levels of screening, eight articles that directly relate to the current systematic review have been chosen for further assessment through full-text reading and analysis. Table 3 presents the selected literature included in this analysis.

Table 3. The literature included in this study

No.	Author	Origin	Method	Sample	Result
1.	Yuan, et al. ¹⁹ (2023)	China	Retrospective cohort	40 patients	High-Intensity Focused Ultrasound (HIFU) showed effectiveness in managing Placenta Accreta Spectrum (PAS) among 40 patients with a median follow-up of 30.5 months. The mean placental tissue elimination time was 45.29 days, and bloody lochia lasted 13.43 days on average, influenced by pre-HIFU residual placenta volume ($R^2 = 0.284$, $P < 0.001$). Menstruation resumed after 58.71 days, with no severe bleeding reported. Complications included one infection (2.5%) and two cases (5.0%) requiring suction curettage for persistent discharge. Of 18 patients with reproductive plans, 7 conceived within 4–53 months, while 11 used contraception. Further research is needed to optimize recovery and reduce complications.
2.	Lin, et al. ²⁰ (2021)	China	Retrospective cohort	34 patients	Baseline characteristics and HIFU ablation

					outcomes were comparable between patients with placenta accreta and placenta increta. While HCG normalization took longer in placenta accreta cases, no significant differences were observed in intraoperative blood loss, time to normal menstruation, or hospital stay duration.
3.	Jiang, et al. ²¹ (2020)	China	Retrospective cohort	94 patients	Among 63 patients treated with HIFU and 31 with UAE, both followed by hysteroscopic resection, baseline characteristics were similar between groups, including age, gravidity, parity, and prior obstetric history. Vaginal bleeding was the primary complaint. Both groups showed comparable outcomes in the number of hysteroscopy sessions, intraoperative blood loss, and hospital stay duration, with no cases requiring hysterectomy.
4.	Guan, et al. ²² (2022)	China	Retrospective cohort	95 patients	All 95 patients were successfully treated with single-session HIFU (sHIFU) or curettage in the control group, with no cases of vaginal hemorrhage. The duration of bloody lochia was similar between groups (25.9 ± 8.6 days for sHIFU vs. 24.2 ± 8.8 days, $P > 0.05$), and serum HCG levels normalized within 30 days in both groups

					without significant differences. Decreased menstrual volume was significantly less common in the sHIFU group (23.08%) compared to the control group (85.71%, $P < 0.001$). Over 2–8 years of follow-up, six pregnancies occurred in the sHIFU group without recurrence of placenta increta, while three pregnancies occurred in the control group, with one recurrence.
5.	He, et al. ²³ (2021)	China	Retrospective cohort	63 patients	The largest diameter of retained placenta accreta was comparable between groups (67.6 ± 14.0 mm vs. 71.6 ± 23.6 mm, $p = .47$). In the early group, hysteroscopic resection was performed 2.7 ± 1.4 days after HIFU, while in the late group, the interval was 34.7 ± 15.0 days ($p < .001$). The late group achieved a significantly higher rate of complete placental resection after one hysteroscopic procedure (73.9% vs. 45%, $p = .03$). Menstrual recovery and pregnancy outcomes were similar between the groups during follow-up.
6.	Caloone, et al. ²⁴ (2019)	France	Exvivo study	19 lesions	A total of 19 single HIFU lesions were created with uniform exposure parameters (75 s exposure time, 90 W acoustic power) at varying distances (2, 6, 7, and 8

					mm) from the uterine serosa. The lesions were homogeneous, spherical in shape, with average diameters of 14.6 ± 2.1 mm and 14.1 ± 2.3 mm. These lesions appeared as hyperechoic regions on sonograms immediately after HIFU exposure. A strong correlation ($r=0.89$, $p<0.05$) was found between the distance of the HIFU lesion from the placenta surface measured by ultrasound and gross pathology.
7.	Xu, et al. ²⁵ (2024)	China	Prospective cohort	17 patients	All patients presented with irregular vaginal bleeding following pregnancy termination and were unresponsive to medical treatment. They were diagnosed with uterine arteriovenous fistula (UAVF) and concurrent intrauterine residue using three-dimensional color Doppler ultrasonography, uterine angiography, or pelvic-enhanced MRI. HIFU was used under real-time ultrasound guidance to ablate the arteriovenous malformation. Following hysteroscopic removal of retained products of conception, pathological examination showed tissue consistent with pregnancy and abnormal blood vessels in some areas. Postoperative follow-up with monthly color

					Doppler ultrasound and menstrual status indicated normal recovery without signs of arteriovenous malformations or intrauterine adhesions.
8.	Shazly, et al. ²⁶ (2021)	Middle east	Retrospective cohort	727 women	Out of 797 women, 727 were eligible for the study. Of these, 592 (81.43%) were managed with uterus-preserving procedures, while 135 (18.56%) underwent cesarean hysterectomy. After adjusting for significant variables, the type of management was not associated with a higher risk of massive blood loss (aOR 1.71, 95% CI 0.78 - 3.81). Factors significantly linked to increased risk of massive blood loss included body mass index, preoperative hemoglobin, centrally located placenta, diffuse placental invasion, parametrial invasion, and intrauterine fetal death.

Yuan, et al.¹⁹ (2023) showed that single-session HIFU is effective in managing PAS.

Lin, et al.²⁰ (2021) showed that HIFU followed by hysteroscopic resection is a safe and effective treatment option for both placenta accreta and placenta increta.

Jiang, et al.²¹ (2020) showed that HIFU and UAE combined with

hysteroscopic resection are both safe and effective options for managing retained placenta accreta.

Guan, et al.²² (2022) found that simple HIFU is a safe and effective treatment for postpartum placenta increta, allowing the placenta to remain in situ. It offers a promising option for fertility

preservation and subsequent conception.

He, et al.²³ (2021) compared early versus late hysteroscopic resection after HIFU for retained placenta accreta, found that late resection improves the rate of complete placental removal with a single hysteroscopic procedure.

Caloone, et al.²⁴ (2019) suggests that HIFU could be a promising adjuvant treatment during cesarean sections for placenta accreta. However, these results need to be validated in clinical settings.

Xu, et al.²⁵ (2024) showed that combining HIFU ablation with postoperative hysteroscopic surgery is an effective treatment for pregnancy-related UAVF, offering minimal complications and preserving fertility. This approach provides an additional treatment option for patients desiring future fertility.

Shazly, et al.²⁶ (2021) found that when performed by experienced professionals, uterus-preserving procedures do not appear to carry a higher risk of massive blood loss compared to cesarean hysterectomy.

DISCUSSION

High-Intensity Focused Ultrasound (HIFU) is emerging as an effective, non-invasive treatment for managing Placenta Accreta Spectrum (PAS) disorders. Studies have shown that HIFU can help eliminate placental tissue and facilitate recovery without the need for more invasive surgical methods. Yuan et al. (2023) found that HIFU effectively treated PAS in 40 patients, with a mean placental tissue elimination time of 45.29 days, and menstruation resumed after an average of 58.71 days. These findings suggest that HIFU is an effective alternative for PAS management, offering a less invasive option for uterine preservation.¹⁹

HIFU has been shown to be effective in treating various forms of PAS, including placenta accreta and placenta increta. Lin et al. (2021) demonstrated that HIFU followed by hysteroscopic resection is a safe and effective treatment for both placenta accreta and increta. The study revealed no significant differences in intraoperative blood loss, time to

normal menstruation, or hospital stay duration between the two types of PAS, further supporting HIFU's versatility in treating these conditions. The results indicate that HIFU may offer comparable outcomes to other treatments, making it a viable option for PAS management.²⁰

HIFU's safety profile is encouraging, with minimal complications reported across multiple studies. Yuan et al. (2023) reported only one infection (2.5%) and two cases (5.0%) of persistent discharge requiring suction curettage, emphasizing that severe bleeding remains an uncommon complication. Guan et al. (2022) also supported HIFU's safety, with no reported cases of vaginal hemorrhage. These findings suggest that when performed by skilled practitioners, HIFU carries a relatively low risk of major complications, making it a safe option for patients with PAS.¹⁹

HIFU has demonstrated a promising ability to preserve fertility in patients with PAS. Yuan et al. (2023) found that among 18 patients desiring future pregnancies, 7 successfully conceived within 4–53

months following HIFU treatment.¹⁹ Similarly, Guan et al. (2022) observed that patients treated with HIFU for postpartum placenta increta maintained their fertility and had no recurrence of PAS. These results highlight the potential of HIFU as a fertility-preserving option for patients with PAS, offering hope for women who may otherwise face hysterectomy.²²

Timing of hysteroscopic resection after HIFU treatment plays a crucial role in the effectiveness of PAS management. He et al. (2021) found that performing hysteroscopic resection later after HIFU treatment resulted in a higher rate of complete placental removal with just one procedure. This suggests that a delayed approach may be more beneficial than an early resection, optimizing the chances for complete placental elimination and improving overall treatment outcomes.²³

HIFU's potential extends beyond PAS management to other pregnancy-related complications, such as uterine arteriovenous fistulas (UAVF). Xu et al. (2024) showed that HIFU combined with hysteroscopic

surgery effectively treated patients with UAVF and retained products of conception. The treatment resulted in normal recovery without recurrence of arteriovenous malformations or intrauterine adhesions, highlighting the broader utility of HIFU in treating complex obstetric conditions that threaten fertility.²⁵

Long-term follow-up is critical for evaluating the sustained benefits of HIFU in PAS management. Guan et al. (2022) conducted follow-up over 2–8 years and found that patients treated with HIFU experienced no recurrence of placenta increta and had favorable fertility outcomes. Six pregnancies occurred in the HIFU group, suggesting that HIFU not only provides immediate relief but also contributes to long-term reproductive health. This long-term data further reinforces the potential of HIFU in preserving fertility while managing PAS.²²

Additional research is needed to refine HIFU protocols and optimize patient outcomes. Yuan et al. (2023) called for further studies to enhance treatment efficacy, reduce

complications, and standardize recovery protocols. More randomized controlled trials comparing HIFU with other treatment modalities, such as uterine artery embolization (UAE) or hysterectomy, would provide stronger evidence for its superiority or equivalence. Investigating the long-term fertility outcomes of HIFU-treated patients is also crucial for assessing the sustainability of fertility preservation.^{19,24}

HIFU represents a significant advancement in the treatment of PAS, offering a non-invasive option for managing this challenging condition. The evidence suggests that HIFU is effective in treating PAS while minimizing complications and preserving fertility. However, further research is needed to optimize the procedure and ensure the best possible outcomes for patients. As studies continue to explore its efficacy, HIFU may become a cornerstone of PAS management, particularly for those seeking to preserve their reproductive health while avoiding the risks of more invasive treatments.²⁷

CONCLUSION

HIFU offers a promising, non-invasive alternative for managing Placenta Accreta Spectrum (PAS), preserving fertility, minimizing complications, and ensuring positive outcomes. While further research is needed, it could become a standard treatment option in obstetrics and gynecology.

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