

## RESEARCH ARTICLE OPEN ACCESS

# Intended Conservative Management Versus Caesarean Hysterectomy for Known or Suspected Placenta Accreta Spectrum: A Cost-Effectiveness Analysis

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## ABSTRACT

**Objective:** We examined the cost-effectiveness of conservative management (CM) compared to planned caesarean hysterectomy (CH) for placenta accreta spectrum (PAS).

**Design:** A cost-effectiveness analysis in a theoretical cohort of patients.

**Setting:** A decision analytic model.

**Population:** A theoretical cohort of 1000 pregnant patients with PAS greater than 20 weeks gestation.

**Methods:** In base case analysis, we assumed that between 20% and 40% of individuals would be eligible for CM. Model inputs were derived from the literature. Analysis was conducted from a healthcare system perspective with a 1 year analytic horizon. Outcomes included hysterectomy, surgical site infection (SSI), length of hospitalisation, intensive care unit (ICU) admission and death. An incremental cost-effectiveness ratio (ICER) of \$50 000 per quality-adjusted life year (QALY) defined cost-effectiveness. Sensitivity analyses were performed.

**Main Outcome Measures:** The cost gained per life year and per QALY.

**Results:** For base case estimates, CM was the cost-saving strategy with an ICER of \$9330.51 USD. Compared to CH, CM resulted in 905 fewer hysterectomies, 80 fewer instances of SSI and five fewer deaths. CM resulted in 149 more admissions with length of stay > 5 days and 25 more ICU admissions. In probabilistic sensitivity analysis, CM was the cost-effective strategy in 71% of runs and the dominant strategy in 42% of runs.

**Conclusions:** CM was the cost-effective strategy for the management of PAS in greater than 70% of iterations of our model. Modelling demonstrated significant uncertainty in the comparative effectiveness of the two strategies, highlighting the need for prospective research evaluating the effectiveness of CM.

## 1 | Introduction

Placenta accreta spectrum (PAS) is a major contributor to maternal morbidity and mortality worldwide [1, 2]. The optimal

management of PAS is unknown given a relative dearth of data to guide management [1–4]. The American College of Obstetricians and Gynaecologists suggests that the most widely accepted management strategy is planned caesarean

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hysterectomy (CH), wherein the placenta remains in situ after the delivery and is removed en bloc with the uterus with or without interval hysterectomy [1]. However, this approach is associated with risks of postpartum haemorrhage, urinary tract injury, potential need for reoperation, maternal death and infertility [5–8].

Given the known morbidity of this surgery, additional strategies for the management of PAS have been proposed. Conservative management (CM) has been explored as a viable alternative management option, and for the purpose of this project, intentional retention of the placenta without planned hysterectomy is specifically referred. Initial studies demonstrated lower frequencies of significant haemorrhage compared with CH [9–11]. Further, the prospect of future fertility is retained with CM, albeit with a high risk of recurrent PAS [8, 9]. Further, a major risk to proceeding with CM is that there is no definitive guarantee of the ability to avoid emergent intraoperative hysterectomy/conversion from the CM strategy. Thus, the complications of placenta accreta, including haemorrhage and the need for hysterectomy, may still arise at a delayed interval from the time of delivery [9, 10].

We sought to explore the potential cost and effectiveness of employing a strategy of performing conservative management without intended interval hysterectomy, presuming that the benefits of CM could be reproduced on a broader scale. We performed a decision analysis to evaluate whether planned CH or CM was the cost-effective strategy for the management of PAS.

## 2 | Methods

A decision-analytic model, constructed from a healthcare payer's perspective, was created using TreeAge Pro (Healthcare Version: 2023 Williamstown, MA) to simulate a theoretical cohort of 1000 pregnant women with known or suspected placenta accreta spectrum (PAS) greater than 20 weeks gestation. This sample size was chosen to reflect the annual frequency of PAS in the US at about 0.17% of all pregnancies [1]. Most probabilities were evaluated with a horizon of 1 year postpartum, with the exception being the probability of readmission and reoperation with a horizon of 14 days and length of stay as more or less than 5 days in our analysis. The Institutional Review Board at the University of Chicago deemed this study as exempt from review (IRB23-0514).

A schematic of a portion of the decision tree is displayed in Figure 1. Studies included in our analysis represent data from multidisciplinary care centers and often, specifically, placenta accreta Centers of Excellence. We assumed that 25% (range 1%–40%) of individuals entering the decision analysis would be eligible for CM. Eligibility for CM was defined as reaching the gestational age of delivery of 34 weeks gestation, without clinical complications necessitating emergent delivery and without the evidence of percreta or contraindication to conservative management surgically. Placenta percreta was intentionally excluded from our analysis due to the literature suggesting worse maternal outcomes for pregnant people with placenta percreta undergoing CM [5, 9]. Using estimates derived from expert opinion in the field of PAS outcomes research (B.D.E. and A.P.),

we assumed that 50% of pregnant people in the CM arm would accept CM as a management strategy (range 25%–75%), and of those who accepted CM, 35% (20%–50% range) would meet their intended delivery date without experiencing the need for an emergent CH. Among those who met their planned delivery date, we assumed that 78% would not experience haemodynamic instability during their surgery, which would require the need to abandon CM and convert to CH (Table 1).

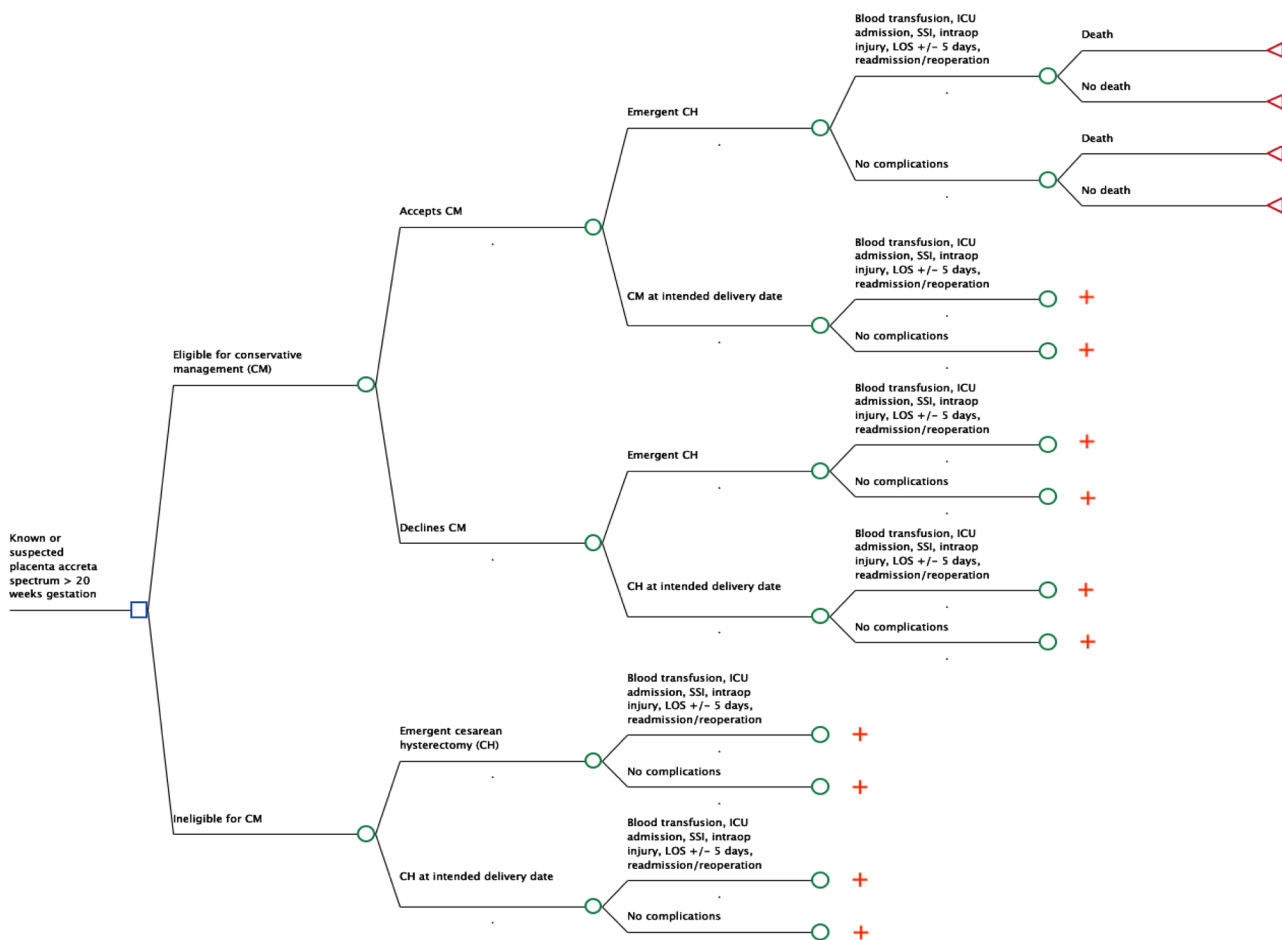
Maternal outcomes measured in the model included the following: Blood products transfused, intraoperative injury, surgical site infection, readmission or reoperation, intensive care unit (ICU) admission, length of stay less than or greater than 5 days and maternal death. These baseline probability model inputs were derived from the literature as cited below (Table 1).

Costs in the model were derived from the literature as well as the Healthcare Cost and Utilisation Project (HCUP) and were converted to 2023 United States dollars. The costs for hospital length of stay were derived from daily admission costs for individuals in the ICU, labor and delivery or medical/surgical units. Costs of intraoperative injury were derived from the literature from general surgery, urology and gynaecologic oncology. Costs of blood transfusion were considered per unit of blood products transfused. Cost of ICU admission was derived from critical care literature and generalised for the interventions that may be required in the ICU, including intubation and cardiopulmonary support.

Utilities were considered from the maternal perspective because we assumed that neonatal outcomes and utilities would not differ between strategies, and planned delivery timing would be the same. We chose to use quality-adjusted life year (QALY), a measure of improvement or decrements in overall health. All utilities were derived from the literature, or, if lacking, by consensus of the authors.

We assumed that the willingness to pay (WTP) would be defined as an incremental cost-effectiveness ratio (ICER) of \$50 000 USD/QALY and performed an additional analysis at WTP of \$100 000 USD to strengthen the findings of our analysis [12]. We report strategies as both cost-effective, meaning the strategy does not exceed the WTP, and as dominant, meaning that the strategy is both cost-saving and more effective than the other strategy. Given the limited analytic horizon, we chose not to discount costs or utilities.

We performed one-way sensitivity analyses for all inputs to identify if any inputs were influencing the outcomes of the model. Further, we chose to perform prespecified two-way sensitivity analyses focused on the eligibility and acceptance of CM, as well as acceptance of CM and achieving successful CM. We performed a Monte Carlo probabilistic sensitivity analysis wherein all inputs to the model were varied simultaneously over 1000 runs. The purpose of a probabilistic sensitivity analysis is to model a real-world experience more closely. Beta distributions were used for probability and utility inputs, and gamma distribution was used for cost inputs. As an additional sensitivity analysis, we performed a threshold analysis by varying all inputs beyond their prespecified ranges to assess if the findings of the decision analysis changed.



**FIGURE 1** | Decision tree diagram comparing conservative management (CM) and caesarean hysterectomy (CH). + indicates branches of the tree hidden to facilitate display; these branches are similar to those displayed.

All portions of this decision analysis adhered to Consolidated Health Economic Evaluation Reporting Standards (Appendix S1) and good practices as elucidated by The Professional Society for Health Economics and Outcomes Research [13].

### 3 | Results

CM was the cost-saving and more effective strategy in base case analysis (Table 2), costing \$9330.51 less than CH and resulting in 0.02 more QALYs. Base case analysis evaluates the model based solely on the inputs seen in Table 1, and is a raw comparison of the data. In this analysis, CM resulted in 905 fewer hysterectomies, 80 fewer instances of surgical site infection and 5 fewer deaths (Table 3).

On one-way sensitivity analyses, model inputs most strongly influencing the outcomes of our model were the probability of length of stay greater than 5 days, utility of hysterectomy and the probability of ICU admission. On prespecified two-way sensitivity analyses focused on the eligibility and acceptance of CM, as well as the acceptance of CM and achieving successful CM, no changes in the cost-effective strategy were noted across the range of inputs for the variables (data not submitted for publication). This suggested that no one model input very strongly influenced the overall outcome of the model in terms of which strategy was cost-effective.

On threshold analysis, we found that CM remained the cost-effective strategy under the multiple extremes of conditions that drove the model results. The most extreme potential outcome is patient mortality, which is a rare but realistic outcome of PAS. Pushing the limits of our analysis to their extremes of the threshold for patient death after both CM and CH, we still found that CM would be the most effective strategy in reducing patient mortality. CH became the more clinically effective and cost-saving strategy at a threshold of 24% of patient deaths, which is much higher than that reported in the literature and clinical data, and an unacceptable mortality rate for any intervention. Given this extreme threshold of mortality which would suggest CH as the dominant strategy, our analysis suggests that CM remains dominant and effective for this measure of patient safety.

On probabilistic sensitivity analysis, we found that CM was the cost-effective strategy in 71% of runs and remained the cost-saving and more effective (dominant) strategy in 42% of runs (Figure 2). Reading the scatterplot counter-clockwise from the top right (Quadrant I to Quadrant IV, bottom right) shows the variability between the costs and effectiveness. Quadrant IV represents the strategy which has increased effectiveness while saving costs, being the most dominant strategy. Quadrant II shows increased costs with decreased effectiveness, representing the strategy of hysterectomy at the WTP of either \$50 000 or \$100 000. The dominant strategy of conservative management

**TABLE 1** | Model input parameters with upper and lower limits for sensitivity analyses.

Parameter	Point estimate	Low	High	References
<b>Costs (\$)</b>				
Blood products	981.705	839.88	1123.53	[26]
Conservative management	16 512.75	7138	21 442	[7–10, 15]
Death	4901.5	4047	20 113	[30]
Emergent hysterectomy	19 874.59	12 307.5	20 512.5	[30]
ICU admission	25 040.99	15 567	34 515.88	[27]
Intraoperative injury (GU or GI)	25 497.86	2290	43 146	[25, 31, 32]
Hospital length of stay < 5 days	6434.08	2573.632	10 294.53	[25, 31, 32]
Hospital length of stay > 5 days	24 449.51	12 868.16	36 030.85	[25, 31, 32]
Readmission or reoperation	10 393	5161	17 494	[6, 32]
Scheduled hysterectomy	19 874.59	12 307.5	20 512.5	[29, 30]
Surgical site infection	17 861.41	400	30 000	[29, 30]
<b>Probabilities</b>				
<b>Caesarean hysterectomy (CH)</b>				
Individuals needing blood products > 4 units pRBC after CH	0.4	0.3221	0.4805	[18–20, 28]
Death after CH	0.0096	0.001	0.02292	[18–20, 28]
ICU admission after CH	0.23	0.1683	0.294	[18–20, 28]
Intraoperative injury in CH	0.148	0.1035	0.192	[18–20, 28]
Hospital LOS > 5 days CH	0.5063	0.3962	0.6165	[18–20, 28]
Readmission or reoperation after CH	0.00966	0.01	0.02029	[18–20, 28]
Surgical site infection after CH	0.30379	0.2023	0.4052	[18–20, 28]
<b>Conservative management (CM)</b>				
Individuals accepting CM	0.5	0.25	0.75	Assumed
Individuals needing blood products after CM	0.1541	0.1096	0.1986	[7–11]
Death after CM	0.0039	0.001	0.01168	[7–11]
ICU admission after CM	0.2574	0.1911	0.3238	[7–11]
Intraoperative injury in CM	0.01976	0.002612	0.03691	[7–11, 25]
Hospital LOS > 5 days CM	0.6666	0.01	0.6666	[7–11, 32]
Readmission or reoperation after CM	0.2891	0.1916	0.3866	[7–11, 32]
Surgical site infection after CM	0.224	0.1723	0.2756	[7–11]
Intended CM being successful	0.784	0.72206	0.8467	Assumed
Meeting eligibility for CM	0.25	0.1	0.4	Assumed
CH prior to intended date/emergent CH	0.376	0.2852	0.467	[7–11]
Meeting intended CM date with stability	0.826	0.2	0.5	[7–11]
<b>Utilities</b>				
Caesarean section	0.788	0.8	0.996	[30]
Death	0.0	0	0	[30]
Hysterectomy	0.615	0.3	0.83	[30]
ICU admission	0.666	0.1	0.7	[30]
Readmission/reoperation	0.666	0.25	0.75	[30]
Surgical site infection	0.82	0.695	0.861	[30]

**TABLE 2** | Base case estimates evaluating the cost-effectiveness of CM versus CH.

Strategy	Cost per person, in 2023 USD	Effectiveness per person, in QALYs	Incremental cost-effectiveness
CM	\$54 575	0.64	—
CH	\$54 701	0.62	\$9330.51

Abbreviations: CH = caesarean hysterectomy; CM = conservative management; QALY = quality-adjusted life year.

**TABLE 3** | Outcomes by management strategy in a theoretical cohort of 1000 patients.

Probabilities of outcomes			
Probability	Conservative management (n = 1000)	Caesarean hysterectomy (n = 1000)	Net in favour of CM
Hysterectomy	95.604	1000	-905
Blood products	153.63	400.529	-247
ICU admission	258.551	230.518	+28
Surgical site infection	224.349	306.262	-82
Readmission/reoperation	289.72	9.575	+280
Death	4.05	9.19	-5

remained regardless of the WTP threshold. When varying the WTP threshold, we noted that CM continued to be the cost-effective strategy in up to 75% of runs (Appendix S2).

## 4 | Discussion

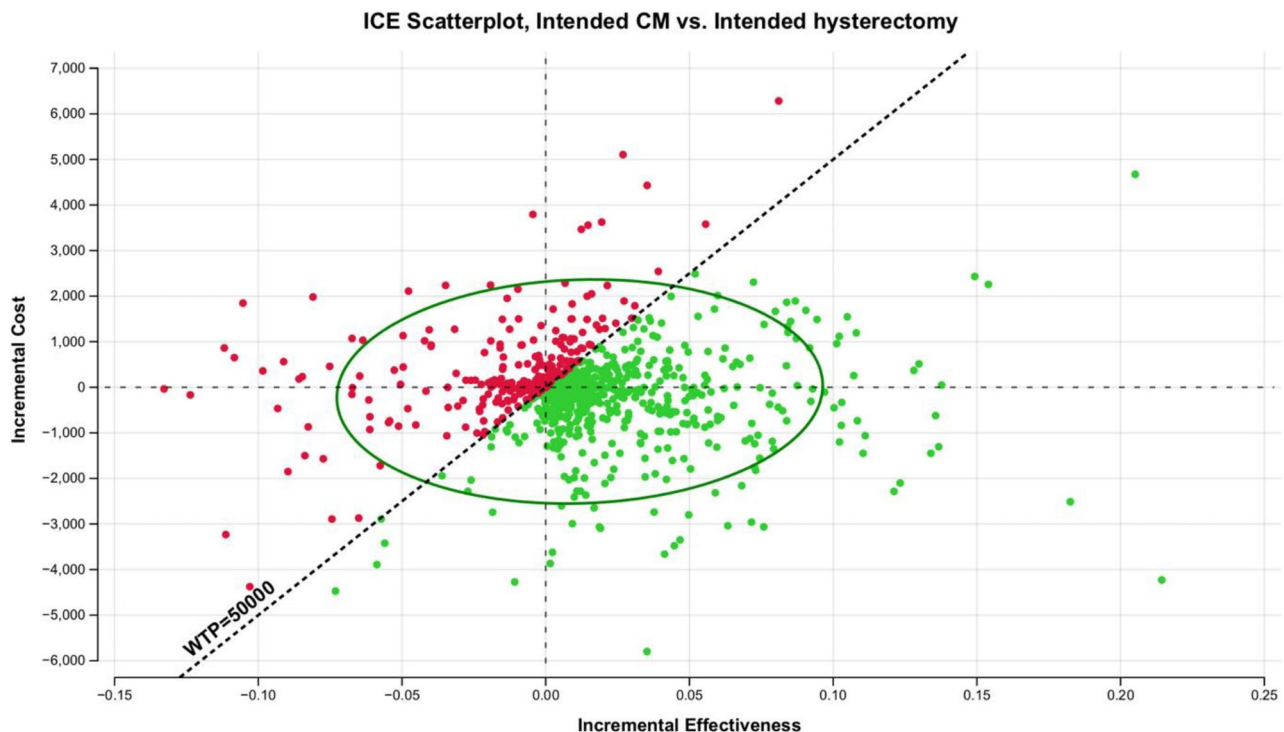
### 4.1 | Main Findings

In this cost-effectiveness analysis, we found that CM of known or suspected PAS is likely to be cost-effective or even cost-saving and more effective (dominant) when compared to CH. When threshold analyses were performed, meeting the intended delivery date without requiring emergent CH in the CM arm, successful uterine preservation and death were associated with a change in the findings of the analysis.

### 4.2 | Interpretation

At present, the standard of care remains CH in the United States of America, though there are PAS centers throughout the world which have proposed CM as a viable option [9, 11–14, 38]. Offering CM also necessitates a multidisciplinary management team comfortable with CM strategies, such as intensive postoperative and outpatient monitoring plans [15–19].

While recognising that either management strategy carries a substantial amount of morbidity for the patient, it is important to recognise that CM may be cost-effective and a potentially less morbid a procedure than previously believed. In our model, we demonstrated that across a wide range of variation, CM can be



**FIGURE 2** | Incremental cost-effectiveness ratio (ICER) scatterplot. The dashed lines represent the willingness-to-pay thresholds of \$50 000. ICERs located to the right of the dashed lines (green) in quadrant I are considered cost-effective. ICERs located to the left (red) are less cost-effective.

a cost-effective strategy for the management of PAS. In clinical practice, the choice of surgical management should continue to be guided by experience, expertise, patient safety and resources. We present our data on cost-effectiveness in order to drive further prospective research and not to replace clinical acumen or decision making in these high-risk scenarios as both CH and CM have significant risk of morbidity.

Importantly, our data highlight the prevalence of morbidity related to any strategy of management for PAS. With significant morbidity such as haemorrhage, postoperative infection, intraoperative injury, ICU admission and even death as potential outcomes for any patient with PAS, it is important to consider our results in the context of limited clinical trial data. Our model demonstrates that avenues for future clinical care, research and innovation include the following: Predicting and potentially intervening to improve the stability of pregnant people electing CM; improving perioperative measures to ensure successful uterine preservation; and reducing the frequency of morbidity and mortality related to unplanned CH. These conclusions only bolster the need not only for rigorous, prospective data to inform future analyses but also the role that PAS Centers of Excellence have in the reduction of morbidity and mortality associated with PAS [20, 21].

Most data for CM come from small cohort studies or case series, owing not only to the overall rarity of PAS as a diagnosis but also the to even rarer incidence of management that does not include CH [16, 17]. A single-site, US-based pilot randomised controlled trial is ongoing (NCT05139498). Though the purpose of the study is to assess the feasibility of randomising individuals to CM or CH, it nevertheless will provide needed data to understand the scope of decision-making and outcomes associated with CM in a rigorous, prospective fashion.

Patient-centred perspectives about the willingness to accept CM and the goals of uterine preservation, as well as future fertility, will add to the growing fund of knowledge about the feasibility and safety of CM in a real-world setting. Until the results of the study are available, other methodologies for assessing the risks and benefits of CM versus CH, such as our decision analysis, lend an important, novel insight into the healthcare resource and patient-level implications of each management strategy. Potential future studies would ideally be prospective, patient-centred, longitudinal, and when possible, randomised to either CM or CH. This type of study would necessitate a PAS Center of Excellence with surgeons experienced in both modes of management and would also be time-intensive and possibly life-altering for patients who may need to relocate to be near such a center for optimal management throughout their pregnancy. Performing the study in a longitudinal manner throughout the entire pregnancy and the postpartum period would also allow for psychological assessments of the patient and help better understand and address the mental health component of this complicated obstetrical condition.

To our knowledge, our analysis is the first decision analysis comparing CM and CH for the management of known or suspected PAS. An important strength of our study is that we also included the probability of pregnant people declining CM, which attempts to mirror the real-world scenario of shared

decision-making. This approach has recently been incorporated into health economic analyses in obstetrics [22].

### 4.3 | Strengths and Limitations

Our study is not without limitations. A major limitation is the limited number of manuscripts available which describe CM. While PAS is extremely rare overall and the clinical significance poses challenges to creating a randomised control trial, the largest prospective study investigating CH versus CM for PAS still included less than 300 patients [9]. However, if clinical outcomes demonstrated in prospective observational studies like PACCRETA can be reproduced more broadly, our results suggest that CM is very likely to be cost-effective or a dominant strategy. Another limitation is that outcomes such as intraoperative, non-urological injury and readmission were extracted from either gynaecologic surgery or general surgery literature and extrapolated to the obstetric population. While these complications are reported in PAS literature, the inconsistencies in reporting between papers made it less reliable for the model [22]. Finally, as previously noted, another limitation is the lack of patient perspectives and data on patient uptake and acceptance of CM for the management of PAS [15]. Though we attempted to model for patient acceptance of CM in our analysis, these values were derived from expert opinion. There is existing literature regarding mental health and lived experiences of patients with a diagnosis of PAS; however this was not integrated into our model due to the lack of robust prospective research. This is an integral area of research, and important frameworks for counselling and management throughout pregnancy have been proposed [23, 24]. The key themes highlighted in the emotional toll that PAS can take on patients include loss of autonomy, fear of pregnancy and personal health outcomes and helplessness due to the perceived lack of medical management options [17]. Therefore, future research must evaluate patient perspectives related to management strategies for PAS.

### 4.4 | Conclusions

In our theoretical cohort of 1000 pregnant people with known or suspected PAS greater than 20 weeks gestation, CM was the dominant and cost-saving strategy compared with CH. Meeting the intended delivery date without requiring emergent CH in the CM arm, successful uterine preservation and death were associated with a change in the findings of the analysis, favouring CH. The overall impact that CM could have on improved maternal morbidity from CH for PAS should not be understated. However, future prospective, ideally randomised, studies should be performed to inform clinicians whether CM has a role in mitigating morbidity and mortality related to PAS.

### Author Contributions

All authors have contributed equally to this research and manuscript preparation. All authors contributed together to the conception and design of the project, the acquisition, interpretation and analysis of data and modelling of data for a decision analytic model. All authors contributed to the drafting of this article as well as to multiple rounds of revisions. All authors have contributed to the final approval of the version

to be published. All authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All authors confirm that there is no case of ghost authorship and no additional contributors who did not qualify for authorship.

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### Disclosure

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### Ethics Statement

The Institutional Review Board at the University of Chicago deemed this study as exempt from review (IRB23-0514).

### Conflicts of Interest

The authors declare no conflicts of interest.

### Data Availability Statement

The data analysed in this study were obtained from peer-reviewed manuscripts available through PubMed and are subject to their data access policies. Additionally, pooled data are available upon request from the study team and within supplementary materials.

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### Supporting Information

Additional supporting information can be found online in the Supporting Information section.