Obstetric Characteristics and Outcomes of Gestational Carrier Pregnancies: A Systematic Review and Meta-Analysis

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Abstract

IMPORTANCE Advancements in assisted reproductive technology (ART) have led to an increase in gestational carrier (GC) pregnancies. However, the perinatal outcomes of GC pregnancies remain understudied, necessitating a deeper understanding of their associated risks.

OBJECTIVE To assess maternal characteristics and obstetric outcomes associated with GC pregnancies.

DATA SOURCES A comprehensive systematic search of publications published before October 31, 2023, using PubMed, Web of Science, Scopus, and Cochrane Library databases was conducted.

STUDY SELECTION Two authors selected studies examining obstetric characteristics and outcomes in GC pregnancies with 24 or more weeks’ gestation. Studies with insufficient outcome information, unavailable data on gestational surrogacies, and non-English language studies were excluded.

DATA EXTRACTION AND SYNTHESIS Adhering to Preferred Reporting Items for Systematic Reviews and Meta-Analysis guidelines, 2 investigators extracted and synthesized both quantitative and qualitative data. Both fixed-effect and random-effect analysis were used to pool data.

MAIN OUTCOMES AND MEASURES The primary outcomes were obstetric characteristics and outcomes, including hypertensive disorders, preterm birth, and low birth weight. Secondary outcomes included severe maternal morbidity and mortality associated with GC pregnancies.

RESULTS Six studies from 2011 to 2023 involving 28,300 GC pregnancies and 1,270,662 non-GC pregnancies were included. GCs accounted for 2.5% of in vitro fertilization cycles (59,502 of 2,374,154 cycles) and 3.8% of ART pregnancies (26,759 of 701,047 ART pregnancies). GC pregnancies were more likely to be conceived by frozen embryo transfer compared with non-GC ART pregnancies (odds ratio [OR], 2.84; 95% CI, 1.56-5.15), and rates of single embryo transfer were similar between the 2 groups (OR, 1.18; 95% CI, 0.94-1.48). GCs were rarely nulliparous (6 of 361 patients [1.7%]) and were more likely to have multifetal pregnancies compared with non-GC ART patients (OR, 1.18; 95% CI, 1.02-1.35). Comparator studies revealed lower odds of cesarean delivery (adjusted OR [aOR], 0.42; 95% CI, 0.27-0.65) and comparable rates of hypertensive disorders (aOR, 0.86; 95% CI, 0.45-1.64), preterm birth (aOR, 0.82; 95% CI, 0.68-1.00), and low birth weight (aOR, 0.79; 95% CI, 0.50-1.26) in GC pregnancies vs non-GC ART pregnancies. Comparatively, GC pregnancies had higher odds of hypertensive disorders (aOR, 1.44; 95% CI, 1.13-1.84) vs general (non-GC ART and non-ART) pregnancies with comparable cesarean delivery risk (aOR, 1.06; 95% CI, 0.90-1.25). Preterm birth and low birth weight data lacked a comparative group using multivariate analysis. Severe maternal morbidity and maternal mortality were rare among GCs.

(continued)
CONCLUSIONS AND RELEVANCE  In this systematic review and meta-analysis, although GC pregnancies had slightly improved outcomes compared with non-GC ART pregnancies, they posed higher risks than general pregnancies. Contributing factors may include ART procedures and increased rates of multiple gestations which influence adverse perinatal outcomes in GC pregnancies.
Trials using specific terms (eAppendix 1 in Supplement 1). Titles, abstracts, and full texts were screened by 2 investigators (Shinya Matsuzaki and Satoko Matsuzaki). From this set, studies exploring the associations of GC pregnancy with relevant outcomes were extracted using keywords such as surrogate mothers (medical subject heading terms) or related keywords of surrogate mothers and pregnancy outcome (medical subject heading terms) or related keywords of pregnancy outcomes.

### Study Selection
Study selection adhered to the patient population, intervention, comparator, outcome, and study type (PICOS) design (eAppendix 2 in Supplement 1). The study inclusion criteria were (1) pregnancy outcomes in gestational surrogacy, (2) studies comparing obstetric outcomes between gestational surrogacy and nonsurrogacy, and (3) pregnancies with 24 or more weeks' gestation. The exclusion criteria comprised (1) insufficient outcome information; (2) unavailable data on the number of gestational surrogacies; (3) non-English language studies; and (4) conference abstracts, editorials, case reports, case series, narrative reviews, systematic reviews, and meta-analyses.

### Data Extraction
Data were extracted by 2 investigators (Shinya Matsuzaki and Satoko Matsuzaki), who recorded the study year, location, first author's name, number of cases, and the relevant outcomes. Pregnant individuals were classified into 3 groups: (1) GC pregnancies, (2) non-GC ART pregnancies, and (3) non-GC non-ART pregnancies. In this study, non-GC pregnancies were defined as non-GC ART and/or non-GC non-ART pregnancies, and general pregnancies included both non-GC ART and non-GC non-ART pregnancies.

### Outcome Measure Analysis and Assessment of Risk of Bias
The 2 primary outcomes were maternal characteristics and obstetric outcomes in GC pregnancies. Areas of interest included HDP, GD, fetal growth restriction, PTB, LBW, intrauterine fetal death, placenta previa, and placental abruption. In the sensitivity analysis, the characteristics of ART treatment of GC pregnancies were explored.

Secondary outcomes included severe maternal morbidity (SMM) and delivery outcomes, such as the rate of CD and postpartum hemorrhage. SMM was based on definitions by the Centers for Disease Control and Prevention (including eclampsia, blood transfusion, and hysterectomy), and modified to include maternal death; intensive care unit admission; and hemolysis, elevated liver enzymes, and low platelets (HELLP) syndrome. A composite of SMMs determined in each study was used for analysis. Risk of bias assessment employed the Risk of Bias in Nonrandomized Studies of Interventions Tool (ROBINS-I).

### Meta-Analysis Plan
Maternal outcome risks were estimated from the eligible studies in experimental and control groups using 95% CIs of reported values to derive odds ratios (ORs). Studies that did not provide raw data were excluded; the majority of studies presented ORs. Study heterogeneity was assessed using I² percentages and a fixed- or random-effect analysis was performed as shown in eAppendix 3 in Supplement 1. Data from continuous and bivariate outcomes were entered for consistency, favoring active interventions due to negative effect sizes or relative risks less than 1. Any adjusted results were based on adjustments that were defined by the original studies to account for confounding variables.

### Statistical Analysis
Baseline demographic differences between groups were assessed using the χ² or Fisher exact test. Meta-analysis and visualizations were performed using RevMan software version 5.4.1 (Cochrane Collaboration). Statistical analyses were also conducted with SPSS version 28.0 (IBM). A 2-sided P < .05 was considered statistically significant.
Results

Study Selection

Of 4231 studies reviewed, 22 studies reported the obstetric outcomes of GC pregnancies (Figure 1 and eTable 1 in Supplement 1). Three studies with overlapping data were identified, and the older study was excluded from the descriptive analysis. Fifteen noncomparator studies were excluded from the main comparator analysis (eTables 2-4 in Supplement 1). As a result, 6 studies involving 28,300 GC pregnancies and 1,270,662 non-GC pregnancies underwent further descriptive analysis (Figure 1).

Study Characteristics

All 6 studies were retrospective studies published between 2011 and 2023 (no randomized clinical studies). The majority of the studies (5 studies [83.3%]) originated from the US, and 1 study (16.7%) was from the UK. Among the 6 studies, 1 compared obstetric outcomes between GC pregnancies and general pregnancies, and all compared the outcomes between GC pregnancies and non-GC ART pregnancies (Table 1).

In the 6 eligible studies, age at ART treatment and ART type (frozen or fresh embryo transfer) were reported in 4 studies, and rate of single embryo transfer was reported in 3 studies. Prior live birth was not reported in any study (Table 1). The method of endometrial preparation was unavailable in all studies. Maternal age and nulliparity were specified in 1 study, and multiple pregnancy rates were specified in 5 studies (Table 2).

Figure 1. Study Selection Scheme of the Systematic Literature Search

6517 Studies identified
3846 Scopus
2085 Web of Science
551 PubMed
35 Cochrane

2286 Duplicate records removed

4231 Records screened by title review

3906 Records excluded after screening

325 Records screened by abstract review

279 Records excluded after abstract review

46 Full-text articles assessed for eligibility

40 Full-text articles excluded
16 No relevant outcomes
4 No GC patients
4 Ineligible study type
1 Overlapping data
15 Noncomparator studies

6 Comparator studies included in meta-analysis

GC indicates gestational carrier.

* Descriptive statistics of noncomparator studies are described in eTable 2, eTable 3, and eTable 4 in Supplement 1.
Risk of Bias of Included Studies

Among the 6 identified comparator studies (GC pregnancies vs non-GC pregnancies), risk of bias assessments were conducted. There was moderate bias (moderate quality) in 4 studies\(^3,17,22,28\) and severe bias (low quality) in 2 studies\(^25,30\) (eTable 5 in Supplement 1).

Table 1. Characteristics of Patients With and Without GCs at ART Treatment

<table>
<thead>
<tr>
<th>Study characteristic</th>
<th>Participants by study, No./total No. (%)</th>
<th>Shandley et al(^{17}) 2023</th>
<th>Swanson et al(^{22}) 2021</th>
<th>Segal et al(^{28}) 2018</th>
<th>Sunkara et al(^{28}) 2017</th>
<th>Perkins et al(^3) 2016</th>
<th>Gibbons et al(^{30}) 2011</th>
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<td>Data source</td>
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<tr>
<td>Comparison</td>
<td>GC vs ART</td>
<td>GC vs ART vs general</td>
<td>GC vs IP</td>
<td>GC vs ART</td>
<td>GC vs ART</td>
<td>GC vs ART</td>
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<tr>
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<td>Age &gt;35 ya(^a)</td>
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<td>189691/633775 (29.9)</td>
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<td>1.4 (0.7)</td>
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<td>2281/14682 (15.5)(^b)</td>
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</tbody>
</table>

Abbreviations: ART, assisted reproductive technology; CORS, Clinic Outcome Reporting System; ET, embryo transfer; GC, gestational carrier; HFEA, Human Fertilization and Embryology Authority; IP, ART pregnancies of intended parents; NA, not applicable; NASS, National ART Surveillance System; SART, The Society for Assisted Reproductive Technology; Utah, Utah Department of Health Office of Vital Records and Statistics.

\(^a\) Status at ART treatment.

\(^b\) Elective single embryo transfer.
Measured Outcomes

The following relevant outcomes were assessed in the 6 comparator studies: HDP (1 study), GD (0 studies), PTB (4 studies), LBW (4 studies), CD (1 study), maternal mortality (1 study), and SMM (1 study). Adjusted ORs (aORs) of obstetric outcomes in multivariate analyses were detailed for HDP (1 study), PTB (2 studies), LBW (2 studies), and CD (1 study).

Table 2. Maternal Outcomes of GC Pregnancies

<table>
<thead>
<tr>
<th>Study characteristic</th>
<th>Outcome by study, OR (95% CI)</th>
</tr>
</thead>
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<tr>
<td></td>
<td>Shandley et al, 2012</td>
</tr>
<tr>
<td>Location</td>
<td>US</td>
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<tr>
<td>Comparison</td>
<td>GC vs ART*</td>
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<tr>
<td>Participants, No.</td>
<td>441 905</td>
</tr>
<tr>
<td>GC pregnancies, No.</td>
<td>21 649</td>
</tr>
<tr>
<td>Control participants, No.</td>
<td>420 256</td>
</tr>
<tr>
<td>Age, median (IQR), y</td>
<td>31 (28-34) in GC vs 38 (33-43) in ART</td>
</tr>
<tr>
<td>Nulliparous, No./Total No. (%)</td>
<td>NA/6/361 (1.7)</td>
</tr>
<tr>
<td>Multiple pregnancies, No./Total No. (%)</td>
<td>3197/21 649 (14.8)</td>
</tr>
<tr>
<td>Maternal complication</td>
<td>Unadjusted HDP</td>
</tr>
<tr>
<td>Unadjusted PTB</td>
<td>0.97 (0.94-1.01)</td>
</tr>
<tr>
<td>Adjusted PTB</td>
<td>0.78 (0.61-0.99)</td>
</tr>
<tr>
<td>Unadjusted LBW</td>
<td>0.49 (0.36-0.67)</td>
</tr>
<tr>
<td>Adjusted LBW</td>
<td>0.62 (0.44-0.89)</td>
</tr>
<tr>
<td>Unadjusted mortality</td>
<td>2.74 (0.17-44.06)</td>
</tr>
<tr>
<td>Unadjusted SMM</td>
<td>1.61 (0.72-3.60)</td>
</tr>
<tr>
<td>Adjusted SMM</td>
<td>1.03 (0.51-2.07)</td>
</tr>
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</table>

Abbreviations: ART, assisted reproductive technology; CD, cesarean delivery; GC, gestational carrier; HDP, hypertensive disorders of pregnancy; IP, ART pregnancies of intended parents; LBW, low birth weight; NA, not applicable; OR, odds ratio; PTB, preterm birth; SMM, severe maternal morbidity.

a Non-GC ART pregnancies.
a Number of pregnancies with live births.

a Restricted to singleton pregnancies.

a Number of ART cycles.
a Adjusted for age, nulliparity, and tobacco.
a Estimated with RevMan version 5.4.1.

b Adjusted for female age category, period of treatment, number of previous in vitro fertilization cycles, previous live birth occurrence, cause of infertility, mean number of embryos transferred, and initial singleton or multiple pregnancies that lead to singleton live births.

b Model adjusted for age, use of assisted hatching, intracytoplasmic sperm injection, preimplantation genetic diagnosis, fresh or frozen donor oocyte, and number of embryos transferred, reduction in fetal heart.

b Adjusted for age, nulliparity, chronic hypertension, and substance use.

b Comparison with patients conceived by frozen embryo transfer.

b Adjusted for age, nulliparity, chronic hypertension, and substance use.
ART Treatment for GC Pregnancies

The cumulative rate of GC in vitro fertilization cycles was 2.5% (59,502 of 2,374,154 cycles) among ART cycles. GC pregnancies were more likely to be conceived by frozen embryo transfer than non-GC ART pregnancies (OR, 2.84; 95% CI, 1.56-5.15), whereas the use of single embryo transfer was similar between the 2 groups (OR, 1.18; 95% CI, 0.94-1.48) (Figure 2).

Rate of GC Pregnancies

Among the 6 comparator studies, 1 clarified the number of GC pregnancies among general pregnancies.22 Four studies clarified the number of GC pregnancies among ART pregnancies,3,17,25,28 and 2 studies were excluded because the total number of ART pregnancies was not clarified (Table 1).22,30 Based on this data, GC pregnancies comprised approximately 3.8% of ART pregnancies (26,759 of 701,047 ART pregnancies) and 0.1% of all pregnancies (361 of 509,376 pregnancies).

Patient Characteristics

Of the 6 comparator studies, 1 compared maternal age between GC pregnancies and non-GC ART pregnancies (Table 2).22 The median (IQR) maternal age was lower in GC pregnancies (31 [28-34] years) than in non-GC ART pregnancies (38 [33-43] years) (P < .001). There was a lower prevalence of nulliparity among GC pregnancies (6 of 361 [1.7%]) than among general pregnancies (166,441 of 509,015 [32.7%]) (P < .001); there was also a lower prevalence of nulliparity among GC pregnancies than non-GC ART pregnancies (350 of 563 [62.2%]) (P < .001). In the noncomparator studies,18-21,24,26,27,31-37 the cumulative mean (range) maternal age of GCs was 34.2 (32.7-38.8) years and the rate of nulliparity was 1.0% (12 of 1222 patients; range 0.1%-3.0%).

Five studies3,17,22,25,28 included information on multiple gestation (ranging from 3197 of 21,649 pregnancies [14.8%] to 1453 of 3857 pregnancies [37.7%]). One study22 reported a significantly higher rate of multiple gestation in GC pregnancies as compared with general pregnancies (OR, 15.27; 95% CI, 11.86-19.66). When compared with non-GC ART pregnancies, patients with GC pregnancies were more likely to have multiple gestation (OR, 1.18; 95% CI, 1.02-1.35).3,17,22,25,28 In the noncomparator studies,18-21,24,26,27,31-37 the cumulative rate of multiple gestation (excluding singleton-restricted studies) reached 21.6% (443 of 2055 patients; range 0.0%-34.7%).

Figure 2. Meta-Analysis for the Assisted Reproductive Technology (ART) Treatment of Gestational Carrier (GC) Pregnancies

The rate of FET

The pooled odds ratio for unadjusted analysis for frozen embryo transfer (FET; A) and unadjusted analysis for single embryo transfer (SET; B) between GC pregnancies vs non-GC ART pregnancies. Heterogeneity among the studies in each analysis was defined as considerable heterogeneity in unadjusted random-effect analysis. Some values listed in the figure might be slightly different from the original values because of the calculation in RevMan version 5.4.1.
HDP

One comparator study\textsuperscript{22} compared HDP risks between GC pregnancies and general pregnancies and between GC pregnancies and non-GC ART pregnancies (Table 2). This study found more HDP in GC pregnancies than in general pregnancies (aOR, 1.44; 95% CI, 1.13-1.84) and similar HDP risk between GC pregnancies and non-GC ART pregnancies (aOR, 0.86, 95% CI, 0.45-1.64).\textsuperscript{22} Singleton deliveries-specific analysis was unavailable for HDP.

PTB

PTB was assessed in 4 of 6 comparator studies.\textsuperscript{3,17,25,28} In the pooled analysis, PTB risks were comparable between GC pregnancies and non-GC ART pregnancies, evident in both unadjusted random-effects (OR, 0.93; 95% CI, 0.74-1.17; $I^2 = 95\%$; $\chi^2_3 = 65.84$; $P < .001$) and adjusted fixed-effects analyses (available only for singleton pregnancies restricted data in 2 studies\textsuperscript{25,28}) (aOR, 0.82; 95% CI, 0.68-1.00; $I^2 = 0\%$; $\chi^2_1 = 0.68$; $P = .41$) (Figure 3).

LBW

Four comparator studies assessed LBW in GC pregnancies.\textsuperscript{3,25,28,30} The pooled analysis indicated comparable LBW risk between GC pregnancies and non-GC ART pregnancies in both unadjusted

\begin{figure}
\centering
\includegraphics[width=\textwidth]{figure3.png}
\caption{Meta-Analysis for the Association of Gestational Carrier (GC) Pregnancies With Preterm Birth (PTB) and Low Birth Weight (LBW)}
\end{figure}
random-effects (OR, 0.80; 95% CI, 0.57-1.13; $I^2 = 89\%$; $\chi^2 = 27.76$; $P < .001$)$^{3,25,28,30}$ and adjusted random-effects analyses (available only for singleton pregnancies restricted data in 2 studies$^{25,28}$), but the adjusted analysis was not statistically significant (aOR, 0.79; 95% CI, 0.50-1.26; $I^2 = 72\%$; $\chi^2 = 3.52$; $P = .06$) (Figure 3).

**CD Risk**

A nationwide study in the US investigated the association of GC pregnancies with CD risk.$^{22}$ In this unadjusted analysis, GC pregnancies had similar CD risk compared with general pregnancies (OR, 1.21; 95% CI, 0.96-1.54) but a lower CD risk compared with non-GC ART pregnancies (OR, 0.22; 95% CI, 0.17-0.30) (Table 2). These findings were consistent in multivariate analysis, indicating comparable CD rates between GC pregnancies and general pregnancies (aOR, 1.06; 95% CI, 0.90-1.25) and lower CD risks in GC pregnancies compared with non-GC ART pregnancies (aOR, 0.42; 95% CI, 0.27-0.65). Singleton-specific analysis was unavailable for CD.

**SMM and Maternal Mortality**

SMM was determined in 1 comparator study$^{22}$ that assessed the composite evaluation of intensive care unit admission, eclampsia,HELLP, transfusion, and hysterectomy. The composite risk of SMM was similar between GC pregnancies and general pregnancies (aOR, 1.03; 95% CI, 0.51-2.07), whereas the composite risk was lower in GC pregnancies compared with non-GC ART pregnancies (aOR, 0.17; 95% CI, 0.04-0.81). Maternal mortality was assessed in 1 comparator study,$^{22}$ which included 361 GC pregnancies with no maternal deaths, whereas 256 of 509 015 cases of maternal death (0.1%) were seen in general pregnancies (OR, 2.74; 95% CI, 0.17-44.06) (Table 2).

**Discussion**

The results from this systematic review and meta-analysis demonstrated 4 principal findings. First, GC pregnancies represented 3.8% of ART pregnancies and 0.1% of all pregnancies. Second, although there was insufficient evidence on obstetric outcomes of GC pregnancies, especially regarding SMM, these pregnancies often involve multiparous patients and a high rate of multiple gestations. Third, obstetric outcomes of GC pregnancies, excluding CD and SMM, were similar to those seen in ART pregnancies but could result in worse outcomes compared with unassisted pregnancies. Fourth, GC pregnancies may have higher HDP risks than non-GC pregnancies. While some findings aligned with existing knowledge, the scarcity of comparator studies in prospective settings underscores the need for further investigation.

**Primary Outcomes: Maternal Characteristics and Obstetric Outcomes**

Pregnancies in multiparous patients with a history of successful, uncomplicated term pregnancies are typically lower risk.$^{38}$ However, studies consistently found associations of ART pregnancies with higher risk of adverse obstetric outcomes and multiple gestation compared with non-ART conceptions.$^{39-41}$ Notably, the cause of infertility further elevates risk of adverse obstetric outcomes during ART pregnancies, particularly with multiple gestation, leading to increased chances of PTB, HDP, and LBW.$^{42-44}$ Thus, ART and multiple gestation may be the main factors associated with increased risk for GC pregnancies, whereas multiparous patients without infertility and a history of uncomplicated pregnancies tend to have good prognosis.

A retrospective study$^{27}$ showed higher odds of twin pregnancies, PTB, GD, placental previa, and CD in GC pregnancies (103 patients) vs the GC’s own prior pregnancies (294 patients). Another 2020 study in the US with a limited sample size found similar obstetric outcomes (PTB, GD, postpartum hemorrhage, fetal growth restriction, placental abruption, and abnormal placentation) when comparing a GC singleton pregnancy (78 patients) with their own prior singleton pregnancies (71 patients).$^{37}$
A retrospective study that compared the obstetric outcomes between GCs with singleton gestation (284 pregnancies) and multiple gestation (77 pregnancies) showed that GC pregnancies with multiple gestation had increased odds of PTB compared with GC pregnancies with singleton gestation (aOR, 29.3; 95% CI, 11.0-78.0) and CD (aOR, 5.6; 95% CI, 3.1-10.2). The poorer prognosis of GC pregnancies may primarily stem from higher rates of multiple gestation. Therefore, efforts to reduce multiple gestation, such as elective single embryo transfer, are crucial to improving the obstetric outcomes of GC pregnancies.

In the present study, PTB and LBW risks were comparable between GC pregnancies and non-GC ART pregnancies, but no studies included non-GC non-ART controls. One study found lower CD risks but similar HDP risks in GC pregnancies than in non-GC ART pregnancies. The increased HDP following oocyte donation is theorized to be caused by an immunological maladaptation to the foreign antigens from the fetus. Gestational surrogacy involves carrying a pregnancy that is the result of either the intended parent’s or parents’ gametes, or donor gametes. Theoretically, immune reactions to foreign antigens in gestational surrogacy may be comparable with responses observed in people after receiving oocyte donations, which increases the risk of HDP compared with autologous ART.

Another potential factor that could increase the risk of HDP in GC pregnancies is the widespread use of frozen embryo transfer. In this study, GCs were more likely to conceive with frozen embryo transfer than non-GCs. A meta-analysis of 3 randomized trials involving 1193 pregnancies after frozen embryo transfer and 1205 after fresh embryo transfer showed an increased risk of HDP after frozen embryo transfer compared with fresh embryo transfer. A population-based study in Norway reported a comparable HDP risk between fresh embryo transfer and natural conception (aOR, 1.02; 95% CI, 0.98-1.07), whereas frozen embryo transfer was associated with an increased HDP risk compared with natural conception (aOR, 1.74; 95% CI, 1.61-1.89). Although the type of endometrial preparation was unavailable in this study, these data are suggestive in that frozen embryo transfer use in GCs could potentially increase the risk of HDP.

Secondary Outcomes: SMM and Delivery Outcomes

The American Society for Reproductive Medicine (ASRM) committee recommends selecting GCs who are aged 21 to 45 years, with at least 1 previous term delivery without complications, less than 5 previous deliveries, less than 3 previous CDs, and a stable family environment. In adherence to these recommendations, GC pregnancies will have the following characteristics: (1) fertile multiparous patients with previous uncomplicated deliveries, (2) younger maternal age, (3) normal psychological evaluation, and (4) normal medical evaluation. Although GCs have these characteristics, GC pregnancies are a result of ART, which has a known risk of multiple gestation pregnancy. Given the notable risks described throughout the data, gestational surrogates should undergo rigorous screening and testing to determine appropriate candidates.

SMM was examined in only 1 comparator study that was underpowered due to the limited number of included GC pregnancies (361 patients). Thus, the risk of SMM in GC pregnancies is still unknown. More extensive studies are needed to examine the association of GC pregnancies with SMM. Notably, 1 study evaluated outcomes in GC pregnancies in patients who did not match the ASRM safety guidelines. The outcomes showed a correlation with severe obstetric and neonatal complications. Although SMM was rare in these GC pregnancies that did not abide by ASRM guidelines, these pregnancies did have higher rates of CD, neonatal morbidity, and PTB. Thus, careful GC candidate selection may substantially improve obstetric outcomes.
Limitations

This study had several limitations. First, there was inherent bias from the inclusion of retrospective studies as well as confounding variables. Second, no included studies comprehensively analyzed patient obstetric history to investigate the association of gestational surrogacy with obstetric outcomes. Consequently, a causal relationship between gestational surrogacy and maternal outcomes could not be established. Third, publication bias remains a substantial concern, potentially skewing findings toward positive associations of maternal outcomes with gestational surrogacy.

Fourth, there are limited comparative studies examining maternal outcomes in gestational surrogacy, requiring more comprehensive investigations. Moreover, eligible studies of the current systematic review were missing key outcome variables, thus limiting the ability to perform meaningful meta-analyses and limiting the conclusiveness and impact of the study. This weakness was due to the limited available obstetric outcomes of the data sources used in the eligible studies. Given the challenges associated with conducting a randomized clinical trial, a prospective study may be appropriate.

Fifth, data on previous pregnancies were absent, but a history of PTB, HDP, or CD is associated with an increased rate of subsequent pregnancy complications. Finally, psychological and physical evaluations for gestational surrogates could decrease obstetric complications, potentially introducing selection bias. Acknowledging this limitation is crucial when interpreting the results of the current study.

Sixth, although multiple gestations are associated with adverse outcomes, the outcomes controlling for gestation in the analysis were unavailable because of the lack of data in the eligible studies. Elective single embryo transfer is recommended to decrease multiple gestation in ART pregnancies, especially in GC pregnancies. In alignment with the nationwide push promoting single embryo transfer, it is likely that some of these outcomes have improved over time. Nevertheless, these data were not available for the current systematic review and further research considering these factors is warranted to improve the obstetric outcomes of GC pregnancies.

Conclusions

In this systematic review and meta-analysis of characteristics and maternal outcomes of GC pregnancies, we found comparable obstetric outcomes between GC pregnancies and non-GC ART pregnancies, but a lack of comparisons with non-GC non-ART pregnancies persists. There is a need for further research to comprehensively understand obstetric outcomes in GC pregnancies and better understand the associated risk profile.
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