The Journal of Maternal-Fetal & Neonatal Medicine

ISSN: (Print) (Online) Journal homepage: informahealthcare.com/journals/ijmf20

# The association of assisted reproductive technology with fetal malpresentation: a systematic review and meta-analysis

**Konstantinos Stavridis, Maria Pisimisi, Olga Triantafyllidou, Theodoros Kalampokas, Nikolaos Vlahos & Stavroula L. Kastora**

**To cite this article:** Konstantinos Stavridis, Maria Pisimisi, Olga Triantafyllidou, Theodoros Kalampokas, Nikolaos Vlahos & Stavroula L. Kastora (2024) The association of assisted reproductive technology with fetal malpresentation: a systematic review and meta-analysis, The Journal of Maternal-Fetal & Neonatal Medicine, 37:1, 2313143, DOI: 10.1080/14767058.2024.2313143

**To link to this article:** https://doi.org/10.1080/14767058.2024.2313143

© 2024 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group

Published online: 05 Feb 2024.

Submit your article to this journal

Article views: 1191

View related articles

View Crossmark data

Full Terms & Conditions of access and use can be found at https://informahealthcare.com/action/journalInformation?journalCode=ijmf20

THE JOURNAL OF MATERNAL-FETAL & NEONATAL MEDICINE
2024, VOL. 37, NO. 1, 2313143
https://doi.org/10.1080/14767058.2024.2313143

Taylor & Francis
Taylor & Francis Group

REVIEW ARTICLE

OPEN ACCESS Check for updates

# The association of assisted reproductive technology with fetal malpresentation: a systematic review and meta-analysis

Konstantinos Stavridis[a], Maria Pisimisi[b], Olga Triantafyllidou[a], Theodoros Kalampokas[a], Nikolaos Vlahos[a] and Stavroula L. Kastora[c]

[a]2nd Department of Obstetrics and Gynecology, "Aretaieion" University Hospital, Athens, Greece; [b]School of Medicine, National and Kapodistrian University of Athens, Athens, Greece; [c]EGA Institute for Women's Health, University College London, London, UK

**ABSTRACT**

**Background:** Since its introduction, assisted reproductive technology (ART) has developed into a common clinical practice around the world; yet it still raises a lot of questions. Throughout time, many researchers have investigated its association with several obstetric incidences and its consequences on perinatal outcomes. The aim of the current meta-analysis was to estimate the correlation between ART procedures and malpresentation of the fetus in singleton pregnancies.

**Methods:** The study was conducted according to the Preferred Reporting Items of Systematic Reviews and Meta-analyses (PRISMA) guidelines and prospectively registered under the PROSPERO database (CRD42023458084). Five databases (Embase, MEDLINE®, APA PsycInfo, Global Health, Health Management Information Consortium (HMIC)) and two additional sources were searched from inception to 31 May 2023. Quality of the included studies was assessed using the ROBINS-1 scale, whilst quality of evidence by the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) framework. Summative and subgroup data as well as heterogeneity were generated by the Cochrane platform RevMan Web.

**Results:** Overall, 11 studies were included in the study with a total of 3,360,134 deliveries. Results indicate a higher risk of malpresentation at delivery in fetuses conceived through ART than those conceived naturally (RR: 1.50, (95% confidence interval (CI):1.30, 1.73)). This risk decreased when adjustments for potential confounders were applied (RR = 1.12, 95% CI 1.02, 1.23).

**Conclusions:** Based on observational studies, this meta-analysis indicated that singleton pregnancies conceived through ART are associated with higher risk of malpresentation than those conceived naturally, albeit the difference was lower when potential confounders were examined. Thus, future large studies are required to better understand possible reversible and irreversible factors of this relationship.

**ARTICLE HISTORY**
Received 21 October 2023
Revised 18 January 2024
Accepted 23 January 2024

**KEYWORDS**
ART; IVF; malpresentation; meta-analysis; systematic review

## Introduction

Fetal malpresentation, including breech, transverse/oblique, and compound position, refers to a fetus with a fetal part apart from the head engaging the maternal pelvis. Breech presentation, the most common malposition, constitutes a rather challenging obstetrical condition, accounting for 3–4% of term deliveries [1]. Its etiology is not yet clarified; however, several factors have been identified as predisposing; preterm labor, placental location, advanced maternal age, previous breech presentation, congenital uterine malformation, and nulliparity seem to increase the risk of malpresentation [2–6]. Breech presentation is strongly implicated in adverse perinatal outcomes [7,8]. However, breech presentation may not be an independent risk factor for adverse neonatal outcomes [9,10]. The optimal way of treating a breech delivery remains a controversial topic of discussion among obstetricians. Cesarean section is typically considered a safe way of delivery in these cases; nonetheless, it is linked to an increase in maternal morbidity and mortality [11–13].

Increasing demand has led assisted reproductive technology (ART) to gain ground in modern societies. Since the first successful pregnancy after IVF treatment in 1978, over 10 million infants have been born using

**CONTACT** Konstantinos Stavridis stavridis.kost@gmail.com 2nd Department of Obstetrics and Gynecology, "Aretaieion" University Hospital, Leof. Vasilisis Sofias 76, Athens GR 11528, Greece
© 2024 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group
This is an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. The terms on which this article has been published allow the posting of the Accepted Manuscript in a repository by the author(s) or with their consent.

ART procedures [14]. However, emerging evidence suggests that despite its popularity, ART may be associated with multiple adverse obstetric and perinatal outcomes, such as low birth weight, preterm birth, small for gestational age fetuses, stillbirth, and perinatal mortality, when compared to spontaneously conceived pregnancies [15,16].

Studies comparing the incidence of breech delivery in singleton pregnancies following ART and natural conception (NC) have led to inconsistent results [7, 16–18]. Since the presentation of the fetus is a crucial factor affecting the choice of delivery, and hence, predisposing several possible obstetric complications, it is essential that this subject is studied more thoroughly.

The aim of the present meta-analysis is to report the incidence of fetal malpresentation following ART procedures, compared to spontaneously conceived pregnancies.

## Materials and methods

### Search strategy

A systematic review was conducted according to the guidelines of the Preferred Reporting Items of Systematic Reviews and Meta-analyses (PRISMA) [19]. The study protocol was registered prospectively and accessed under the PROSPERO database (CRD42023458084). We performed an independent literature search for relevant studies from inception to 31 May 2023 across five databases: Embase (OVID), MEDLINE (OVID), APA PsycInfo (OVID), Global Health (OVID), and Health Management Information Consortium (HMIC) (OVID). Additional records were identified through registers, including Research Square and MedRxiv. The MedRxiv search was simplified according to database search functionality. The following search was applied in OVID: (malpresentation or malposition or impacted head or transverse or occiput posterior or oblique or breech).mp AND (*In vitro* fertilization or IVF or ART or assisted reproduction or IUI or ICSI).mp AND (Caesarian or CS or vaginal or SVD or spontaneous or delivery or birth).mp. Cross references were hand-searched.

### Inclusion and exclusion criteria

Retrospective, prospective, and case-control studies reporting fetal malpresentation in which the pregnancy was conceived with assisted reproduction techniques (*in vitro* fertilization or intracytoplasmic sperm injection) compared to NC were included in the present meta-analysis. Case series, case reports, conference abstracts, and posters were excluded. Studies reporting twin pregnancies and multiple gestations were excluded. Randomized controlled trials were sought however due to the ethically sensitive nature of the subject, as expected none were identified. No geographical restrictions were applied.

### Data extraction

After removing duplicates, citations were screened by title and abstract, and then full texts were appraised to determine their eligibility by two investigators (K.S., S.K.). The full manuscripts of studies that were deemed to meet our inclusion criteria were obtained. Where the reviewer disagreed on study eligibility, this was resolved by discussion with a third investigator. Data from each article were extracted by one investigator (K.S.) and re-validated by another (S.K.). The following data were obtained from each study: first author's name, publication year, study type, country, sample size (post withdrawals), numbers of patients in the two comparator groups (ART and NC), maternal age (mean ± SD), birthweight (mean ± SD), number of malpresentations, and inclusion and exclusion criteria (Tables 1 and 2).

### Outcome

The primary outcome was the incidence of malpresentation per participating conception mode, including breech presentation, and transverse and oblique lie.

### Quality assessment

The risk of bias was assessed by two independent reviewers (K.S., S.K.), using the ROBINS-1 tool for assessing the risk of bias in non-randomized studies [27]. Risk-of-bias assessment figures were created via the web-app robvis (Risk-Of-Bias VISualization) [28]. Overall, grading the quality of evidence was assessed by the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) framework [29].

### Data analysis and meta-analysis

After the data extraction, a statistical analysis was performed. Study context and design were compared, and the studies considered suitably homogeneous were used for pooling. A meta-analysis was conducted by computing the risk ratio (RR) and random effects (REs) from the original data using Haensel–Mantel method with Review Manager Web (RevMan Web) [30].

**Table 1.** Demographics of included studies.

| Study | Study type | Country | Time period of study | Maternal age ART (mean ± SD) | Maternal age NC (mean ± SD) | Inclusion criteria | Exclusion criteria |
|---|---|---|---|---|---|---|---|
| Chen et al. [16] | Retrospective cohort | Australia | 2012–2018 | 35.0 ± 4.8 | 29.7 ± 5.7 | Singleton pregnancies, ART or OI or spontaneous conceived | Multiple pregnancy |
| Slavov [20] | Ambidirectional cohort | Bulgaria | 2013–2017 | NA | NA | Singleton pregnancy, gestational age > 22 weeks and birthweight > 600 g | Multiple pregnancy |
| Noli et al. [21] | Retrospective cohort | Italy | 2010–2015 | NA | NA | Singleton pregnancy | Multiple pregnancy, transverse or oblique presentation, SGA |
| Stern et al. [22] | Retrospective cohort | United States | 2004–2010 | 34.5 ± 4.5 | 27.0 ± 5.9 | Singleton pregnancy or fetal death >20 weeks, primiparous women | NA |
| Zsirai et al. [23] | Retrospective cohort | Hungary | 1996–2011 | NA | NA | Singleton pregnancy | Multiple pregnancy, transverse or oblique presentation, <37 gestational weeks |
| Stojnic et al. [24] | Case-control | Serbia | 2006–2010 | 36.450 ± 4.218 | 35.391 ± 4.174 | Singleton pregnancy, >26 weeks gestational age | NA |
| Romundstad et al. [7] | Retrospective cohort | Norway | 1984–2006 | NA | NA | Singleton pregnancies with length of gestation of 22 weeks or more and offspring birthweight of at least 500 g | Age < 20 years and parity ≥5 in the spontaneously conceived group |
| Isaksson et al. [25] | Case-control | Finland | 1993–1999 | NA | NA | Pregnancies ending in birth | Triplet pregnancies and pregnancies resulting in abortion were excluded from analysis |
| Reubinoff et al. [26] | Case-control | Israel | 1983–1993 | 32.7 ± 4.1 | 33.5 ± 4.2 | Only pregnancies leading to live births (>25 weeks gestation or >500 g birthweight), ART sample: IVF was the only way to conceive) | NA |
| Tan et al. [17] | Case-control | England | 1978–1987 | NA | NA | Patients who delivered live-born or stillborn babies at >28 weeks (cases), sequential deliveries to primiparous women in 1988, 1989 (controls) | NA |
| Frydman et al. [18] | Case-control | France | 1981–1984 | 32.5 ± 3.5 | 28.6 ± 4.2 | Pregnancies occurring between April 1981 and July 1984 | NA |

ART: assisted reproductive technology; NC: natural conception; NA: not applicable; OI: ovulation induction.

**Table 2.** Study characteristics and outcomes.

| Study | Sample size (deliveries/ post-dropouts) | ART, *n* | NC, *n* | Breech after ART | Breech from NC | Transverse or oblique from ART | Transverse or oblique from NC |
|---|---|---|---|---|---|---|---|
| Chen et al. [16] | 264,550 | 10,694 | 253,856 | 710/10,694 | 12,390/253,856 | 37/10,694 | 1012/253,856 |
| Slavov [20] | 925 | 402 | 523 | 44/402 | 23/523 | 4/402 | 2/523 |
| Noli et al. [21] | 432,822 | 8531 | 424,291 | 566/8531 | 15,959/424,291 | NA | NA |
| Stern et al. [22] | 173,130 | 5768 | 167,362 | 793/5768 | 19,202/167,362 | NA | NA |
| Zsirai et al. [23] | 1,270,061 | 7838 | 1,262,223 | 456/7838 | 41,242/1,262,223 | NA | NA |
| Stojnic et al. [24] | 1268 | 634 | 634 | 80/634 | 56/634 | NA | NA |
| Romundstad et al. [7] | 1,209,151 | 8229 | 1,200,922 | 419/8229 | 40,386/1,200,922 | NA | NA |
| Isaksson et al. [25] | 2315 | 1970 | 345 | 77/1970 | 11/345 | NA | NA |
| Reubinoff et al. [26] | 520 | 260 | 260 | 23/260 | 17/260 | NA | NA |
| Tan et al. [17] | 1472 | 494 | 978 | 20/494 | 59/978 | NA | NA |
| Frydman et al. [18] | 3920 | 79 | 3841 | 11/79 | 166/3841 | NA | NA |

ART: assisted reproductive technology; NC: natural conception; NA: not applicable.

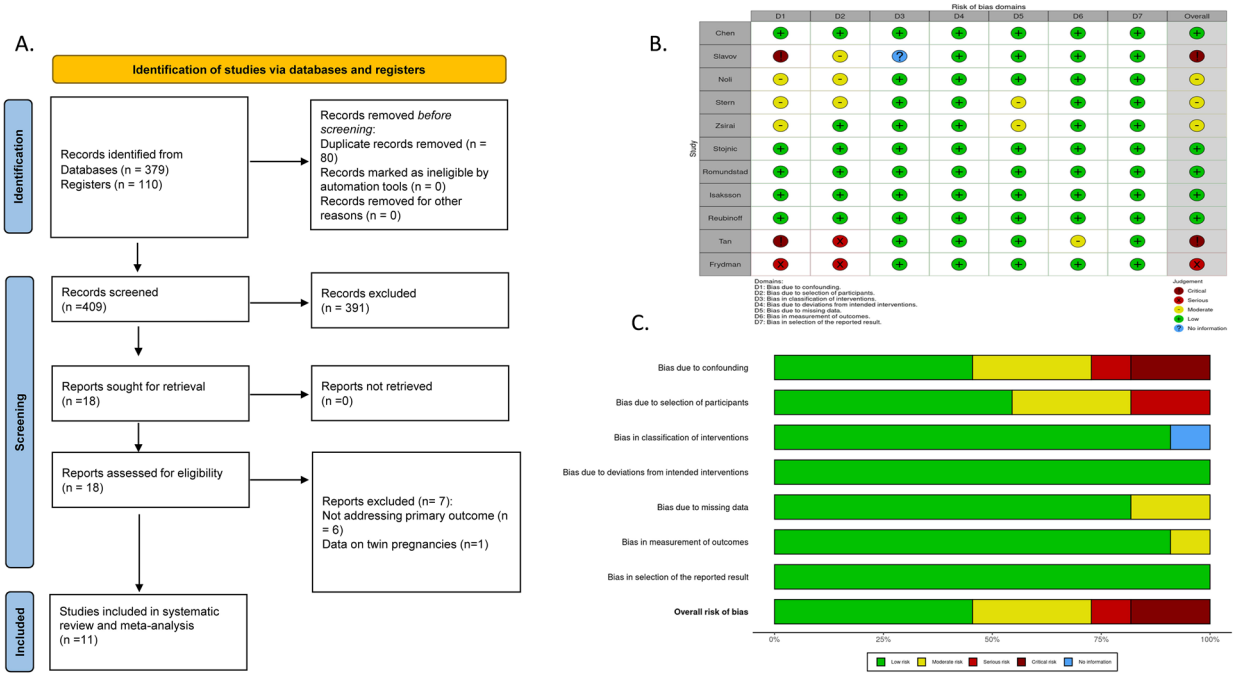


**Figure 1.** (A) Preferred reporting items for systematic reviews and meta-analyses flowchart, (B) ROBINS-1 per study, and (C) ROBINS-1 summary plot.

Statistical heterogeneity was quantified using $I^2$ statistics and Cochrane's *Q* tests. Heterogeneity was further examined through clinically relevant subgroupings as follows: (a) subgroup according to study design, (b) subgroup according to study weight, and (c) subgroup according to risk of bias. Funnel plot was used to explore for publication bias.

## Results

The initial search retrieved 489 results. After duplicates were removed, a total of 409 articles remained. We identified 18 studies eligible for full-text screening (Figure 1(A)). A total of 11 studies met eligibility criteria, including five retrospective [7, 16, 21–23], one ambidirectional [20], and five case-controls [17,18, 24–26]. As no eligible RCT was identified, the ROBINS-1 tool for assessing the risk of bias was utilized. Five studies were considered of low risk of bias [7, 16, 24–26], three of moderate risk of bias [21–23], and three of serious or critical risk of bias [17,18, 20] (Figure 1(B,C)). Overall, the certainty of evidence based on the GRADE framework was deemed to be low (Figure 2).

### *Study characteristics*

A total of 3,360,134 deliveries were included in the present meta-analysis. Of the included studies, one was

**Author(s):**

**Question:** [intervention] compared to [comparison] for [health problem and/or population]

**Setting:**

**Bibliography:**

| Certainty assessment | | | | | | | № of patients | | Effect | | Certainty | Importance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| № of studies | Study design | Risk of bias | Inconsistency | Indirectness | Imprecision | Other considerations | [intervention] | [comparison] | Relative (95% CI) | Absolute (95% CI) | | |
| **Malpresentation** | | | | | | | | | | | | |
| 11 | observational studies | serious[a] | not serious | serious[b] | not serious | strong association all plausible residual confounding would reduce the demonstrated effect | | | **RR 1.50** (1.30 to 1.73) | **2 fewer per 1,000** (from 2 fewer to 1 fewer) | ⨁⨁◯◯ Low | |

**CI:** confidence interval; **RR:** risk ratio

**Explanations**

a. control for confounding factors not adequate from the majority of included studies

b. The research question of some included studies was not malpresentation, but this could be extracted indirectly

**Figure 2.** Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) framework.

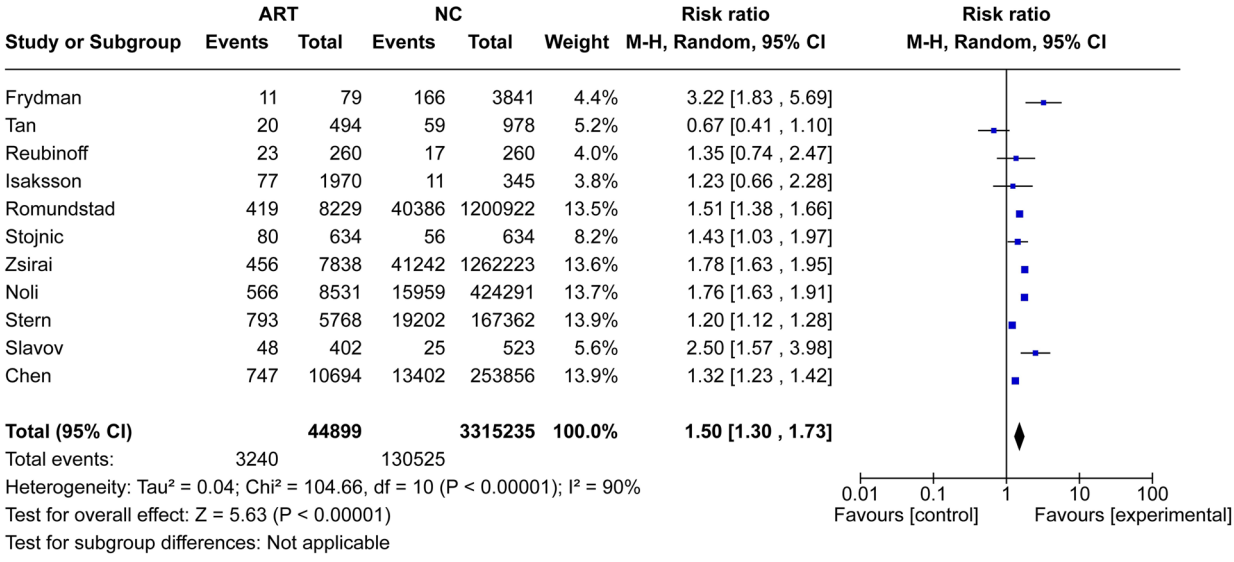


**Figure 3.** Maternal age (mean ± SD) (A) birthweight (mean ± SD) (B). Images generated with GraphPad Prism V. 9 (GraphPad Software, La Jolla, CA).

conducted in Australia [16], one in Bulgaria [20], one in Italy [21], one in the USA [22], one in Hungary [23], one in Serbia [24], one in Norway [7], one in Finland [25], one in Israel [26], one in England [17], and one in France [18]. Most of the studies under-reported the ethnicity of the participants. Of the total patient sample, 3,315,235 (98.7%) pregnancies were conceived naturally, whereas 44,899 (1.3%) were conceived through ART. There was no statistical difference between the mean maternal age and the mean birthweight of the two groups, $p = .1$ and $p = .35$, respectively (Figure 3).

## *Meta-analysis*

Collectively, regarding total malpresentation events, RR was 1.50 (95% confidence interval (CI) 1.30, 1.73), $I^2 = 90\%$ (Figure 4), suggesting that ART pregnancies are associated with 50% higher malpresentation risk than of those conceived naturally. To explore the notable heterogeneity, subgroup analyses, either by study design (cohort studies; RR = 1.38, 95% CI = 0.86, 2.20)/case-control studies; RR = 1.55, 95% CI = 1.33, 1.82) or by study weight (large studies; RR = 1.50, 95% CI = 1.27, 1.76/small studies; RR = 1.53, 95% CI = 0.99, 2.35) did not explain the high heterogeneity (Figures 5 and 6). However, when accounting only the low risk of bias studies in the meta-analysis, summative heterogeneity was successfully reduced to 15%, suggesting that subgrouping by risk of bias explained the differences between studies. As such, when introducing only the low risk of bias in the meta-analysis, RR was 1.43 (95% CI 1.32, 1.54), $I^2 = 15\%$ (Figure 7). To

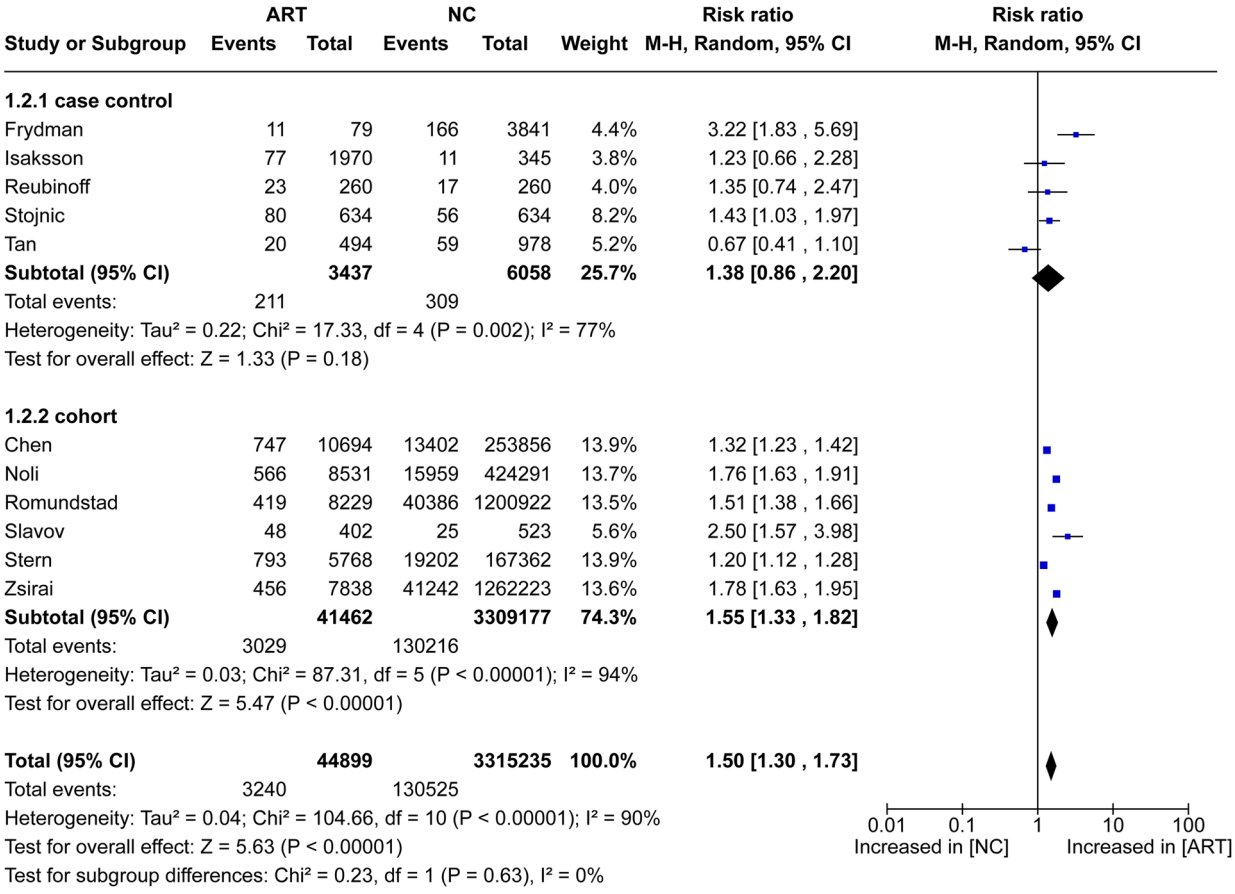


Figure 4. Forest plot regarding total malpresentation events.

account for confounders after adjusted RRs, a further analysis ($n$ = 4 studies) highlighted that ART pregnancies are associated with 12% higher malpresentation risk than those achieved naturally (RR = 1.12, 95% CI 1.02, 1.23) (Figure 8). The confounders that the studies adjusted for, namely maternal age, parity, birthweight, gestational age, maternal education, smoking, etc., are partially dissimilar. Therefore, the results of the adjusted RR forest plot should be examined with caution.

Lastly, publication bias was considered to be low, based on the symmetric appearance of the funnel plot (Figure 9).

## Discussion

In the present systematic review and meta-analysis, we aimed to explore the association of ART with fetal malpresentation compared to fetal malpresentation in spontaneously conceived pregnancies. The pooled estimated indicated that ART pregnancies may have 50% higher incidence of malpresentation than naturally conceived pregnancies, albeit the notably high heterogeneity.

A previous meta-analysis of observational studies regarding the same topic, concluded similar results with the present study (RR = 1.58; 95% CI: 1.17, 1.98) [31]. However, no analysis of available adjusted RRs was reported. As strong confounders can interfere in the association of the research question, we believe that an inclusion of adjusted RRs analysis is crucial.

The high heterogeneity between studies could be explained by the different characteristics of the included studies, the various confounding factors that have been taken into consideration in the analyses, and possibly the differentiation in ART techniques throughout time.

Several studies have suggested that the perinatal outcomes of ART pregnancies may be worse than those of naturally conceived pregnancies, primarily due to the increased maternal age and the resulting consequences in perinatal morbidity and mortality [32,33]. However, even in naturally conceived pregnancies with a fetal malposition, there is a higher incidence of low birth weight and prematurity [15, 34]. The reason why ART technology is associated with adverse perinatal outcomes is multifactorial and could be attributed to the IVF or ICSI technology, the

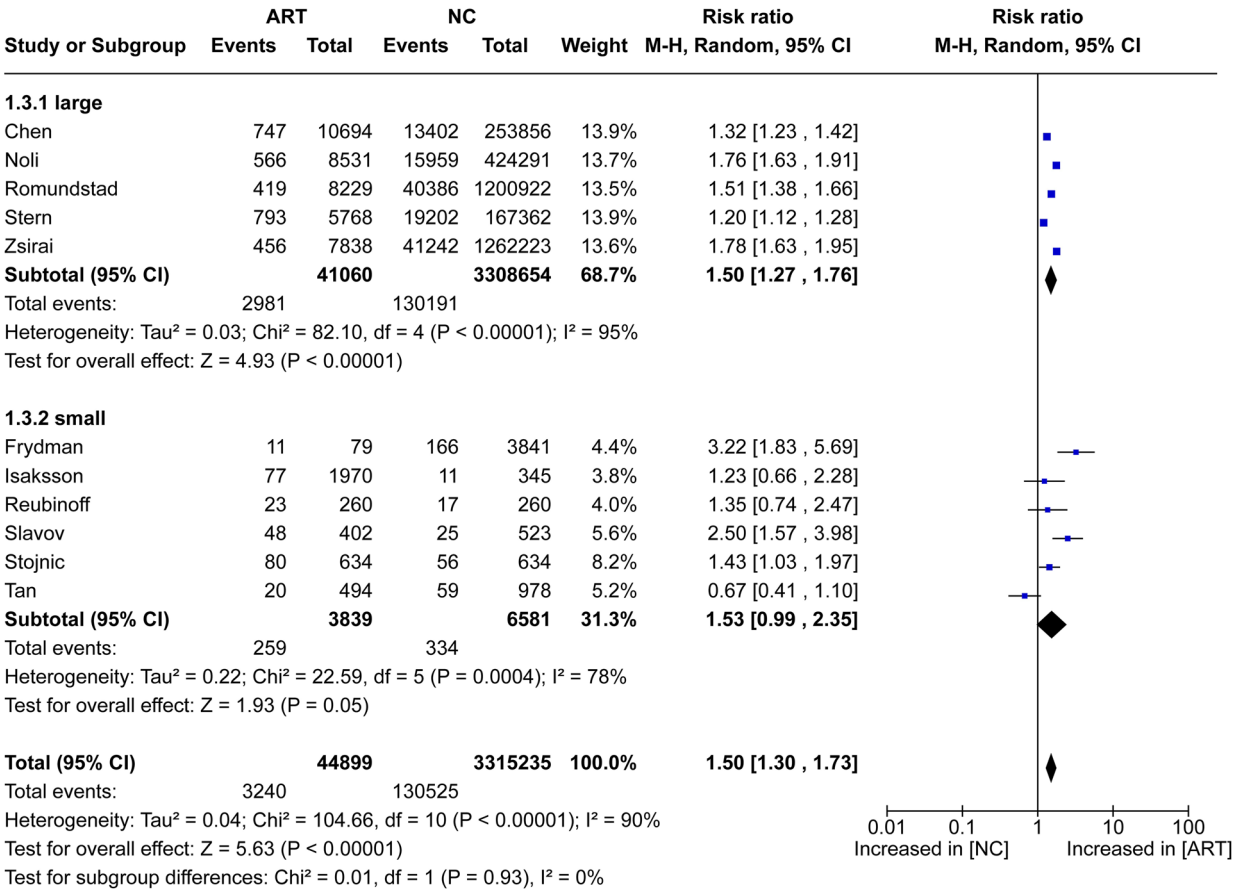


Figure 5. Forest plot subgroup by study type.

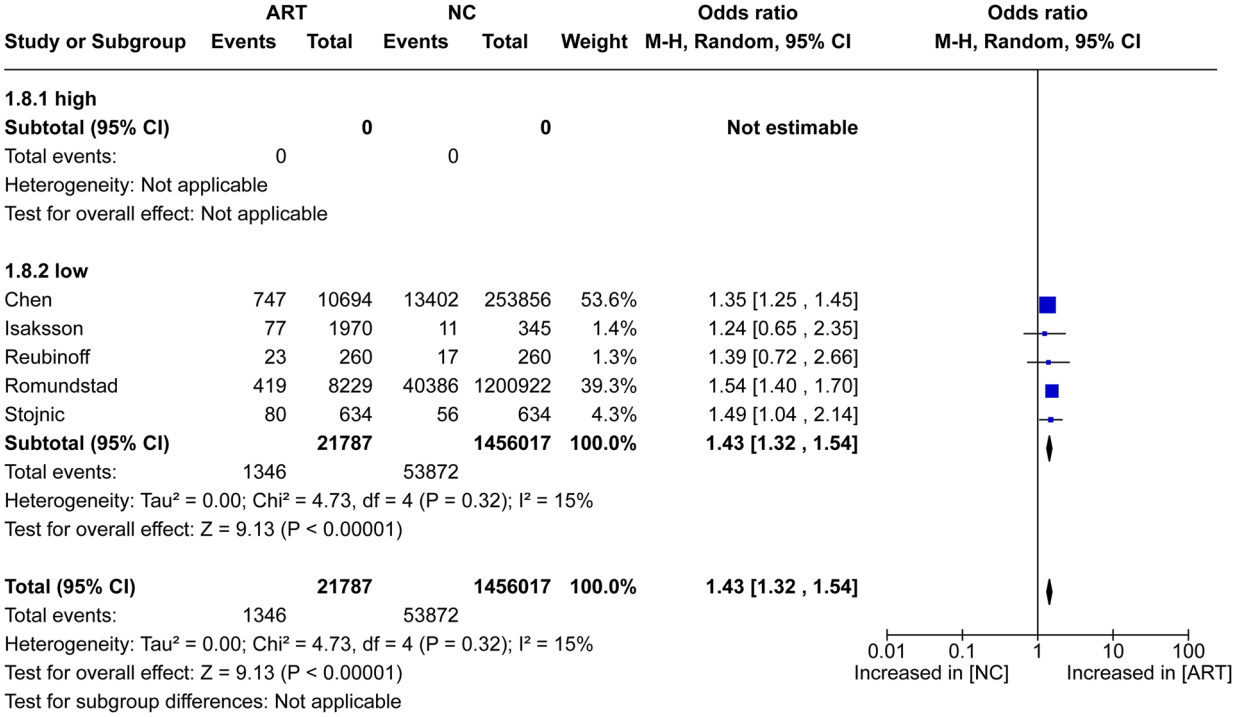


Figure 6. Forest plot subgroup by study weight.

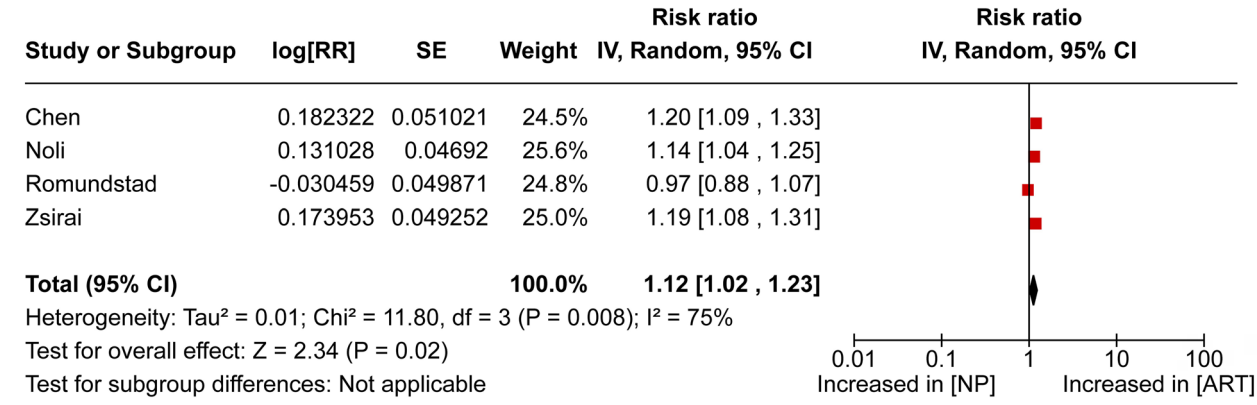


Figure 7. Forest plot subgroup by risk of bias.

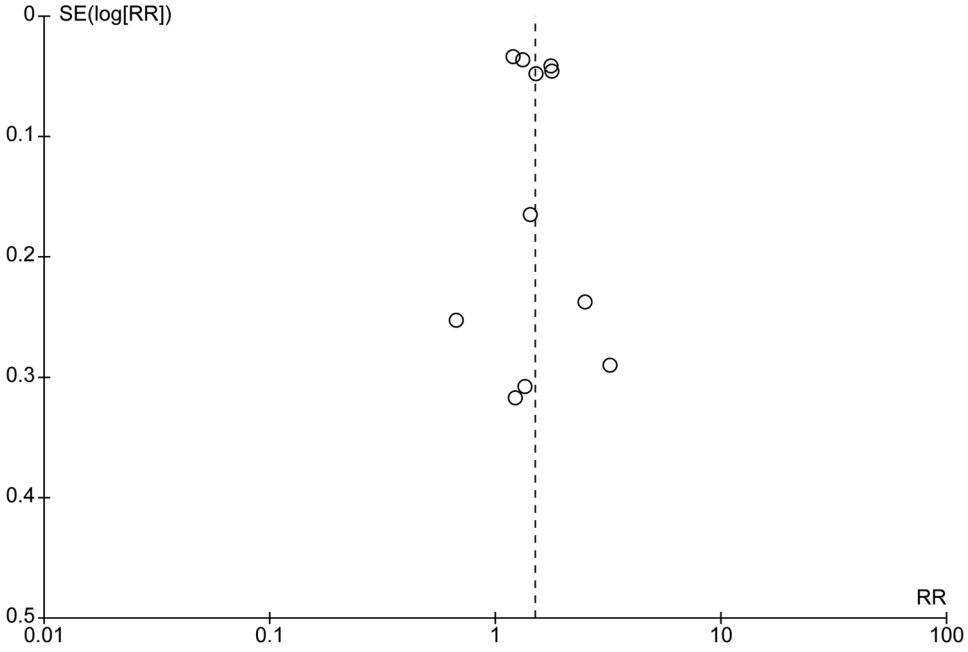


Figure 8. Forest plot of studies with adjusted RR.

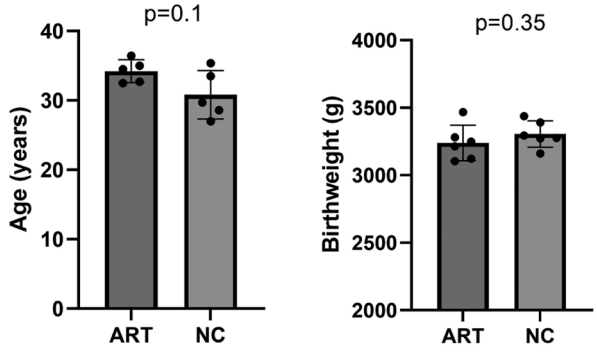


Figure 9. Funnel plot.

medications used, and the inherent patient characteristics [35]. Additionally, the choice of artificially thawed or fresh embryos for transfer may have different implications regarding perinatal outcomes, as studies have shown that frozen embryo transfers may be associated with a higher risk of preterm birth compared to fresh embryo transfers [36,37]. Furthermore, the timing of embryo transfer and the quality of the embryos used can also impact perinatal outcomes in ART pregnancies [35].

Overall, breech presentation is linked to worse birth outcomes than cephalic presentation, regardless of how the pregnancy was conceived (naturally or with ART) [7,8]. The question of the present meta-analysis was whether ART technology could lead to worse perinatal outcomes by increasing the odds of breech presentation. Various studies have indicated a higher risk of breech presentation in ART pregnancies than naturally conceived pregnancies [18, 25,26, 38–40]. However, inter-ART approach comparison, IVF

vs. ICSI, in terms of perinatal outcomes, did not highlight a statistically significant difference between the two techniques [35]. Several confounding factors that may affect the propensity for increased breech presentation in ART conceived pregnancies have been recognized. The most significant ones are reported to be maternal age, birthweight, gestational age and parity [7, 16]. While the crude odds ratios (ORs) have been notably higher in many studies, the adjusted ORs failed to highlight a significant difference between naturally- and ART-conceived pregnancies. This has been further indicated in the adjusted RR pool estimate analysis, which indicated a 12% increase in malpresentation risk with ART pregnancies. However, it should be noted that confounding factors adjusted in the four studies [7, 16, 21, 23] are not identical, suggesting that interpretation of the results should be with caution. None of the included studies controlled for uterine malformations [7, 41] or familiar predispositions [42] to breech presentation, which could also interfere in the questioned association.

Our study has several limitations. First, our analysis included only observational studies, which are susceptible to confounding factors. Expectedly, due to the ethical implications, randomized trials were not recorded, increasing in turn selection and attrition bias. Additionally, a notably high heterogeneity between the studies was identified, which was largely attributable to inherent risk of bias. Confounding factors upon the risk of breech delivery and/or other malpresentations such as previous cesarean section, polyhydramnios, congenital fetal and uterine abnormalities and placentation disorders, as well as ART specific parameters (ovarian stimulation protocol employed, quality and characteristics of embryos transferred) have been significantly under-reported across studies, in turn potentially skewing analysis integrity.

### *Wider implications for clinical practice*

Among the priority objectives of current obstetricians is the reductions of CS, since CSs are associated with worse maternal outcomes [11–13]. Regarding the management of breech deliveries, the findings from the Term Breech Trial (TBT) resulted in the adoption of CS for term breech pregnancies [43]. Following studies confirmed these results [44]. Consequently, to reduce the rate of CSs, the research community has focused on identifying risk factors related to breech presentation. This meta-analysis indicated that ART procedures are associated with an increased risk of malpresentation in general, albeit this association may be related to modifiable factors and underlying mechanisms that future studies should reveal.

## Conclusions

Singleton pregnancies conceived through ART may be associated with a higher risk of fetal malpresentation at delivery than those pregnancies conceived naturally. Adjusted for potential confounding factors, analysis highlighted that the risk is considerably lower than what was reported from the crude numbers. Future larger studies, controlled for the aforementioned confounders, should identify reversible and irreversible factors of fetal malpresentation and to highlight a structured clinical approach toward a reduction of the resulting perinatal mortality and morbidity.

## Author contributions

KS: conception of the idea, study design, screening, data extraction, data analysis, quality assessment, and writing. MP: study design, screening, data extraction, and quality assessment. OT: study design and writing. TK: study design and writing. NV: study design and writing. SLK: study design, data analysis and writing.

## Disclosure statement

No potential conflict of interest was reported by the author(s).

## Funding

The authors report no external funding for this study.

## ORCID

Konstantinos Stavridis http://orcid.org/0000-0001-6921-0573
Maria Pisimisi http://orcid.org/0000-0002-0913-5556
Theodoros Kalampokas http://orcid.org/0000-0003-1379-894X
Stavroula L. Kastora http://orcid.org/0000-0003-4470-5267

## Data availability statement

The data that support the findings of this study are openly available in figshare at https://doi.org/10.6084/m9.figshare.24316978.

## References

[1] Walker S, Scamell M, Parker P. Standards for maternity care professionals attending planned upright breech births: a Delphi study. Midwifery. 2016;34:1–12. doi: 10.1016/j.midw.2016.01.007.
[2] Zhou Z, Wu J, Zhang G, et al. Spontaneous cephalic version and risk factors for persistent breech presentation: a longitudinal retrospective cohort study. J Matern Fetal Neonatal Med. 2022;35(25):9452–9459. doi: 10.1080/14767058.2022.2041596.
[3] Fruscalzo A, Londero AP, Salvador S, et al. New and old predictive factors for breech presentation: our experi-

ence in 14 433 singleton pregnancies and a literature review. J Matern Fetal Neonatal Med. 2014;27(2):167–172. doi: 10.3109/14767058.2013.806891.

[4] Fianu S, Václavínková V. The site of placental attachment as a factor in the aetiology of breech presentation. Acta Obstet Gynecol Scand. 1978;57(4):371–372. doi: 10.3109/00016347809154033.

[5] Ben-Rafael Z, Seidman DS, Recabi K, et al. Uterine anomalies. A retrospective, matched-control study. J Reprod Med. 1991;36(10):723–727.

[6] Toijonen AE, Heinonen ST, Gissler MVM, et al. A comparison of risk factors for breech presentation in preterm and term labor: a nationwide, population-based case–control study. Arch Gynecol Obstet. 2020;301(2):393–403. doi: 10.1007/s00404-019-05385-5.

[7] Romundstad LB, Romundstad PR, Sunde A, et al. Assisted fertilization and breech delivery: risks and obstetric management. Hum Reprod. 2009;24(12):3205–3210. doi: 10.1093/humrep/dep301.

[8] Danielian PJ, Wang J, Hall MH. Long-term outcome by method of delivery of fetuses in breech presentation at term: population based follow up. BMJ. 1996;312(7044):1451–1453. doi: 10.1136/bmj.312.7044.1451.

[9] Macharey G, Gissler M, Rahkonen L, et al. Breech presentation at term and associated obstetric risks factors—a nationwide population based cohort study. Arch Gynecol Obstet. 2017;295(4):833–838. doi: 10.1007/s00404-016-4283-7.

[10] Azria E, Kayem G, Langer B, et al. Neonatal mortality and long-term outcome of infants born between 27 and 32 weeks of gestational age in breech presentation: the EPIPAGE cohort study. PLOS One. 2016;11(1):e0145768. doi: 10.1371/journal.pone.0145768.

[11] Macharey G, Toijonen A, Hinnenberg P, et al. Term cesarean breech delivery in the first pregnancy is associated with an increased risk for maternal and neonatal morbidity in the subsequent delivery: a National Cohort Study. Arch Gynecol Obstet. 2020;302(1):85–91. doi: 10.1007/s00404-020-05575-6.

[12] Weiniger CF, Lyell DJ, Tsen LC, et al. Maternal outcomes of term breech presentation delivery: impact of successful external cephalic version in a nationwide sample of delivery admissions in the United States. BMC Pregnancy Childbirth. 2016;16(1):150. doi: 10.1186/s12884-016-0941-9.

[13] Fernández-Carrasco FJ, Cristóbal-Cañadas D, Gómez-Salgado J, et al. Maternal and fetal risks of planned vaginal breech delivery vs planned caesarean section for term breech birth: a systematic review and meta-analysis. J Glob Health. 2022;12:04055. doi: 10.7189/jogh.12.04055.

[14] De Geyter C, Wyns C, Calhaz-Jorge C, et al. 20 years of the European IVF-monitoring Consortium Registry: what have we learned? A comparison with registries from two other regions. Hum Reprod. 2020;35(12):2832–2849. doi: 10.1093/humrep/deaa250.

[15] Jackson RA, Gibson KA, Wu YW, et al. Perinatal outcomes in singletons following in vitro fertilization: a meta-analysis. Obstet Gynecol. 2004;103(3):551–563. doi: 10.1097/01.AOG.0000114989.84822.51.

[16] Chen AX, Hunt RW, Palmer KR, et al. The impact of assisted reproductive technology and ovulation induction on breech presentation: a whole of population-based cohort study. Aust N Z J Obstet Gynaecol. 2023;63(3):434–440. doi: 10.1111/ajo.13663.

[17] Tan S-L, Doyle P, Campbell S, et al. Obstetric outcome of in vitro fertilization pregnancies compared with normally conceived pregnancies. Am J Obstet Gynecol. 1992;167(3):778–784. doi: 10.1016/s0002-9378(11)91589-0.

[18] Frydman R, Belaisch-Allart J, Fries N, et al. An obstetric assessment of the first 100 births from the in vitro fertilization program at Clamart, France. Am J Obstet Gynecol. 1986;154(3):550–555. doi: 10.1016/0002-9378(86)90600-9.

[19] Moher D, Liberati A, Tetzlaff J, et al. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. Ann Intern Med. 2009;151(4):264–269, w64. doi: 10.7326/0003-4819-151-4-200908180-00135.

[20] Slavov SS. Malpresentation of the fetus in singleton pregnancies after in vitro fertilization. Open Access Maced J Med Sci. 2021;9(B):573–576. doi: 10.3889/oamjms.2021.6450.

[21] Noli SA, Baini I, Parazzini F, et al. Preterm birth, low gestational age, low birth weight, parity, and other determinants of breech presentation: results from a large retrospective population-based study. Biomed Res Int. 2019;2019:9581439. doi: 10.1155/2019/9581439.

[22] Stern JE, Liu C-L, Cabral HJ, et al. Factors associated with increased odds of cesarean delivery in ART pregnancies. Fertil Steril. 2018;110(3):429–436. doi: 10.1016/j.fertnstert.2018.04.032.

[23] Zsirai L, Csákány GM, Vargha P, et al. Breech presentation: its predictors and consequences. An analysis of the Hungarian Tauffer Obstetric Database (1996–2011). Acta Obstet Gynecol Scand. 2016;95(3):347–354. doi: 10.1111/aogs.12834.

[24] Stojnic J, Radunovic N, Jeremic K, et al. Perinatal outcome of singleton pregnancies following in vitro fertilization. Clin Exp Obstet Gynecol. 2013;40(2):277–283.

[25] Isaksson R, Gissler M, Tiitinen A. Obstetric outcome among women with unexplained infertility after IVF: a matched case-control study. Hum Reprod. 2002;17(7):1755–1761. doi: 10.1093/humrep/17.7.1755.

[26] Reubinoff BE, Samueloff A, Ben-Haim M, et al. Is the obstetric outcome of in vitro fertilized singleton gestations different from natural ones? A controlled study. Fertil Steril. 1997;67(6):1077–1083. doi: 10.1016/s0015-0282(97)81442-2.

[27] Sterne JA, Hernán MA, Reeves BC, et al. ROBINS-I: a tool for assessing risk of bias in non-randomised studies of interventions. BMJ. 2016;355:i4919. doi: 10.1136/bmj.i4919.

[28] McGuinness LA. robvis: an R package and web application for visualising risk-of-bias assessments. Github; 2019 [cited 2021 Jul 31]. Available from: https://github.com/mcguinlu/robvis

[29] Guyatt G, Oxman AD, Akl EA, et al. GRADE guidelines: 1. Introduction—GRADE evidence profiles and summary of findings tables. J Clin Epidemiol. 2011;64(4):383–394. doi: 10.1016/j.jclinepi.2010.04.026.

[30] Review Manager Web (RevMan Web). Version 4.6.0. The Cochrane Collaboration; 2022. Available at revman.cochrane.org.

[31] Jenabi E, Khazaei S. The association of between assisted reproduction technology and malpresentation/induction of labor: a meta-analysis. J Matern Fetal Neonat Med.

2018;31(20):2782–2787. doi: 10.1080/14767058.2017.1355905.

[32] Gissler M, Malin Silverio M, Hemminki E. In-vitro fertilization pregnancies and perinatal health in Finland 1991–1993. Hum Reprod. 1995;10(7):1856–1861. doi: 10.1093/oxfordjournals.humrep.a136191.

[33] Workshop Group TEC. The ESHRE Capri Workshop Group. Hum Reprod. 2000;15(8):1856–1864. doi: 10.1093/humrep/15.8.1856.

[34] McGovern PG, Llorens AJ, Skurnick JH, et al. Increased risk of preterm birth in singleton pregnancies resulting from in vitro fertilization–embryo transfer or gamete intrafallopian transfer: a meta-analysis. Fertil Steril. 2004;82(6):1514–1520. doi: 10.1016/j.fertnstert.2004.06.038.

[35] Ombelet W, Cadron I, Gerris J, et al. Obstetric and perinatal outcome of 1655 ICSI and 3974 IVF singleton and 1102 ICSI and 2901 IVF twin births: a comparative analysis. Reprod Biomed Online. 2005;11(1):76–85. doi: 10.1016/s1472-6483(10)61302-8.

[36] Raja E-A, Bhattacharya S, Maheshwari A, et al. Comparison of perinatal outcomes after frozen or fresh embryo transfer: separate analyses of singleton, twin, and sibling live births from a linked national in vitro fertilization registry. Fertil Steril. 2022;118(2):323–334. doi: 10.1016/j.fertnstert.2022.05.010.

[37] Maheshwari A, Pandey S, Shetty A, et al. Obstetric and perinatal outcomes in singleton pregnancies resulting from the transfer of frozen thawed versus fresh embryos generated through in vitro fertilization treatment: a systematic review and meta-analysis. Fertil Steril. 2012;98(2):368–377.e9. doi: 10.1016/j.fertnstert.2012.05.019.

[38] Zádori J, Kozinszky Z, Orvos H, et al. Dilemma of increased obstetric risk in pregnancies following IVF-ET. J Assist Reprod Genet. 2003;20(6):216–221. doi: 10.1023/a:1024103427374.

[39] Wennerholm UB, Bergh C. Perinatal outcome in children born after assisted reproductive technologies. Ups J Med Sci. 2020;125(2):158–166. doi: 10.1080/03009734.2020.1726534.

[40] Silberstein T, Levy A, Harlev A, et al. Perinatal outcome of pregnancies following in vitro fertilization and ovulation induction. J Matern Fetal Neonatal Med. 2014;27(13):1316–1319. doi: 10.3109/14767058.2013.856415.

[41] Green LK, Harris RE. Uterine anomalies. Frequency of diagnosis and associated obstetric complications. Obstet Gynecol. 1976;47(4):427–429.

[42] Nordtveit TI, Melve KK, Albrechtsen S, et al. Maternal and paternal contribution to intergenerational recurrence of breech delivery: population based cohort study. BMJ. 2008;336(7649):872–876. doi: 10.1136/bmj.39505.436539.BE.

[43] Hannah ME, Hannah WJ, Hewson SA, et al. Planned caesarean section versus planned vaginal birth for breech presentation at term: a randomised multicentre trial. Term Breech Trial Collaborative Group. Lancet. 2000;356(9239):1375–1383. doi: 10.1016/s0140-6736(00)02840-3.

[44] Pasupathy D, Wood AM, Pell JP, et al. Time trend in the risk of delivery-related perinatal and neonatal death associated with breech presentation at term. Int J Epidemiol. 2009;38(2):490–498. doi: 10.1093/ije/dyn225.