Successful pregnancy and delivery in a Chinese female with pituitary stalk interruption syndrome following in vitro fertilization and embryo transfer: a case report and literature review

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Case Report

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Abstract

Background

Pituitary stalk interruption syndrome (PSIS) in female patients is mainly characterized by short stature, primary amenorrhea, absent or incomplete sexual maturation, and infertility. Successful pregnancies among these patients are still extremely rare. This study was designed to describe a successful pregnancy and delivery in a Chinese female with PSIS following in vitro fertilization and embryo transfer.

Methods

Contrast-enhanced magnetic resonance imaging (MRI) scanning of the hypothalamus-pituitary region and genetic analysis of PSIS-associated genes was performed via whole-exome sequencing to identify the potential genetic causes of this disorder. We additionally explored the feasibility to overcome the infertility by controlled ovarian hyperstimulation and frozen-thawed embryo transfer under multiple pituitary hormone supplementation.

Results

We found that the 28-year-old Chinese woman with PSIS exhibited characteristic symptoms including multiple pituitary hormone deficiency, typical triad signs in MRI scanning, undetectable serum gonadotropins and estradiol levels, and invisible antral follicles in both ovaries. While no pathogenic/possible pathogenic variants that could or partly explain the typical clinical phenotype of PSIS were found following whole-exome sequencing. At the first attempted controlled ovarian hyperstimulation cycle, 14 oocytes were retrieved, and 6 embryos were acquired. Artificial endometrial preparation and frozen-thawed embryo transfer were performed one month after oocyte retrieval, and one day-5 blastocyst was transferred, resulting in a clinical pregnancy. Under close monitoring during pregnancy and multiple hormones dosage modulation, she delivered a healthy boy by elective cesarean section and the newborn developed normally under 1-year follow-up.

Conclusions

This is the first report of a successful pregnancy achieved in a woman with PSIS following in vitro fertilization and frozen-thawed embryo transfer. Under continuous hormonal supplementation and pregnancy monitoring, in vitro fertilization and embryo transfer might serve as a safe and effective treatment for infertility among PSIS women.
Pituitary stalk interruption syndrome (PSIS) occurs in 0.5 in 1,000,000 live-born births, of which almost 80% are male[1]. The clinical manifestations of PSIS vary on the basis of single or multiple pituitary hormone deficiency (also known as panhypopituitarism), largely characterized by growth hormone deficiency accompanied with or without gonad, thyroid or adrenal gland dysfunction, while posterior pituitary function is essentially unaffected in these patients[2]. The diagnosis of PSIS was mainly based on hypopituitarism symptoms and typical triad signs in magnetic resonance imaging (MRI) scanning (hypoplastic anterior pituitary, ectopic posterior pituitary, and absence of pituitary stalk). Pituitary stalk interruption syndrome can be caused by perinatal delivery injury, immunity factors, genetic variations, etc.; however, the etiologies and pathogenic mechanisms of most patients are still poorly understood[3]. A history of abnormal perinatal delivery, trauma, or asphyxia during childbirth has been regarded as the major etiology in the occurrence and development of this disorder in the past few decades. In recent years, the discovery of familial cases and consanguineous cases has also suggested antenatal origins; thus, the hypothesis that a portion of pituitary development abnormalities may be attributed to genetic defects is widely accepted. The heterogeneity of the etiologies and pathogenesis hinders the precise and accurate discrimination of this disorder; therefore, appropriate therapeutic strategies are still lacking.

Several female cases affected by PSIS have been reported, while pregnancies either spontaneously or through assisted reproductive techniques in these women were very rare. Gonadotropins deficiency causes infertility in women with hypopituitarism due to ovarian follicle growth defects. Although advances in assisted reproductive techniques provide methods to restore fertility in women affected by hypopituitarism, only a few cases of successful pregnancy and delivery have been reported; additionally, high rates of obstetric and neonatal complications have been reported, perhaps due to uterine defects secondary to endocrine deficiency[4]. Optimizing the strategy of hormone replacement based on the physiological changes in the pituitary hormone axis during pregnancy in healthy women is a prerequisite for successful pregnancy and delivery. The placenta is now considered a new source of hormones during pregnancy. However, the potential effects of pregnancy on the pituitary function of hypopituitarism patients are still not clear.

In this case report, we described a case of successful pregnancy and delivery in a female of childbearing age characterized by multiple pituitary hormone deficiency, which was caused by PSIS. To the best of our knowledge, this is the first report to describe a successful pregnancy and delivery in PSIS female patients following in vitro fertilization and embryo transfer.

**Methods And Results**

**Clinical and biochemical presentation**

A 28-year-old female patient sought medical treatment for infertility without contraception for 4 years. She seemed well without any abnormal physical features and was 44 kg in weight and 155 cm in height (body mass index 18.31 kg/m²). The parents found that the girl was obviously shorter than her peers at the age of 7, and she was diagnosed with growth hormone deficiency based on the clinical symptoms
and biochemical testing; no detailed data on the height and weight of this patient during her development process were available. Additionally, the elevated thyroid stimulating hormone level and reduced free thyroxine level indicated a diagnosis of hypothyroidism, and a 4-cm elevation in height was achieved in half a year thanks to supplementation with growth hormone and levothyroxine (10 mg three times daily) following the diagnosis. Growth hormone supplementation therapy was discontinued after that due to personal reasons. Levothyroxine replacement therapy was resumed due to the diagnosis of hypothyroidism again from age 15 until now. The karyotype of her chromosomes was normal (46, XX). Menarche was not reached spontaneously until 18 years of age under estrogen replacement treatment, and the menstrual disorder was obviously improved; thus, the treatment was continued until now. Serum follicle-stimulating hormone (FSH) and luteinizing hormone (LH) levels were undetectable (< 0.1 IU/L), and estradiol levels were also under the detection limit (< 5 pg/ml) at the first visit to our clinic (Table 1). The uterus size, 3.4·1.9·3.1 cm, was slightly smaller than normal, and antral follicles were not detected under ultrasound detection. 17-β estradiol/17-β estradiol and dydrogesterone (2/10 mg, Femoston, Abbott, Netherlands) and estradiol valerate (2 mg, Progynova, Bayer, Germany) were orally prescribed daily to promote uterine development. Serum anti-Müllerian hormone (AMH) levels at the age of 29 were 1.52 ng/ml and 1.63 ng/ml with a 4-month interval. The uterus size increased to 5.5·2.8·4.2 cm during 2 years of estrogen replacement treatment, and thyroid function was also under the normal range with the assistance of levothyroxine supplementation, while antral follicles in both ovaries were still not observed. Due to multiple pituitary hormone deficiencies in this patient, pituitary MRI was performed to evaluate hypothalamic-pituitary and pituitary stalk function. Contrast-enhanced MRI scanning of the pituitary gland showed hypoplastic anterior pituitary, ectopic posterior pituitary, and absence of pituitary stalk (Fig. 1), indicating the typical triad of symptoms in PSIS. Thus, the diagnosis of PSIS was made according to the above clinical symptoms and MRI scanning.
Table 1

<table>
<thead>
<tr>
<th>Age (year)</th>
<th>15</th>
<th>28</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hight (cm)</td>
<td>121</td>
<td>155</td>
</tr>
<tr>
<td>Wight (kg)</td>
<td>21</td>
<td>41</td>
</tr>
<tr>
<td>Follicle-stimulating hormone (U/L)</td>
<td>2.5</td>
<td>0.1</td>
</tr>
<tr>
<td>Luteinizing hormone (U/L)</td>
<td>5.4</td>
<td>&lt; 0.1</td>
</tr>
<tr>
<td>Estradiol (pg/mL)</td>
<td>11.3</td>
<td>&lt; 5</td>
</tr>
<tr>
<td>Progesterone (ng/mL)</td>
<td>0.03</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>Testosterone (ng/mL)</td>
<td>0.02</td>
<td>&lt; 0.03</td>
</tr>
<tr>
<td>Prolactin (ng/mL)</td>
<td>0.04</td>
<td>3.25</td>
</tr>
<tr>
<td>Thyroid-stimulating hormone (mIU/L)</td>
<td>8.02</td>
<td>0.031*</td>
</tr>
<tr>
<td>free triiodothyronine (pg/ml)</td>
<td>1.03</td>
<td>3.26*</td>
</tr>
<tr>
<td>free thyroxine (ng/dl)</td>
<td>0.66</td>
<td>1.61*</td>
</tr>
<tr>
<td>Adrenocorticotropic hormone (pg/ml)</td>
<td>-</td>
<td>4.09</td>
</tr>
<tr>
<td>Anti-Müllerian hormone (ng/mL)</td>
<td>-</td>
<td>1.52</td>
</tr>
<tr>
<td>Uterus size (mm)</td>
<td>-</td>
<td>34<em>19</em>31</td>
</tr>
<tr>
<td>Ovarian size (mm)</td>
<td>-</td>
<td>Left: 16*12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Right: undetectable</td>
</tr>
</tbody>
</table>

*means that the hormone levels detected under levothyroxine supplementation therapy

This patient was the fourth child of a nonconsanguineous couple of Chinese Han origin, and short stature and other endocrine disorders were all absent in her three older sisters. She was born full term via vaginal delivery while in complete breech presentation, and she had moderate asphyxia during childbirth. The birth weight and length were normal, and no significant medical or family history of short stature was observed in this family. Symptoms of diabetes insipidus, such as polydipsia, polyuria, nocturia, and nocturnal enuresis, were not observed in this female. To identify the potential genetic causes of PSIS in this female, peripheral blood samples were collected, and whole-exome sequencing was performed using the BGISEQ-2000 sequencing platform by the Beijing Genome Institution (Wuhan, China) according to the manufacturer’s protocol. However, after several filtering steps and bioinformatics analysis of the sequencing data, no pathogenic/possible pathogenic variants that could or partly explain the typical clinical phenotype of PSIS were found in this female.
In Vitro Fertilization And Embryo Transfer

Before the controlled ovarian hyperstimulation (COH) cycle, the patient was placed on a 4-week pretreatment of hormone replacement therapy (17-β estradiol/17-β estradiol and dydrogesterone, 2/10 mg, Femoston) combined with rGH (recombinant human growth hormone; GeneScience Pharmaceuticals, Changchun, China) supplementation to promote the follicle development due to invisible antral follicles in both ovaries. Gonadotropin stimulation began on the second day of menstrual bleeding with daily intramuscular injection of 150 IU HMG (human menopausal gonadotropin, Menotrophins; Livzon, Zhuhai, China), accompanied by daily subcutaneous injections of 4.5 IU rGH and 2 mg estradiol valerate orally. Because of the slow growth rate of ovarian follicles, the dose of HMG was increased to 225 IU on the sixth day of stimulation, whereas the rGH and estradiol valerate doses remained unchanged. A gonadotropin-releasing hormone (GnRH) antagonist or agonist was not added to the patient because of extremely low levels of endogenous gonadotropins during the ovarian stimulation, which was similar to the functions of GnRH antagonist or agonist to inhibit premature LH surge. On day 13, the peak estradiol level was 3,328 pg/mL, 11 ovarian follicles reached 18 mm, the LH level was still under the detection threshold (< 0.1 IU/L), the progesterone level was 0.624 ng/ml, and the endometrial thickness was 8.5 mm with a trilaminar pattern. Final oocyte maturation was triggered with 3,000 IU HCG (human chorionic gonadotrophin; Livzon, Zhuhai, China), and the patient underwent transvaginal follicle aspiration under total intravenous anesthesia approximately 36 hours later. Fourteen oocytes were retrieved, of which 12 were mature (M-II) and 2 were immature (1 GV and 1 MI). Conventional in vitro fertilization was performed since the husband’s semen examination was normal. The patient made a full recovery after oocyte retrieval, and ovarian hyperstimulation syndrome did not appear. A day-3 eight-cell high-quality embryo was transferred 3 days after oocyte retrieval (Fig. 2), a biochemical pregnancy was achieved while no clinical pregnancy was established. Five high-quality blastocysts were cryopreserved by the Vitrification Cooling protocol for further frozen-thawed embryo transfer (FET). A serum AMH level tested before the frozen-thawed embryo transfer procedure revealed a slightly elevated level with a value of 2.88 ng/ml.

Artificial endometrial preparation was started with oral estradiol valerate (4 mg/d to 8 mg/d for a total of 23 days) and daily injection 4.5IU rGH approximately one month after the failure of fresh embryo transfer, in view of thin endometrial thickness (5.8 mm) after 23 days of oral estradiol valerate, higher doses of oral 17-β estradiol and addition of vaginal 17-β estradiol tablets (Femoston, Abbott) were administered with a maximum estradiol of 8 mg per day. And 75 IU HMG daily injection was co-administered due to the thin endometrial thickness (4.7 mm) on the 28th day of endometrial preparation until endometrial thickness reached 7 mm. After another 23 days of auxiliary addition of HMG, the endometrial thickness reached 7.3 mm with a trilaminar pattern, three ovarian follicles with a diameter of 9.5mm, 9.0mm, 7.5mm was observed and serum estradiol level was 4,510 pg/ml. One dose of 10,000 IU HCG in conjunction with progesterone in oil (20 mg) was administered by intramuscular injection for endometrial transformation, and routine luteal phase support methods were performed. One frozen-thawed 3AB blastocyst was transferred 5 days later (Fig. 3), and a clinical intrauterine pregnancy was established.
under transvaginal ultrasound 4 weeks later. Supplement with daily oral levothyroxine 100 µg, aspirin 0.1 g, prednisone 2.5 mg and subcutaneous injection of 4.5 IU rGH were administered consistently until the clinical pregnancy was established.

**Gestation Management**

After confirming the clinical pregnancy of this patient, a regular prenatal examination was conducted during the whole pregnancy. Several kinds of hormone replacement therapy, including growth hormone, levothyroxine and adrenocorticotropic hormone, along with luteal phase support medications were initiated or continued to use following pre-pregnancy prescription. Whether growth hormone supplementation should be continued during pregnancy remains unclear because of the unidentified maternal and fetal side effects of growth hormone supplementation. We reviewed the literature and decided to reduce the dosage of growth hormone to 0.3 mg (1 IU) daily, in view of the lack of sufficient safety data during pregnancy, from the gestation of 8 weeks until the end of the second trimester (gestation of 26 weeks) to discontinue the supplement. Levothyroxine doses were increased to 125 µg daily from 100 µg daily, and we exchanged prednisone to hydrocortisone with a dosage of 10 mg daily after 8 weeks of gestation until delivery. Serum levels of growth hormone, insulin-like growth factor-1, adrenocorticotropic hormone, cortisol, and thyroid hormone were carefully followed with monthly measurements during the entire pregnancy. A healthy male baby was delivered by elective cesarean section at a gestation of 36 weeks and 4 days (Fig. 4), weighing 2.86 kg with Apgar scores of 9/10 at 1 and 5 min respectively. The newborn was fed milk powder because the patient had no lactation after delivery, which might be due to the pituitary gland lacks prolactin secretion, as prolactin-releasing factors from the hypothalamus cannot be transmitted to the pituitary gland. The latest follow-up showed that the child was both physically and mentally healthy (including height, weight, intelligence and neurologic development were all comparable to his peers) at 1 year of age.

**Discussion**

Pituitary disorders are rare and can almost be accompanied by disorders of gonadal function and fertility. The clinical manifestations of this disorder are complex and diverse due to the heterogeneous etiologies of PSIS. Due to the popularization of MRI in clinical practice, case reports on PSIS have gradually increased in recent years. Typical MRI scanning plays a vital role in the diagnosis of PSIS. Several phenotypic features were very common in PSIS patients but occurred across a range of variations, including growth hormone deficiency (100%), gonadotrophins deficiency (97.2%), corticotrophin deficiency (88.2%), and thyroid hormone deficiency (70.3%)[8]. In addition, multiple anterior pituitary hormone deficiency was frequently (over 90%) observed in adult patients with PSIS[9, 10]. In our case, growth hormone deficiency, thyroid hormone deficiency, gonadotrophins deficiency and partial corticotrophin deficiency all presented gradually and generally progressed from childhood to adulthood. Hormone replacement therapy is an effective therapy approach and should be initiated as early as possible in these patients. Growth hormone plays an essential role during the growth period in humans,
and various other hormones can also affect growth rate\[11\]. If PSIS patients present before the joining of epiphyses, they still have a strong chance of reaching their normal height and preventing short stature under growth hormone supplementation. And gonadal steroid hormone supplementation should be postponed in these cases to prevent premature epiphyseal closure in the presence of estrogen exposure\[12\].

Male predominance was observed in this disorder, and the prevalence in females is approximately 1/7 of that in males\[10\] and is also rarely familial (approximately 5%)\[13\]. Panhypopituitarism in females is very rare, and the fertility of these patients has not been fully investigated. Furthermore, for late-onset PSIS, primary amenorrhea/oligomenorrhea or infertility could be the main clinical manifestation, but little is known about the optimal approach to treat fertility disorders in patients with adult-onset PSIS. In our case, although antral follicles were invisible in both ovaries and gonadotrophin levels were almost undetectable, the AMH level remained in the normal range and showed a mild elevation during the entire treatment. Given that folicle number is positively correlated with serum AMH levels, we propose that the ovarian reserve in this PSIS woman might not be compromised, although the hypothalamus-pituitary-gonadal axis was mostly disrupted, indicating that the controlled ovarian hyperstimulation process would still work to promote the activation and growth of quiescent follicles in this patient. Due to the extremely low levels of endogenous FSH and LH, follicle development and maturation are relatively difficult to obtain spontaneously, and in vitro fertilization treatment is an effective approach to adjust gonadotropin dosages to modulate the ovarian response to controlled ovarian hyperstimulation and to prevent the occurrence of ovarian hyperstimulation syndrome. Our data revealed that oocyte quality and quantity in females affected by PSIS were mainly not impaired, as demonstrated by the appreciable number of oocytes retrieved, and the successful pregnancy and healthy offspring obtained from frozen-thawed embryo transfer. Growth hormone supplementation in the process of in vitro fertilization have been reported to improve ovarian response to gonadotropins, endometrial receptivity, clinical pregnancy and live birth rates, especially in poor ovarian response patients\[14\]. Fresh embryo transfer failed to achieve clinical pregnancy and frozen-thawed embryo transfer with ultra-long estradiol replacement therapy to promote endometrial growth resulted in successful clinical pregnancy and delivery in our patient, suggesting that subsequent frozen-thawed embryo transfer might be an optimal therapeutic option for PSIS woman to achieve pregnancy. However, due to the limited data available, whether the quality and quantity of ovarian follicles are impaired in PSIS women remains to be elucidated in future investigations. Thus, follow-up of the growth development and long-term fertility of the offspring born from PSIS women is necessary to be closely monitored.

We searched the literature and found that several cases of successful pregnancies and deliveries were reported in panhypopituitarism female patients in the past few decades. Panhypopituitarism was mainly caused by surgical removal of pituitary macroadenoma\[15\], corticotropic adenoma\[16\], and suprasellar germinoma\[17\], while successful pregnancies and deliveries either spontaneously or by assisted reproduction were still not found in PSIS female patients. The results of a population-based study on pregnancy outcomes in women with panhypopituitarism showed that the risk of maternal infection and congenital anomalies was higher in women affected by panhypopituitarism, and no significant
differences were found in the risk of developing gestational hypertension, gestational diabetes mellitus, placental abruption, preterm delivery, small for gestational age or other pregnancy complications[18]. The results should be interpreted with caution due to the small number of cases in each subgroup and inaccurate documentation or missing data. The pregnancies recorded in this research were also mostly achieved by assisted reproduction, seeing that spontaneous pregnancies in patients affected by pituitary dysfunction were extremely difficult and only reported in partial hypopituitarism females with uncompromised gonadal function.

In addition, due to the deficiency of multiple pituitary hormones in female patients with PSIS, growth hormone, thyroxine and adrenal cortex hormones should be continuously supplemented and closely monitored throughout the entire pregnancy. Hormone replacement therapy in hypopituitary women is crucial during pregnancy. Recent reports suggested that increased risks of pregnancy in hypopituitarism were caused by uterine dysfunction, which resulted from maternal cortisol, thyroid hormone, and growth hormone deficiency[19]. To avoid potential uterine abnormalities and associated pregnancy complications, single-embryo transfer should be advocated in PSIS female patients. Due to major hormonal changes during pregnancy, hormone replacement therapy needs to be closely followed by endocrinologists, obstetricians and multidisciplinary cooperation. As hepatic corticosteroid-binding globulin and thyroxin-binding globulin production significantly increased under the effect of placental estrogen during normal pregnancy, an increased requirement of cortisol and thyroxin supplementation in hypopituitarism women during pregnancy should be noted[20]. In addition, growth hormone deficiency was another major contributor to the poor pregnancy rate in PSIS female patients. In females, growth hormone plays a fundamental role in follicular development and maturation. Growth hormone substitution can usually be continued during pregnancy in patients with growth hormone deficits, while no definitive conclusions have been established to date[21]. Therefore, whether the replacement of growth hormone during pregnancy is mandatory still needs further exploration.

In addition to pituitary insufficiency, PSIS can also be associated with other midline and ophthalmic abnormalities. While these abnormalities were relatively unusual (less than 10%) in Chinese patients[22], the female in our report also had no symptoms of midline defects or ophthalmic abnormalities. Fanconi’s anemia, a rare autosomal recessive hematological disease, was also observed to be accomplished by PSIS[23], suggesting that gene mutations may play a significant role in the pathogenesis of PSIS. In humans, multiple gene mutations or sequence variants in PROP1, PTCH1, PTCH2, LHX4, POU1F1, HESX1, OTX2, SOX3, NBPF9 and GPR161 and so on, have been postulated to be involved in PSIS[24–26].

Brauner et al. [27] performed exome sequencing in 52 PSIS cases and found that rare and novel genetic variants were identified in 75% of PSIS patients, which mainly involved in midline development and/or pituitary development or function, syndromic and non-syndromic forms of hypogonadotropic hypogonadism, syndromic forms of short stature, cerebellum atrophy with optic anomalies, axonal migration, and agenesis of the corpus callosum. Here, we failed to discover any candidate genetic variants associated with PSIS in this female using whole-exome sequencing and bioinformatic analysis, considering that the patient was born after a difficult breech delivery, we deduced that the pathogenesis of this disorder might be mostly due to perinatal trauma during childbirth. However, we still cannot
exclude the possibility that the proband may have an undetected genetic abnormality causing PSIS or increasing the susceptibility to damage to the hypothalamic-pituitary region, owing to the limitations of whole-exome sequencing. Moreover, Mendelian forms of PSIS are detected infrequently (less than 5%), and a polygenic etiology has also been suggested[28, 29]. Additionally, environmental factors may also be implicated in the pathogenesis of PSIS, and such environment-gene interactions may explain the spectrum of phenotypes seen in several PSIS pedigrees[30, 31].

Conclusions

In conclusion, to the best of our knowledge, this is the first report of successful pregnancy and delivery following in vitro fertilization and embryo transfer in a female with hypogonadism due to PSIS who continued growth hormone, thyroid hormone, and glucocorticoid supplementation therapy before and during pregnancy. This case indicated the feasibility of achieving successful pregnancy in female patients affected by PSIS under multiple pituitary hormone supplementation and close monitoring during pregnancy.

Abbreviations

PSIS: Pituitary stalk interruption syndrome; MRI: Magnetic resonance imaging; FSH, Follicle-stimulating hormone; LH, Luteinizing hormone; AMH: Anti-Müllerian hormone; COH: Controlled ovarian hyperstimulation; rGH: Recombinant human growth hormone; HMG: Human menopausal gonadotropin; GnRH: Gonadotropin-releasing hormone; HCG: Human chorionic gonadotrophin; FET: Frozen-thawed embryo transfer; E2: Estradiol; P: Progesterone; OPU: Oocyte pick-up; ACTH: Adrenocorticotropic hormone; COR: Cortisol; FT4: Free thyroxine; FT3: Free triiodothyronine; TSH: Thyroid-stimulating hormone; IGF-1: Insulin-like growth factor 1.

Declarations

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The authors would like to acknowledge the patient for participating and supporting this study.

Author contributions

JZ contributed to the research design, patient data collection, and drafting and revising the manuscript. XL, XZ, YL, ZW and LZ contributed to clinical disposition and manuscript revision. SC formulated clinical diagnosis and treatment plan, supervised the study, revised the manuscript, and approved the final version for publication. All authors contributed to the article and approved the final manuscript.

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**Availability of data and materials**

The original contributions presented in the study are included in the present article. Further inquiries about additional data and information are available from the corresponding author upon reasonable request.

**Ethics approval and consent to participate**

This study was approved by the Medical Ethics Committee of Nanfang Hospital, Southern Medical University (NFEC-2020-242). Written informed consent was obtained from the patient for the publication of this case report, and all procedures were performed in accordance with the Declaration of Helsinki.

**Consent for publication**

Not applicable.

**Competing interests**

The authors have no conflict of interest to declare.

**References**


Figures
Figure 1

Magnetic resonance imaging enhancement scanning of the pituitary of this female affected by pituitary stalk interruption syndrome. (A) Midsagittal enhanced T1-weighted image showed an ectopic posterior pituitary at the level of the median eminence (vertical arrow), along with a hypoplastic anterior pituitary, while the horizontal arrow points to the supposed pituitary stalk, which is absent. (B) Coronal T2-weighted image showing the ectopic posterior pituitary (vertical arrow) and the absence of a pituitary stalk.
Figure 2

The medication administration record and sex hormone values in the controlled ovarian hyperstimulation process are shown. Abbreviations: COH, controlled ovarian hyperstimulation; FSH, follicle-stimulating hormone; LH, luteinizing hormone; E2, estradiol; P, progesterone; rGH, recombinant human growth hormone; HMG, human menopausal gonadotropin; HCG, human chorionic gonadotrophin; OPU, oocyte pick-up.
Figure 3

The medication administration record and endometrial thickness values in the frozen-thawed embryo transfer cycles are shown. Abbreviations: FET, frozen-thawed embryo transfer; rGH, recombinant human growth hormone; HCG, human chorionic gonadotrophin
Figure 4

The medication administration record and several endocrine hormone values are shown. Abbreviations: ACTH, adrenocorticotropic hormone; COR, cortisol; HGH, human growth hormone; FT4, free thyroxine; FT3, free triiodothyronine; TSH, thyroid-stimulating hormone; IGF-1, insulin-like growth factor 1; rGH, recombinant human growth hormone