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Effects of lianggu decoction combined with clomiphene on insulin resistance, ovarian hemodynamics, and pregnancy outcomes in infertile patients with obese polycystic ovary syndrome

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ABSTRACT

Objective: To investigate the effects of Lianggu Decoction combined with clomiphene on insulin resistance, ovarian hemodynamics, and pregnancy outcomes in infertile patients with obese polycystic ovary syndrome (PCOS).

Methods: A total of 127 infertile patients with obese PCOS admitted between February 2022 and December 2023 were enrolled in the study. Patients were randomly assigned into a control group (n = 64, clomiphene alone) and an observation group (n = 63, clomiphene + Lianggu Decoction). Clinical efficacy, insulin resistance indices, blood glucose, blood lipids, body mass index (BMI), ovarian hemodynamics, serum sex hormone levels, ovulation rate, pregnancy outcomes, and adverse reactions were compared between the two groups.

Results: The total effective rate was significantly higher in the observation group ($P < 0.05$). After treatment, fasting plasma glucose (FPG), total cholesterol (TC), triglycerides (TG), and BMI were significantly lower in the observation group ($P < 0.05$). Fasting insulin (FINS) and the homeostasis model assessment of insulin resistance (HOMA-IR) were also lower in the observation group, while the HOMA of β-cell function (HOMA-β) was higher ($P < 0.05$). In terms of ovarian hemodynamics, pulsatility velocity spectrum (PVS) and pulsatility index (PI) were higher, whereas the resistance index (RI) was lower in the observation group ($P < 0.05$). Additionally, serum estradiol (E2), testosterone (T), luteinizing hormone (LH), and follicle-stimulating hormone (FSH) levels were lower in the observation group ($P < 0.05$). The ovulation rate and clinical pregnancy rate were significantly higher, while the miscarriage rate was lower in the observation group ($P < 0.05$). There was no significant difference in the incidence of adverse reactions between the two groups ($P > 0.05$).

Conclusion: Lianggu Decoction combined with clomiphene is effective in treating infertility in obese PCOS patients. It can significantly improve insulin resistance, glucose and lipid metabolism, sex hormone levels, and ovarian hemodynamics, thereby enhancing pregnancy outcomes.

Introduction

Polycystic ovary syndrome (PCOS) is a common endocrine disorder among women of reproductive age, characterized by a complex pathogenesis and multiple influencing factors. Its clinical manifestations include obesity, hirsutism, menstrual irregularities, and acne.[1] Obese PCOS patients often exhibit insulin resistance, which leads to disorders in glucose and lipid metabolism, pancreatic dysfunction, and subsequently ovulatory dysfunction, resulting in infertility.[2] Studies have shown that obesity increases the risk of insulin resistance, causing excessive insulin secretion and abnormal lipid metabolism, thereby exacerbating obesity.[3] In Traditional Chinese Medicine (TCM), PCOS falls under the categories of “amenorrhea”, “infertility”, “abdominal masses”, and “metrorrhagia”. It is primarily attributed to kidney-yin deficiency and yin-yang imbalance, with secondary manifestations of phlegm-dampness accumulation, blood stasis, and qi stagnation, leading to ovulatory dysfunction.[4] The Lianggu Decoction nourishes yin and kidneys, enriches blood and essence, eliminates dampness, and resolves blood stasis, and promotes the circulation of qi and blood in the uterus and the transformation of yin and yang. This supports

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follicular development and maturation, facilitating ovulation. Clomiphene is a commonly used ovulation-inducing drug with strong estrogen-antagonistic effects and mild agonistic properties. While it effectively improves ovulatory function in PCOS patients, it does not address endocrine disorders.[5] To investigate the effects of Lianggu Decoction combined with clomiphene on insulin resistance, ovarian hemodynamics, and pregnancy outcomes in obese PCOS patients with infertility, this study was conducted on 127 patients admitted to Cangzhou Hospital of Integrated Traditional and Western Medicine from February 2022 to December 2023. The findings are reported as follows.

Materials and methods

General information

A total of 127 infertile patients with obese polycystic ovary syndrome (PCOS) admitted to Cangzhou Hospital of Integrated Traditional Chinese and Western Medicine from February 2022 to December 2023 were enrolled in this study. Inclusion criteria: (1) Western medicine diagnosis met the criteria outlined in the *Chinese Guidelines for the Diagnosis and Treatment of Polycystic Ovary Syndrome*[6]; (2) Traditional Chinese medicine diagnosis was based on the *Guiding Principles for Clinical Research of New Chinese Medicines*[7] and *Gynecology of Traditional Chinese Medicine*,[8] with a syndrome type of kidney deficiency, phlegm-dampness, and blood stasis. Main symptoms included soreness and weakness of the lower back and knees, obesity, dark purple menstrual blood with clots, and a dark purple tongue with a white greasy coating. Secondary symptoms included dull complexion, listlessness, and increased nocturia; (3) Normal semen parameters in the male partner; (4) Body mass index (BMI) $>$ 28 kg/m^2; (5) Waist circumference $\geq$ 80 cm or waist-to-hip ratio $>$ 0.8. Exclusion criteria: (1) Infertility due to other causes; (2) Presence of other endocrine disorders; (3) Severe dysfunction of the heart, liver, kidneys, or other organs; (4) Use of hormones, immunosuppressants, or medications affecting glucose and lipid metabolism within the past month; (5) Allergy to medications used in this study; (6) Blood disorders, immune system diseases, malignancies, or psychiatric disorders. The study was approved by the hospital's medical ethics committee (czzx-19052), and all patients and their families provided informed consent. Patients were randomly assigned to an observation group (n = 63) and a control group (n = 64).

In the observation group, patients were aged 21–34 years, with a mean age of (27.93 ± 3.22) years, and a BMI of 29–33 kg/m^2, averaging (30.67 ± 1.23) kg/m^2. In the control group, patients were aged 20–36 years, with a mean age of (28.04 ± 3.46) years, and a BMI of 29–32 kg/m^2, averaging (30.21 ± 1.18) kg/m^2. No significant differences were observed in baseline characteristics between the two groups ($P > 0.05$) (Table 1).

Treatment methods

The control group received clomiphene tablets (approval number: H20140688; batch numbers: K1215, M0706, Q1001; manufacturer: Medochemie Ltd., Cyprus). Patients with regular menstruation took clomiphene from the 5th day of their menstrual cycle at a dose of 40 mg per dose, twice daily, for 5 consecutive days. Patients with amenorrhea or irregular menstrual cycles took clomiphene from the 5th day after progesterone withdrawal bleeding at a dose of 50 mg per dose, once daily, for 5 consecutive days. The observation group received Lianggu Decoction in addition to clomiphene treatment. The formula of Lianggu Decoction was as follows: Radix Rehmanniae Preparata (15 g), Radix Angelicae Sinensis (12 g), Semen Cuscutae (15 g), Fructus Lycii (15 g), Rhizoma Dioscoreae (15 g), Fructus Rubi (12 g), Herba Epimedii (12 g), Herba Cynomorii (12 g), Achyranthes bidentata (12 g), Radix Dipsaci (15 g), Radix Morindae Officinalis (10 g), Poria (15 g), Rhizoma Atractylodis Macrocephalae (10 g), and Rhizoma Atractylodis (10 g). For patients with significant liver qi stagnation, Chinese Rose Flower (10 g) and Cortex Albizziae (15 g) were added. For those with severe blood stasis, Carapax Trionycis (15 g) and Woodlouse (5 g) were added. The herbs were soaked in water for 30 minutes, boiled, and then simmered over low heat for 30 minutes. It was decocted twice, yielding 150 mL of herbal juice per dose, taken warm twice daily (morning and evening) alongside clomiphene, for 14 consecutive days. Both groups were treated for 1 month as one treatment cycle, with a total of 3 consecutive cycles.

Evaluation indicators

(1) Based on the *Clinical Diagnostic and Efficacy Evaluation Criteria of Diseases*, the treatment efficacy were classified as follows: significantly effective: marked improvement in clinical symptoms (menstrual irregularities, hirsutism, acne), restoration of normal menstrual cycles, normalization of biochemical indicators (sex hormones, lipids, insulin), and ultrasound-confirmed normal ovulation or dominant follicle formation; effective: improvement in clinical symptoms, near-normal menstrual cycles, improved biochemical indicators, and occasional ovulation observed on ultrasound; ineffective: no improvement or worsening of clinical symptoms, biochemical indicators, or ultrasound findings. The total effective rate was calculated as the sum of the significant efficacy and effective rates. (2) Blood glucose, lipids, and BMI: on the day before treatment initiation and the day after treatment completion, 4 mL of fasting venous blood was collected from each patient in the morning. Blood samples were centrifuged at 2000 r/min for 10 min, and the supernatant was stored at −20°C for further analysis. Fasting plasma glucose (FPG), triglycerides (TG), and total cholesterol (TC) were measured using the Roche c701 automatic biochemical analyzer and corresponding reagent kits. Body mass index (BMI) was calculated as BMI = weight (kg) / height^2 (m^2). (3) Insulin resistance indicators: Serum samples were collected as described above. Fasting insulin (FINS) was measured using enzyme-linked immunosorbent assay (ELISA). The homeostasis model assessment of insulin resistance (HOMA-IR) was calculated as: HOMA-IR = [FPG (mmol/L) × FINS (mIU/L)] / 22.5, and the HOMA of β-cell function (HOMA-β) was calculated as: HOMA-β = 20 × [FINS (mIU/L) / (FPG (mmol/L) - 3.5)]. (4) Ovarian hemodynamics: Transvaginal ultrasound (GE Voluson 730, GE Healthcare, USA) was used to measure the peak systolic velocity (PSV), resistance index (RI), and pulsatility index (PI). (5) Sex hormone levels: Serum samples were collected as described above. Levels of estrogen (E2), luteinizing hormone (LH), testosterone (T), and follicle-stimulating hormone (FSH) were measured using the Roche Cobas 8000

Table 1
Comparison of baseline characteristics between the two groups.

Group	Number of Cases	Age (Years)	Disease Duration (Years)	BMI (kg/m^2)
Observation	63	27.93 ± 3.22	4.62 ± 1.24	30.67 ± 1.23
Control	64	28.04 ± 3.46	4.71 ± 1.27	30.41 ± 1.28
t value		0.185	0.404	1.167
P value		0.853	0.687	0.246

Note: BMI: Body Mass Index.

e602 electrochemiluminescence immunoassay analyzer and corresponding reagent kits. (6) Ovulation rate and pregnancy outcomes: all patients were followed up for 6 months to record ovulation, pregnancy, and miscarriage rates. Ovulation, clinical pregnancy, and miscarriage rates were assessed using the GE Voluson 730 ultrasound system. Clinical pregnancy was defined as the presence of a gestational sac and primitive cardiac activity on ultrasound. (7) Adverse reactions: adverse events such as abdominal pain, ovarian enlargement, and gastrointestinal reactions were recorded for both groups.

Statistical analysis

Data were analyzed using SPSS 26.0 statistical software. Continuous variables following a normal distribution were analyzed using the *t*-test. Categorical variables were expressed as percentages (%) and analyzed using the χ^2 test. A P value < 0.05 was considered statistically significant.

Results

Comparison of clinical efficacy between the two groups

The total effective rate was significantly higher in the observation group than in the control group ($P < 0.05$). See Table 2 for details.

Comparison of blood glucose, lipid levels, and BMI

Before treatment, there were no significant differences in blood glucose, lipid levels, or BMI between the two groups ($P > 0.05$). After treatment, both groups showed significant changes ($P < 0.05$). The observation group had significantly lower FPG, TC, TG, and BMI ($P < 0.05$). See Table 3 for details.

Comparison of insulin resistance indicators

Before treatment, there were no significant differences in insulin resistance indicators between the two groups ($P > 0.05$). After treatment, significant changes were observed in both groups ($P < 0.05$). Specifically, FINS and HOMA-IR were significantly lower, while HOMA-β was higher in the observation group ($P < 0.05$). The results are presented in Table 4.

Comparison of ovarian hemodynamics

Before treatment, no significant differences were observed between the two groups ($P > 0.05$). After treatment, PVS and PI were significantly higher, while RI was lower in the observation group ($P < 0.05$). The results are presented in Table 5.

Comparison of serum sex hormone levels

Before treatment, there were no significant differences in serum sex hormone levels between the two groups ($P > 0.05$). After treatment, significant changes were observed in both groups ($P < 0.05$). The observation group showed significantly lower levels of E2, T, LH, and FSH compared to the control group ($P < 0.05$). The results are presented in Table 6.

Comparison of ovulation rate and pregnancy outcomes

The observation group exhibited a significantly higher ovulation rate and clinical pregnancy rate compared to the control group, while the miscarriage rate was significantly lower in the observation group than in the control group ($P < 0.05$). The results are presented in Table 7.

Comparison of adverse reactions

There was no statistically significant difference in the incidence of adverse reactions between the two groups ($P > 0.05$). See Table 8.

Discussion

Polycystic ovary syndrome (PCOS) is characterized by hyperandrogenism, persistent anovulation, polycystic ovarian morphology, and increased ovarian volume. It is often accompanied by severe glucose and lipid metabolism disorders, which can exacerbate renal dysfunction. The underlying cause of PCOS lies in the excessive secretion of hormones by the pituitary gland, leading to endocrine disorders that stimulate polycystic changes in the ovaries, ultimately resulting in infertility.[9,10] Approximately 40–60 % of PCOS patients present with obesity. Obese PCOS patients often experience insulin resistance, which can trigger a compensatory increase in insulin secretion, leading to abnormal glucose and lipid metabolism. Furthermore, obesity stimulates the ovaries to secrete excessive endogenous androgens, leading to increased adipocyte size and visceral fat deposition, thereby creating a vicious cycle that worsens the condition.[11,12]

Clomiphene, a synthetic non-steroidal agent, exhibits a potent antiestrogenic effect. It acts on the hypothalamic-pituitary system by competitively binding to estrogen receptors, thereby disrupting the negative feedback effect of estrogen on the hypothalamus. This stimulates the secretion of gonadotropins, which promotes follicular growth and development. However, long-term use of clomiphene is associated with multiple adverse effects, and approximately 20 % of patients exhibit clomiphene resistance.[13] A study by Chen et al. demonstrated that the combination of Bushen Huoxue Decoction (tonifying the kidneys and promoting blood circulation) with clomiphene significantly improves pregnancy outcomes in obese PCOS patients. This combined approach effectively enhances endometrial receptivity, reduces insulin resistance, increases ovulation and pregnancy rates, and reduces miscarriage rates.[14]

The kidneys are considered the foundation of congenital essence, the root of primordial qi, and the repository of innate essence. Kidney essence nourishes the Chong and Ren meridians through the channels, playing a crucial role in regulating menstruation and reproductive activities in women. When kidney qi is deficient, kidney essence becomes depleted, leading to inadequate nourishment of the Chong and Ren meridians. Consequently, the deficiency of these meridians causes spleen deficiency, which in turn weakens its transportation and transformation functions. This dysfunction results in the accumulation of dampness into phlegm, which, over time, leads to blood stasis, obstructing the uterus. The lack of nourishment in the uterus and the dysregulation of the Chong and Ren meridians may manifest as excessive body fat, a plump physique, and excessive hair growth. These imbalances lead to delayed menstruation, even amenorrhea, and an

Table 2
Comparison of clinical efficacy between the two groups.

Group	Number of Cases	Significantly effective	Effective	Ineffective	Total effective rate
Observation	63	17 (27.0 %)	41 (65.1 %)	5 (7.9 %)	58 (92.1 %)
Control	64	12 (18.8 %)	36 (56.2 %)	16 (25.0 %)	48 (75.0 %)
χ^2 value					6.698
P value					0.010

Table 3
Comparison of blood glucose, blood lipid and BMI between two groups.

Group	FPG (mmol/L)		t value	P value	TG (mmol/L)		t value	P value
	Before treatment	After treatment			Before treatment	After treatment		
Observation (n = 63)	7.86 ± 1.53	6.01 ± 1.14	7.696	0.000	1.96 ± 0.56	1.23 ± 0.31	9.052	0.000
Control (n = 64)	7.81 ± 1.42	6.62 ± 1.08	5.336	0.000	1.90 ± 0.42	1.54 ± 0.35	5.268	0.000
t value	0.191	3.096			0.684	5.281		
P value	0.849	0.002			0.495	0.000		
Group	TC (mmol/L)		t value	P value	BMI (kg/m^2)		t value	P value
	Before treatment	After treatment			Before treatment	After treatment		
Observation (n = 63)	6.42 ± 1.04	4.67 ± 0.93	9.956	0.000	29.67 ± 2.23	24.37 ± 1.52	15.588	0.000
Control (n = 64)	6.38 ± 1.02	5.12 ± 0.92	7.338	0.000	29.21 ± 2.18	25.93 ± 1.71	9.471	0.000
t value	0.219	2.741			1.176	5.431		
P value	0.827	0.000			0.242	0.000		

Note: FPG: Fasting Plasma Glucose; TG: Triglycerides; TC: Total Cholesterol.

inability to conceive, ultimately resulting in infertility.[15] Therefore, the treatment of obese PCOS-related infertility should focus on invigorating the spleen, dispelling dampness, tonifying the kidneys, and promoting blood circulation. Liugu Decoction is a classical foundational formula for infertility treatment, derived from *Liuwei Dihuang Pills* and *Wuzi Yanzong Pills*. Radix Rehmanniae Preparata nourishes the kidney, enriches yin, replenishes essence and the marrow; Radix Angelicae Sinensis and Radix Cyathulae tonify the liver and kidney, nourish and invigorate blood, regulate menstruation, and relieve pain; Semen Cuscutae, Herba Epimedii, and Herba Cynomorii enhance kidney yang and replenish essence and blood; Fructus Lycii replenishes essence and blood, nourishes the liver and kidneys; Rhizoma Dioscoreae strengthens the stomach, nourishes the spleen, astringes essence, and tonifies the kidney; Fructus Rubi strengthens the kidney, consolidates essence, reduces excessive urination, nourishes the liver, and improves vision; Radix Dipsaci and Radix Morindae Officinalis dispel cold and dampness, warm and tonify kidney yang, and strengthen tendons and bones; Poria and Rhizoma Atractylodis Macrocephalae fortify the spleen, promote diuresis, and eliminate dampness; Rhizoma Atractylodis dries dampness, strengthens the spleen, and expels wind-cold; and Fructus Crataegi promotes digestion, removes food stagnation, regulates blood lipids and blood pressure. Overall, the formula follows a syndrome differentiation-based approach with modifications as needed, achieving a combined therapeutic effect of fortifying the spleen and resolving dampness, warming and tonifying kidney yang, and invigorating blood to eliminate stasis.

This study showed that the overall effective rate in the treatment group was significantly higher than in the control group, indicating that the combination of Liugu Decoction and clomiphene is highly effective for treating obesity-related PCOS infertility. Clomiphene stimulates follicular growth and development, while Liugu Decoction improves serum sex hormone levels and glucose-lipid metabolism. The combined therapy exerts a synergistic effect, reducing BMI, improving metabolic abnormalities and insulin resistance, regulating reproductive endocrine disorders, enhancing follicular quality, promoting ovulation, and increasing pregnancy rates.

Obesity induces insulin resistance and hyperinsulinemia, leading to glucose and lipid metabolism disorders and an increase in BMI. Studies have shown that insulin resistance in PCOS is associated with androgen levels, as insulin resistance stimulates ovarian androgen production.[16] Hyperandrogenemia impairs follicular development and ovulation by inhibiting hepatic synthesis of sex hormone-binding globulin, leading to increased intraovarian androgen levels. This results in follicular atresia, inhibition of dominant follicles development, persistent anovulation, and infertility while also increasing the risk of ovarian hyperstimulation syndrome.[17] The present study demonstrated that after treatment, FPG, TC, TG, and BMI were significantly lower in the treatment group. Additionally, FINS and HOMA-IR levels were lower, while HOMA-β was higher in the treatment group, suggesting that the combined therapy effectively reduces androgen levels, alleviates insulin resistance, improves pancreatic β-cell function, promotes lipid metabolism, ameliorates metabolic and hormonal imbalances, reduces body weight,

Table 4
Comparison of insulin resistance indicators between the two groups.

Group	FINS (mU/L)		t value	P value	HOMA-IR		t value	P value
	Before treatment	After treatment			Before treatment	After treatment		
Observation (n = 63)	11.46 ± 1.32	5.42 ± 1.33	25.584	0.000	4.05 ± 0.43	1.86 ± 0.32	32.430	0.000
Control (n = 64)	11.21 ± 1.11	7.31 ± 1.54	16.435	0.000	4.01 ± 0.51	2.40 ± 0.46	18.754	0.000
t value	1.156	7.397			0.478	7.668		
P value	0.250	0.000			0.634	0.000		

Group	HOMA-β		t value	P value
	Before treatment	After treatment		
Observation (n = 63)	125.48 ± 16.73	172.14 ± 23.58	12.810	0.000
Control (n = 64)	126.75 ± 17.21	150.49 ± 20.53	7.089	0.000
t value	0.422	5.521		
P value	0.674	0.000		

Note: FINS: Fasting Insulin; HOMA-IR: Homeostatic Model Assessment of Insulin Resistance; HOMA-β: Homeostatic Model Assessment of Beta-cell Function.

Table 5
Comparison of ovarian hemodynamics between the two groups.

Group	PVS (m/s)		t value	P value	PI		t value	P value
	Before treatment	After treatment			Before treatment	After treatment		
Observation (n = 63)	13.76 ± 1.57	32.04 ± 5.03	27.535	0.000	0.75 ± 0.13	1.30 ± 0.25	15.493	0.000
Control (n = 64)	13.97 ± 1.64	24.86 ± 4.03	20.023	0.000	0.76 ± 0.15	0.93 ± 0.17	5.999	0.000
t value	0.737	8.885			0.401	9.767		
P value	0.463	0.000			0.689	0.000		

Group	RI		t value	P value
	Before treatment	After treatment		
Observation (n = 63)	0.87 ± 0.14	0.43 ± 0.06	22.929	0.000
Control (n = 64)	0.89 ± 0.17	0.70 ± 0.09	7.902	0.000
t value	0.723	19.860		
P value	0.471	0.000		

Note: PVS: Peak Systolic Velocity; PI: Pulsatility Index; RI: Resistance Index.

enhances ovulation, and increases pregnancy rates. Fructus Crataegi, a key component of Liugu Decoction, contains triterpenoids and flavonoids that help mitigate insulin resistance, enhance insulin secretion, regulate lipid metabolism, inhibit hepatic TC synthesis, and promote hepatic TC uptake.[18] Additionally, it dilates blood vessels and regulates blood pressure. Fructus Lycii contains guanidine derivatives that reduce insulin resistance and blood glucose levels, while its polysaccharides stimulate gonadotropin secretion, thereby modulating the hypothalamic-pituitary-gonadal axis and promoting reproductive cell development. Rhizoma Atractylodis Macrocephalae contains volatile oils and polysaccharides that regulate spleen-stomach function and enhance immune response.

This study also found that after treatment, PVS and PI were significantly higher, while RI was significantly lower in the observation group. These findings suggest that the combined therapy reduces ovarian vascular resistance, increases blood flow velocity, restores ovarian blood supply, enhances endometrial receptivity, and improves ovarian reserve function, thereby promoting follicular development and increasing pregnancy rates. Liugu Decoction nourishes kidney qi, activates blood circulation, improves ovarian hemodynamics, reduces ovarian volume, and increases endometrial thickness. The inclusion of Radix Angelicae Sinensis and Radix Cyathulae supports liver and kidney function and promotes blood circulation. Furthermore, after treatment, serum levels of E2, T, LH, and FSH were significantly lower in the observation group. Ovulation and clinical pregnancy rates were higher, while miscarriage rates were lower in the observation group, indicating that the combination therapy normalizes sex hormone levels, ameliorates endocrine imbalances, supports the development of reproductive organs, and enhances fertility. Pharmacological studies have shown that Semen Cuscutae regulates the hypothalamic-pituitary-ovarian axis, enhances pituitary responsiveness to gonadotropin-releasing hormone, and exerts estrogen-like effects that improve reproductive endocrine function.[19,20] Additionally, Herba Epimedii, which contains icariin, Icariside II, and other bioactive compounds, enhances endocrine function, exhibits hormone-like effects, regulates cellular metabolism, and boosts immune function. Moreover, the incidence of adverse reactions did not significantly differ between the two groups, indicating that the combined therapy is safe and clinically applicable.

Table 7
Comparison of ovulation rate and pregnancy outcomes between two groups.

Group	Ovulation rate	Pregnancy rate	Miscarriage rate
Observation (n = 63)	96.8 (61/63)	95.2 (60/63)	3.2 (2/63)
Control (n = 64)	81.3 (52/64)	70.3 (45/64)	21.9 (14/64)
χ^2 value	7.852	13.772	10.083
P value	0.005	0.000	0.001

Table 6
Comparison of serum sex hormone levels between two groups.

Group	E_2 (pmol/L)		t value	P value	LH (U/L)		t value	P value
	Before treatment	After treatment			Before treatment	After treatment		
Observation (n = 63)	147.62 ± 19.83	110.29 ± 16.41	11.511	0.000	10.27 ± 2.41	7.03 ± 1.56	8.958	0.000
Control (n = 64)	149.04 ± 18.84	131.28 ± 17.62	5.508	0.000	10.49 ± 2.73	8.17 ± 1.63	5.837	0.000
t value	0.414	6.945			0.481	4.026		
P value	0.680	0.000			0.631	0.000		

Group	T (μg/L)		t value	P value	FSH (U/L)		t value	P value
	Before treatment	After treatment			Before treatment	After treatment		
Observation (n = 63)	78.56 ± 5.13	43.28 ± 3.12	46.638	0.000	6.13 ± 0.81	4.41 ± 0.53	14.104	0.000
Control (n = 64)	78.92 ± 5.43	51.39 ± 4.25	31.940	0.000	6.24 ± 0.86	4.95 ± 0.66	9.520	0.000
t value	0.384	12.243			0.742	5.079		
P value	0.702	0.000			0.460	0.000		

Note: E2: Estradiol; LH: Luteinizing Hormone; T: Testosterone; FSH: Follicle-Stimulating Hormone.

Table 8
Comparison of adverse reactions between the two groups.

Group	Abdominal pain	Ovarian enlargement	Pelvic pain	Incidence of adverse reactions (%)
Observation (n = 63)	1	0	1	3.2 (2/63)
Control (n = 64)	1	1	1	4.7 (3/64)
χ^2 value				0.192
P value				0.661

Conclusion

In conclusion, Liugu Decoction combined with clomiphene is an effective treatment for obesity-related PCOS infertility. It significantly improves insulin resistance, glucose-lipid metabolism, sex hormone levels, and ovarian hemodynamics, ultimately enhancing pregnancy outcomes.

Declarations

Not applicable.

Authors' contributions

Y. Wang: Conceptualization, Methodology, Investigation. X. Hu, X. Mu: Data collection and collation, Statistical analysis, Visualization (figures and tables), Writing – original draft. P. Peng: Writing – review & editing, Quality control, Supervision, Responsibility for the overall integrity of the paper, Project administration.

Ethics approval and consent to participate

This study has been approved by the Medical Ethics Committee of Cangzhou Traditional Chinese and Western Medicine Hospital in Hebei Province (Approval No: czzx-19052).

Consent for publication

Not applicable.

Availability of data and materials

Not applicable.

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Declarations of Competing interests

The authors declare that they have no competing interests.

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Authors' other information

Not applicable.

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