

Levonorgestrel Intrauterine Therapy for Heavy Menstrual Bleeding: A Synthetic Comparative Study

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Abstract

Background: Heavy menstrual bleeding can impair daily functioning and contribute to iron-deficiency anemia. The levonorgestrel-releasing intrauterine system provides sustained endometrial suppression, whereas tranexamic acid reduces menstrual blood loss through antifibrinolytic activity. Comparing these approaches requires attention to bleeding control, hematologic recovery, and patient preferences.

Objective: To illustrate a clinically plausible framework for comparing six-month outcomes with intrauterine levonorgestrel and oral tranexamic acid using explicitly synthetic data.

Methods: An aggregate, nonrandomized comparison was constructed for 120 hypothetical women aged 25–45 years, divided equally between treatments. The scenario excluded pregnancy, suspected malignancy, active pelvic infection, and uterine cavity distortion. Both groups received oral iron when iron deficiency was present. Prespecified outcomes included pictorial bleeding assessment scores, hemoglobin concentrations, anemia prevalence, and treatment continuation. All numerical observations were created for methodological illustration; no patient records were collected or analyzed.

Results: Median bleeding scores decreased from 140 to 48 with intrauterine therapy and from 138 to 82 with tranexamic acid. Mean hemoglobin increased from 10.8 to 12.3 g/dL and from 10.9 to 11.8 g/dL, respectively. At six months, anemia remained in 12 of 60 women in the intrauterine group and 24 of 60 in the oral-treatment group. Treatment continuation was 90.0% and 83.3%, respectively.

Conclusion: The constructed scenario demonstrates how bleeding reduction and anemia recovery can be assessed together. Its numerical differences are not clinical evidence and cannot establish treatment superiority. Actual comparative research requires prospective recruitment, documented treatment adherence, appropriate ethical oversight, and adjustment for baseline prognostic factors.

Keywords: heavy menstrual bleeding, levonorgestrel, intrauterine system, tranexamic acid, anemia, synthetic data

1. Introduction

Hysterectomy remains an important treatment option for benign gynecological conditions when conservative therapies are ineffective, unsuitable, or inconsistent with patient preferences. Common indications include uterine leiomyomas, adenomyosis, abnormal uterine bleeding, and uterine prolapse. Although minimally invasive techniques and perioperative care pathways have improved

recovery, clinically relevant complications still occur. Identifying potentially modifiable factors before surgery is therefore essential for optimizing outcomes. Preoperative anemia is particularly relevant in gynecology because the conditions leading to hysterectomy may also cause prolonged menstrual blood loss. Nevertheless, anemia may be regarded as an expected consequence of the underlying disorder rather than a separate clinical problem requiring systematic assessment.

Anemia is characterized by a reduced blood hemoglobin concentration and consequently diminished oxygen-carrying capacity. In women undergoing hysterectomy for benign disease, iron deficiency resulting from heavy menstrual bleeding is a frequent cause, but it should not be assumed to explain every case. Inflammation, nutritional deficiencies, renal disease, and other hematological disorders may contribute independently or coexist with iron depletion. Hemoglobin measurement identifies anemia but does not establish its mechanism. When clinically indicated, ferritin, transferrin saturation, inflammatory markers, and additional investigations can help distinguish potential causes. This distinction matters because the effectiveness and timing of treatment depend on the underlying abnormality and the interval available before surgery.

Several mechanisms could link preoperative anemia to an unfavorable postoperative course. Reduced oxygen delivery may limit physiological reserve during surgical blood loss and postoperative stress. Anemic patients may also be more likely to reach clinical thresholds for red blood cell transfusion, particularly during technically complex procedures. Transfusion can be necessary and lifesaving, but it introduces additional clinical considerations and may accompany longer hospitalization or more severe illness. Fatigue and reduced exercise tolerance associated with anemia could also interfere with early mobilization and functional recovery. These mechanisms are biologically plausible, although their contribution to specific postoperative outcomes cannot be established from hemoglobin measurements alone.

The relationship between anemia and surgical outcomes is complicated by factors associated with both the exposure and the procedure. Larger leiomyomas, greater uterine size, and more persistent bleeding may produce lower hemoglobin concentrations while also increasing operative complexity. Surgical route, patient age, obesity, comorbidity burden, and previous pelvic surgery may influence complication risk independently. Access to care and the time between surgical decision-making and the operation may affect opportunities for investigation and treatment. Consequently, an observed association between anemia and postoperative morbidity could partly reflect differences in disease severity, operative characteristics, or broader patient vulnerability rather than an isolated effect of reduced hemoglobin.

Evidence from surgical populations generally supports attention to preoperative anemia, but findings cannot always be transferred directly to benign gynecological surgery. Hysterectomy populations differ from other surgical groups in age distribution, bleeding patterns, underlying pathology, and the proportion of minimally invasive procedures. Within gynecology, studies may combine benign and malignant indications or evaluate operations with substantially different risks. Variation in anemia definitions, laboratory timing, transfusion practices, and outcome ascertainment further complicates interpretation. Evidence focused on a clearly defined benign hysterectomy population can therefore help clarify the clinical relevance of preoperative hemoglobin status within a more comparable surgical context.

Another important consideration is the choice of postoperative endpoint. Transfusion is clinically meaningful, but it is directly influenced by baseline hemoglobin and local transfusion thresholds. An association limited to transfusion may therefore convey a different message from one involving infection, readmission, or other complications. Evaluating transfusion separately from non-transfusion morbidity can improve interpretation and avoid allowing a single practice-sensitive outcome to dominate the findings. Similarly, length of stay reflects recovery but may also be shaped by discharge policies and social circumstances. Clearly specified endpoints and consistent follow-up are necessary to make observed associations clinically interpretable.

Understanding these relationships has practical relevance for preoperative care. Elective surgery may provide an opportunity to identify anemia, investigate its cause, reduce ongoing uterine bleeding, and initiate appropriate treatment. However, the available interval for optimization varies, and postponing

surgery may prolong symptoms or continued blood loss. An observational association between anemia and complications would not, by itself, demonstrate that correcting anemia prevents those complications. It could nevertheless identify patients who warrant more detailed assessment and inform prospective studies of targeted optimization strategies.

Accordingly, this retrospective cohort study examines the association between preoperative anemia and postoperative outcomes among women undergoing elective hysterectomy for benign gynecological indications. The primary outcome is perioperative red blood cell transfusion; secondary outcomes include non-transfusion complications within 30 days, readmission, and length of hospital stay. Analyses account for available patient and operative characteristics. We hypothesize that preoperative anemia is associated with greater transfusion risk, while associations with other outcomes may be less pronounced after adjustment.

2. Materials and Methods

A prospective, parallel-group randomized controlled trial will evaluate whether a structured exercise program reduces menstrual pain in young adults with primary dysmenorrhea compared with standardized self-care education alone. The study will be conducted through outpatient gynecology clinics affiliated with a university teaching hospital. Participants will complete one baseline menstrual cycle followed by three intervention cycles, corresponding to approximately 12–16 weeks depending on cycle length. Recruitment will begin only after institutional ethics approval and prospective trial registration. Written informed consent will be obtained before screening procedures. The protocol will prespecify outcomes, eligibility criteria, safety procedures, and the statistical analysis plan before enrollment.

Eligible participants will be women aged 18–30 years with menstrual cycles occurring every 21–35 days and a clinical history consistent with primary dysmenorrhea for at least six months. Participants must report lower abdominal cramping beginning shortly before or at menstrual onset, usually resolving within 72 hours, and a baseline-cycle peak pain score of at least 4 on an 11-point numerical rating scale. Eligibility will require willingness to maintain existing dietary and nonstudy exercise habits and complete electronic symptom diaries. Participants taking hormonal contraception or other hormonal treatment within the preceding three months will be excluded to limit treatment-related variation in pain and bleeding.

Additional exclusion criteria will include pregnancy, breastfeeding, known endometriosis or adenomyosis, clinically significant uterine fibroids, pelvic inflammatory disease, previous major pelvic surgery, and medical conditions that preclude moderate-intensity exercise. Progressive pelvic pain, persistent intermenstrual pain, abnormal uterine bleeding, deep dyspareunia, or other findings suggesting secondary dysmenorrhea will prompt further clinical assessment before eligibility is determined. Pelvic examination and ultrasonography will be performed when clinically indicated rather than required routinely. A normal ultrasound will not be considered sufficient to exclude endometriosis. Individuals whose assessment leaves substantial concern for secondary pathology will not be enrolled and will receive appropriate clinical referral.

At screening, trained research staff will record age, educational status, employment, age at menarche, menstrual characteristics, obstetric history, smoking status, relevant medical conditions, medication use, and habitual physical activity. Height and weight will be measured using calibrated equipment, and body mass index will be calculated. During the baseline cycle, participants will record pain, analgesic use, bleeding days, and interference with usual activities. A urine pregnancy test will be performed when pregnancy is possible. Participants who do not provide sufficient baseline diary data to establish the qualifying pain score will complete another baseline cycle before randomization.

Participants will be allocated in a 1:1 ratio using a computer-generated random sequence with variable block sizes, stratified by baseline peak pain severity of 4–6 or 7–10. An independent statistician will generate the sequence. Allocation will be concealed through a secure electronic system accessible only after eligibility and baseline assessments are complete. Participants and exercise instructors cannot be blinded because of the intervention's nature. Outcome assessors reviewing diary completeness and the statistician conducting the primary analysis will remain masked to group assignment. Treatment groups will be labeled with neutral codes until the primary analysis has been

finalized.

Both groups will receive standardized education covering menstrual physiology, symptom monitoring, heat application, and appropriate use of analgesics. The intervention group will additionally undertake three 40-minute exercise sessions weekly throughout the three intervention cycles. Each session will include five minutes of warm-up, 20 minutes of moderate-intensity aerobic activity, 10 minutes of lower-trunk mobility and stretching, and five minutes of cool-down. Aerobic intensity will target a perceived exertion of 12–14 on the Borg 6–20 scale. One weekly session will be supervised by a trained physiotherapist, while two will be completed at home using standardized instructions. Activities may be modified during menstruation according to symptoms, with modifications documented.

Control participants will continue their usual activities without receiving the structured exercise program. Both groups will receive weekly administrative reminders to complete diaries, without additional symptom-management counseling. Participants will not be asked to withhold clinically necessary analgesia. Those without contraindications will receive consistent advice on using ibuprofen according to local prescribing guidance; alternative medications will be documented when necessary. Drug name, dose, timing, and indication will be recorded for every analgesic administration. Initiation of hormonal treatment or another dysmenorrhea-directed intervention will be recorded, but participants will remain in follow-up unless they withdraw consent.

The primary outcome will be peak menstrual pain during the third intervention cycle, adjusted for baseline peak pain. Participants will record the worst pain experienced during each 24-hour period on menstrual days 1–3, using a numerical rating scale from 0, indicating no pain, to 10, indicating the worst imaginable pain. Peak pain will be the highest of the three daily ratings. All three ratings will be required to calculate this outcome. Secondary outcomes will include mean pain over these days, analgesic consumption, days of missed work or education, pain-related interference with usual activities, and the proportion achieving at least a 30% reduction in peak pain from baseline. Adherence will be calculated as completed sessions divided by prescribed sessions. Adverse events will be collected weekly and assessed for severity and possible intervention relatedness.

A sample size of 112 participants, with 56 per group, will provide approximately 80% power to detect a between-group difference of 1.5 points in the primary pain outcome, assuming a standard deviation of 2.5, a two-sided significance level of 0.05, and up to 20% attrition. This conservative calculation does not incorporate any precision gained from baseline adjustment. The targeted difference represents a prespecified effect considered potentially relevant rather than a universally established threshold.

The primary analysis will follow the intention-to-treat principle. Analysis of covariance will compare third-cycle peak pain between groups, adjusting for baseline peak pain and recruitment clinic. Results will be reported as adjusted mean differences with 95% confidence intervals. Repeated cycle-level outcomes will be examined using mixed-effects models with participant-specific random intercepts. Missing primary outcomes will be addressed using multiple imputation when its assumptions are considered plausible, with complete-case and missing-not-at-random sensitivity analyses. Secondary analyses will be considered exploratory. A supportive per-protocol analysis will include intervention participants completing at least 70% of prescribed sessions. Data will be stored in an access-controlled database using coded identifiers, with automated range checks and documented resolution of discrepancies.

3. Results

In this illustrative randomized study dataset, 236 women presenting with heavy menstrual bleeding were assessed for eligibility, and 180 were randomized to a levonorgestrel-releasing intrauterine system or oral tranexamic acid, with 90 participants allocated to each group. Among the 56 women not randomized, 24 had structural uterine abnormalities requiring alternative management, 12 had contraindications to a study treatment, and 20 declined participation. Six-month bleeding assessments were available for 84 women in the intrauterine-system group and 82 in the tranexamic-acid group. All randomized participants were included in the primary intention-to-treat analysis, with missing outcome values addressed using multiple imputation.

Baseline demographic and clinical characteristics were broadly comparable between groups. Mean

age was 38.4 ± 6.2 years in the intrauterine-system group and 39.1 ± 5.8 years in the tranexamic-acid group. Median parity was 2 in both groups, with an interquartile range of 1–3. Mean body mass index was 27.1 ± 4.6 and 27.5 ± 4.9 kg/m², respectively. The median reported duration of heavy menstrual bleeding was 14 months in the intrauterine-system group and 15 months in the tranexamic-acid group. No participant had endometrial hyperplasia or malignancy identified during eligibility evaluation.

The baseline pictorial blood assessment chart score averaged 286 ± 98 in the intrauterine-system group and 281 ± 94 in the tranexamic-acid group. Baseline hemoglobin concentrations were 10.8 ± 1.1 and 10.9 ± 1.0 g/dL, respectively. Anemia, defined as hemoglobin below 12.0 g/dL, was present in 73 women (81.1%) assigned to the intrauterine system and 71 (78.9%) assigned to tranexamic acid. Median serum ferritin concentrations were 11 ng/mL (interquartile range, 7–18) and 12 ng/mL (interquartile range, 7–19), respectively. Oral iron supplementation was prescribed according to the same protocol in both groups.

Menstrual bleeding scores decreased in both treatment groups over six months, with a larger reduction among women assigned to the intrauterine system. At three months, observed mean scores were 132 ± 76 in the intrauterine-system group and 177 ± 88 in the tranexamic-acid group. At six months, corresponding scores were 86 ± 62 and 151 ± 81 . In the prespecified analysis adjusting for baseline bleeding score, the estimated between-group difference at six months was –64 points (95% confidence interval, –87 to –41), favoring the intrauterine system. These findings indicate a difference in reported bleeding burden rather than a directly measured difference in menstrual blood volume.

A reduction of at least 50% from baseline bleeding score was documented in 72 women assigned to the intrauterine system and 53 assigned to tranexamic acid. When participants without six-month measurements were classified as nonresponders, response proportions were 80.0% and 58.9%, respectively, corresponding to a risk ratio of 1.36 (95% confidence interval, 1.11–1.67). The absolute difference was 21.1 percentage points (95% confidence interval, 8.0–34.2). Complete-case and multiple-imputation analyses showed the same direction of association, although their estimates differed modestly. The consistency of these analyses reduced, but did not eliminate, concern about bias from missing observations.

Hematologic improvement accompanied the reduction in bleeding. At six months, observed mean hemoglobin concentrations were 12.2 ± 1.0 g/dL in the intrauterine-system group and 11.6 ± 1.1 g/dL in the tranexamic-acid group. The baseline-adjusted between-group difference was 0.5 g/dL (95% confidence interval, 0.2–0.8). Among participants with available measurements, hemoglobin reached at least 12.0 g/dL in 51 of 84 women (60.7%) and 35 of 82 women (42.7%), respectively. Median ferritin increased to 25 ng/mL (interquartile range, 16–38) and 19 ng/mL (interquartile range, 12–29). Because iron supplementation accompanied both interventions, these changes cannot be attributed to bleeding treatment alone. Nevertheless, the parallel differences in bleeding scores and hemoglobin were compatible with greater improvement in iron balance in the intrauterine-system group. Ferritin findings were treated as secondary and exploratory because the study was not powered specifically for differences in iron stores.

In this illustrative randomized cohort of women with nonstructural heavy menstrual bleeding, secondary outcomes generally favored the levonorgestrel-releasing intrauterine system over cyclic oral medroxyprogesterone acetate. Of 120 randomized participants, 60 were allocated to each treatment. Six-month laboratory and questionnaire assessments were available for 56 participants in the intrauterine-system group and 54 in the oral-treatment group. Unless otherwise specified, secondary efficacy results reflect these available cases, whereas adverse-event frequencies use all randomized participants as denominators. These findings are exploratory and do not establish comparative effectiveness beyond the six-month observation period.

Hematologic recovery accompanied the reduction in menstrual blood loss. Mean hemoglobin increased from 10.8 to 12.2 g/dL in the intrauterine-system group and from 10.9 to 11.7 g/dL in the oral-treatment group. After adjustment for baseline hemoglobin, the between-group difference at six months was 0.46 g/dL (95% confidence interval, 0.12–0.80). Median ferritin increased from 12 to 25 ng/mL and from 13 to 19 ng/mL, respectively. Because ferritin values were right-skewed, their

distributions were summarized descriptively rather than interpreted through an unadjusted comparison of arithmetic means. Among participants with baseline anemia and available follow-up measurements, hemoglobin reached at least 12 g/dL in 23 of 35 women receiving the intrauterine system and 16 of 34 receiving oral treatment. Both groups received oral iron when indicated; consequently, hematologic improvement cannot be attributed exclusively to the allocated gynecologic treatment.

Patient-reported functional outcomes showed a similar pattern. On the Menorrhagia Multi-Attribute Scale, where higher scores indicate less disruption from bleeding, mean scores increased from 43.6 to 78.4 with the intrauterine system and from 45.1 to 68.9 with oral therapy. The baseline-adjusted six-month difference was 10.7 points (95% confidence interval, 4.1–17.3). Improvements were most apparent in practical difficulties, work participation, and social activities. Median days of usual activity restricted by menstruation decreased from four to one per cycle in the intrauterine-system group and from four to two in the oral-treatment group. Menstrual pain also declined in both groups, although the adjusted between-group difference on a 0–10 numerical rating scale was small and imprecise: –0.5 points (95% confidence interval, –1.2 to 0.2).

Bleeding-pattern changes differed between treatments. During the first three months, unscheduled spotting was reported by 25 of 60 participants receiving the intrauterine system and 14 of 60 receiving oral therapy. By six months, persistent spotting was reported by eight and six participants, respectively. Amenorrhea occurred in nine intrauterine-system users and two oral-treatment users. These changes were not uniformly perceived as adverse; among participants with amenorrhea, seven in the intrauterine-system group and one in the oral-treatment group reported satisfaction with that bleeding pattern. Counseling records indicated that unpredictable bleeding, rather than amenorrhea itself, was the more frequent reason for treatment dissatisfaction.

No serious treatment-related adverse events were recorded. Two intrauterine systems were expelled, and three were removed because of persistent cramping or unacceptable spotting. In the oral-treatment group, seven participants discontinued medication because of nausea, headache, or difficulty maintaining the prescribed schedule. Treatment discontinuation did not necessarily preclude follow-up assessment. No uterine perforation, clinically diagnosed pelvic inflammatory disease, venous thromboembolism, or pregnancy was documented. However, the sample size and follow-up duration were insufficient to assess uncommon complications reliably.

At six months, 44 of 56 assessed intrauterine-system users and 33 of 54 assessed oral-treatment users described themselves as satisfied or very satisfied. Exploratory analyses did not identify clear modification of the quality-of-life difference by age category or baseline anemia status; interaction estimates were imprecise. Estimates from a sensitivity analysis using multiple imputation for missing six-month outcomes remained directionally consistent with the available-case findings. Because several secondary endpoints were examined without multiplicity adjustment, confidence intervals should be interpreted as measures of estimation uncertainty rather than confirmatory evidence across all outcomes. Longer-term persistence, recurrence of heavy bleeding, and subsequent procedural treatment were not evaluated.

4. Discussion

In this clinic-based cross-sectional study of reproductive-aged women with polycystic ovary syndrome (PCOS), greater insulin resistance was associated with more pronounced menstrual irregularity and a less favorable androgen profile. These relationships were attenuated, but not fully explained, by differences in body mass index and age. The findings support an interpretation of PCOS as a heterogeneous condition in which metabolic and reproductive disturbances frequently overlap. However, they do not establish that insulin resistance causes menstrual dysfunction, nor do they imply that all women with irregular cycles have clinically important metabolic impairment.

The association between insulin resistance and menstrual irregularity is biologically plausible. Compensatory hyperinsulinemia may enhance ovarian androgen production and reduce hepatic synthesis of sex hormone-binding globulin, increasing the bioavailability of circulating androgens. These changes may contribute to disrupted follicular development and less frequent ovulation. Nevertheless, the pathways are unlikely to be linear or uniform across patients. Gonadotropin

secretion, adipose tissue function, genetic susceptibility, and environmental exposures may modify both metabolic status and ovarian activity. Menstrual irregularity should therefore be understood as a clinically accessible indicator of reproductive dysfunction rather than a direct measure of the underlying metabolic mechanism.

The persistence of an association after adjustment for body mass index suggests that overall adiposity does not completely account for the observed pattern. This distinction is relevant because metabolic assessment in gynecologic practice may otherwise become overly dependent on visible excess weight. At the same time, statistical adjustment cannot separate the effects of adiposity and insulin resistance with certainty. Body mass index does not capture visceral fat distribution, muscle mass, or ectopic lipid accumulation, and residual confounding remains possible. Moreover, adiposity may operate partly upstream of insulin resistance, making its treatment as a conventional confounder an imperfect representation of the biological relationship.

The androgen findings also require careful interpretation. Higher estimated free androgen exposure in women with greater insulin resistance would be consistent with the proposed interaction between insulin signaling and ovarian steroidogenesis. However, biochemical measures and clinical manifestations of androgen excess are not interchangeable. Hair growth and acne are influenced by tissue sensitivity, ethnicity, age, and previous treatment, whereas laboratory estimates depend on assay performance and sex hormone-binding globulin concentrations. Consequently, an association with biochemical androgen status should not be interpreted as evidence that insulin resistance reliably predicts the severity of hirsutism or other patient-important symptoms.

From a clinical perspective, these observations favor evaluating reproductive and metabolic concerns together rather than treating them as separate components of PCOS. A consultation prompted by infrequent menstruation provides an opportunity to assess cardiometabolic risk, clarify pregnancy intentions, and discuss the consequences of prolonged anovulation. Yet menstrual patterns alone should not determine the intensity of metabolic investigation. Women with comparatively regular bleeding may still have metabolic abnormalities, while those with marked irregularity may not. In addition, self-reported cycle regularity does not confirm ovulation, which limits its usefulness as a standalone marker of ovarian function.

The results should not be taken to establish a treatment indication based on a fasting insulin-derived index. Such indices are useful for investigating group-level relationships but have important limitations for classifying individuals. Their values vary with laboratory methods, recent behavior, and the physiological conditions surrounding blood collection, and universally applicable diagnostic thresholds are lacking. Clinical decisions should instead integrate established assessments of glycemic status, cardiovascular risk factors, symptoms, and reproductive goals. Whether improving insulin sensitivity would reduce menstrual irregularity in the women represented by this study cannot be determined from a single assessment without longitudinal or interventional evidence.

Several design considerations temper the interpretation. Recruitment through a gynecology clinic may preferentially capture women with more troublesome menstrual or androgen-related symptoms, limiting generalizability to community populations. Recall of cycle intervals may introduce measurement error, particularly among women with long or unpredictable gaps between bleeding episodes. Hormonal contraception and medications affecting glucose metabolism can alter both exposure and outcome measurements; incomplete characterization of recent use could therefore distort associations. Sleep disturbance, dietary patterns, physical activity, and socioeconomic circumstances may also contribute to residual confounding even when routinely available clinical variables are considered.

Finally, the cross-sectional design leaves the temporal ordering of metabolic and reproductive changes unresolved. Both may arise from shared determinants, and their relationship may evolve with age, weight change, and treatment. The principal contribution of these findings is therefore phenotypic rather than causal: they identify a pattern of coexisting abnormalities that merits coordinated clinical assessment. Prospective research with repeated metabolic measurements and more direct assessment of ovulation would help determine whether this pattern predicts persistent reproductive dysfunction or subsequent deterioration in glycemic health.

The clinical relevance of these findings lies in the need to assess suspected adenomyosis as a condition affecting daily functioning rather than as an imaging diagnosis alone. The observed relationship between sonographic features, menstrual symptoms, and health-related quality of life suggests that anatomical assessment and patient-reported outcomes provide complementary information. However, imaging abnormalities should not automatically be interpreted as the cause of every symptom. Dysmenorrhea, heavy menstrual bleeding, and chronic pelvic pain have overlapping gynecological and nongynecological causes, making individualized evaluation essential before attributing the overall symptom burden to adenomyosis.

In practice, these observations support a structured assessment that includes bleeding patterns, pain severity, analgesic use, reproductive intentions, and the effects of symptoms on work, sleep, and sexual well-being. A patient with substantial functional impairment may require active management even when imaging findings are limited. Conversely, an incidental sonographic appearance suggestive of adenomyosis does not necessarily justify treatment in the absence of clinically important symptoms. Assessment for iron deficiency and anemia is particularly relevant when heavy menstrual bleeding is reported, because fatigue and reduced functioning may reflect both bleeding-related consequences and the underlying pelvic disorder.

The findings may also inform shared decision-making, although they do not establish the comparative effectiveness of available treatments. Medical options can be discussed according to the predominant symptoms, contraindications, contraceptive preferences, and plans for pregnancy. Patients should understand that symptom improvement and changes in imaging appearance are not interchangeable treatment goals. Where symptoms persist despite appropriate initial management, reconsideration of the diagnosis and assessment for coexisting pathology may be more useful than assuming that adenomyosis has progressed. Decisions about procedural or surgical treatment require additional consideration of fertility preservation, treatment-related risks, and the uncertainty surrounding individual response.

An important interpretive issue is the possible contribution of coexisting conditions. Leiomyomas and endometriosis may independently affect bleeding, pain, and quality of life, while pelvic floor dysfunction or persistent pain mechanisms may influence symptoms beyond what uterine imaging can explain. Even when recognizable structural abnormalities are considered in an analysis, residual confounding remains possible. In particular, endometriosis may be undetected during routine ultrasound assessment. The relationship between adenomyosis features and symptom burden should therefore be interpreted as an association within a potentially complex clinical phenotype, rather than evidence of a single causal pathway.

A useful aspect of the present analysis is its consideration of patient-reported burden alongside sonographic assessment. Imaging alone cannot capture whether symptoms interfere with ordinary activities or whether a patient considers those symptoms acceptable. Nevertheless, patient-reported measures also have limitations. Recall, expectations, psychological distress, and recent symptom fluctuations may influence responses. Bleeding reports are especially difficult to compare when patients use different menstrual products or have different perceptions of excessive flow. These considerations favor combining validated questionnaires with clinically relevant assessments, rather than treating any individual measure as a complete representation of disease severity.

Several methodological limitations constrain interpretation. The observational nature of the study does not establish whether the sonographic findings preceded the reported symptoms or directly contributed to them. Selection into clinical assessment may also enrich the sample for symptomatic patients, limiting applicability to community populations or individuals with incidental findings. Ultrasound interpretation is operator dependent, and diagnostic confidence can vary with image quality, uterine anatomy, and the criteria applied. Without systematic histopathological confirmation, some diagnostic misclassification is possible; however, requiring tissue confirmation would preferentially include surgically treated patients and introduce a different selection bias. Prior or current hormonal treatment could additionally modify both symptom reporting and sonographic appearance.

Future research should prioritize longitudinal evaluation using clearly specified imaging criteria and

repeated, validated symptom measures. Such studies could determine whether particular sonographic patterns predict persistent symptoms, treatment response, or deterioration in quality of life. Reproductive outcomes warrant separate evaluation because associations with pain or bleeding cannot be assumed to imply impaired fertility. Broader recruitment across clinical and community settings would improve generalizability, while assessment of coexisting pelvic conditions and treatment exposure would strengthen interpretation. Intervention studies should focus on outcomes meaningful to patients, including sustained symptom relief, treatment continuation, adverse effects, and preservation of reproductive choices.

Overall, the present findings support an integrated approach to suspected adenomyosis that combines imaging with careful assessment of symptoms and functional impact. Their principal implication is not that sonographic severity should dictate management, but that anatomical findings should be interpreted within the patient's broader clinical context. Further prospective evidence is needed before specific imaging patterns can reliably guide prognosis or treatment selection. Until then, symptom-directed care and shared decision-making remain appropriate foundations for management.

5. Conclusion

This study supports an association between central adiposity and an unfavorable metabolic profile among reproductive-aged women with polycystic ovary syndrome. Within the population evaluated, greater waist circumference was associated with less favorable measures of glucose regulation and lipid metabolism, including among some women whose body mass index was not elevated. These findings suggest that body mass index alone may not fully characterize metabolic vulnerability in this heterogeneous gynecological condition. However, the cross-sectional design precludes conclusions about temporal relationships or causality, and the observed associations should not be interpreted as evidence that central adiposity independently causes metabolic dysfunction.

The clinical implication is that assessment of women with polycystic ovary syndrome should extend beyond menstrual irregularity, hyperandrogenic symptoms, and fertility concerns. Simple anthropometric measurements, interpreted alongside medical history, blood pressure, and appropriate laboratory testing, may provide a more complete picture of metabolic health. Waist circumference could be a useful adjunct to routine assessment, but the present findings do not establish a diagnostic threshold or demonstrate that its inclusion improves clinical outcomes. Its use should therefore complement, rather than replace, established approaches to cardiometabolic evaluation.

The presence of metabolic abnormalities among women without elevated body mass index also warrants attention. A normal-range body mass index should not be assumed to exclude dysglycemia or dyslipidemia in patients with polycystic ovary syndrome. At the same time, anthropometric measurements should not be used to label individual patients as metabolically unhealthy without corroborating clinical evidence. Evaluation should remain individualized, sensitive to weight-related stigma, and attentive to family history, medication exposure, reproductive goals, and other factors that may influence both risk assessment and management decisions.

These results also reinforce the importance of coordinated care between gynecological and primary care services. Counseling can address physical activity, dietary quality, sleep, and sustainable health behaviors while preserving a patient-centered focus on symptoms and reproductive priorities. Nevertheless, this study did not evaluate an intervention and cannot determine whether reducing waist circumference would improve metabolic markers, restore ovulation, or increase pregnancy rates. Recommendations concerning lifestyle support or pharmacological treatment must therefore rest on the broader clinical evidence and individual indications rather than on these observational associations alone.

Several limitations temper the interpretation of the findings. Recruitment from a clinical setting may have favored women with more prominent symptoms or greater healthcare access, limiting generalizability. Residual confounding by diet, physical activity, treatment history, and other unmeasured characteristics remains possible. A single assessment may not adequately represent fluctuating hormonal and metabolic states. Additionally, variation in polycystic ovary syndrome

phenotype may influence the strength and consistency of the observed relationships.

Future prospective studies should evaluate whether waist circumference adds predictive value beyond body mass index and established clinical risk factors across diverse populations. Repeated measurements and standardized characterization of reproductive and metabolic phenotypes would help clarify temporal patterns. Overall, the study favors a broader, individualized approach to metabolic assessment in polycystic ovary syndrome while underscoring that association is not prediction, and that improved risk characterization must ultimately demonstrate meaningful benefit for patients.

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