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Original Research

Can the Ovary Be Preserved? Trajectory of Anti-Müllerian Hormone After Ovarian Detorsion: A Retrospective Cohort Study

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Abstract

Background: This study aimed to evaluate the longitudinal trajectory of ovarian reserve by measuring serum anti-Müllerian hormone (AMH) levels in adult patients who underwent surgical detorsion for ovarian torsion, and to investigate the impact of symptom duration and selected clinical factors on postoperative AMH recovery. **Methods:** This retrospective cohort study included patients who underwent surgical detorsion for ovarian torsion and had serum AMH measurements available preoperatively and at 3 and 6 months postoperatively. Patients who underwent oophorectomy or had incomplete follow-up data were excluded. Demographic characteristics, symptom duration, torsion laterality, surgical approach, presence of polycystic ovary syndrome (PCOS), and surgical procedure (detorsion alone or detorsion with cystectomy) were recorded. Changes in AMH over time were analyzed using the Friedman test with pairwise Wilcoxon signed-rank comparisons. Subgroup differences were performed using the Mann-Whitney U or Fisher's exact test. **Results:** A total of 34 patients were included in this study. Median AMH levels rose from 3.00 ng/mL (interquartile range [IQR]: 2.10–5.00) preoperatively to 4.00 ng/mL (IQR: 2.60–4.88) at 3 months and 5.00 ng/mL (IQR: 3.60–6.00) at 6 months postoperatively (overall $p < 0.001$). AMH levels were significantly higher at both 3 and 6 months compared with preoperative values ($p = 0.021$ and $p < 0.001$, respectively), with a further increase observed between 3 and 6 months ($p < 0.001$). No significant differences in AMH recovery were observed based on PCOS status, surgical approach, surgical procedure, or torsion laterality. **Conclusions:** Ovarian reserve recovery after detorsion appears to be time-dependent, and longitudinal assessment of AMH provides a more informative evaluation than single postoperative measurements. Prolonged symptom duration is associated with reduced biochemical recovery of ovarian reserve, highlighting the importance of early diagnosis and prompt surgical intervention in ovarian torsion.

Keywords: ovarian torsion; detorsion; ovarian reserve; anti-Müllerian hormone; fertility preservation

1. Introduction

Ovarian torsion, although relatively uncommon among gynecologic emergencies, represents a clinically critical condition that may result in permanent loss of ovarian function when diagnosis and surgical intervention are delayed [1]. The pathophysiological process typically begins with impairment of venous and lymphatic drainage followed by reduced arterial perfusion and the development of ischemia–reperfusion injury, which may ultimately lead to irreversible damage to ovarian tissue [2].

Traditionally, a dark or necrotic macroscopic appearance of the torsed adnexa was often considered sufficient justification for oophorectomy. However, long-term follow-up studies and clinical series have demonstrated that ovarian function can be preserved after detorsion irrespective of macroscopic appearance and that conservative management is both feasible and safe [3,4]. Accordingly, contemporary clinical practices increasingly advocate ovarian-sparing surgery whenever possible, particularly in patients with fertility concerns [5].

Despite this shift in surgical practice, the question of whether the ovary can truly be "saved" has largely been addressed using short-term clinical outcomes or indirect indicators of ovarian function. Objective and quantitative assessment of ovarian reserve has been explored in only a limited number of studies. Anti-Müllerian hormone (AMH) secreted by granulosa cells and reflective of the antral follicle pool is a stable and widely accepted biomarker of ovarian reserve [6,7]. Nevertheless, most available data on AMH changes following ovarian torsion are derived from pediatric populations, and longitudinal evidence describing the temporal pattern of AMH recovery after detorsion in adult women remains scarce [8]. Furthermore, few studies have examined symptom duration in relation to biochemical recovery of ovarian reserve, leaving the clinically relevant question of "how late is too late" insufficiently answered [9].

In this study, we aimed to evaluate longitudinal changes in preoperative and post-detorsion serum AMH levels at 3 and 6 months in patients with ovarian torsion. We also investigated the potential impact of symptom duration and the presence of polycystic ovary syndrome (PCOS) on ovarian reserve recovery to provide biochemical evidence to support ovarian-sparing surgical management.

Table 1. Baseline demographic and clinical characteristics of the study population (n = 34).

Characteristic	Value
Age, years	27.5 (21.0–32.0)
PCOS, n (%)	9 (26.5%)
Symptom duration, hours	8.5 (6.0–12.0)
Side of torsion, n (%)	
– Right	22 (64.7%)
– Left	12 (35.3%)
Surgical approach, n (%)	
– Laparoscopy	23 (67.6%)
– Laparotomy	11 (32.4%)
Surgical procedure, n (%)	
– Detorsion only	24 (70.6%)
– Detorsion + cystectomy	10 (29.4%)
Postoperative complications, n (%)	0 (0%)

Abbreviations: n, number; PCOS, polycystic ovary syndrome.

2. Materials and Methods

This retrospective cohort study was designed to evaluate the biochemical trajectory of ovarian reserve in patients who underwent surgical detorsion for ovarian torsion and was approved by the Sancaktepe Şehit Prof. Dr. İlhan Varank Training and Research Hospital Scientific Research Ethics Committee. Patients who were operated on with a preliminary diagnosis of ovarian torsion and received detorsion during surgery within the specified study period were eligible for inclusion. Patients with preoperative and postoperative serum AMH measurements at 3 and 6 months were included. Patients who underwent oophorectomy or had missing follow-up data were excluded from the study. During the study period, a total of 40 patients underwent surgical detorsion for suspected ovarian torsion. Of these, two patients were excluded because oophorectomy was performed at the time of surgery, and four were excluded because complete longitudinal AMH measurements (preoperative, 3-month, and 6-month) were unavailable.

Demographic characteristics, obstetric history, presence of PCOS, symptom duration (defined as the interval from pain onset to surgical intervention, in hours), torsion laterality (right/left), surgical approach (laparoscopy or laparotomy), and type of surgical procedure (detorsion alone or detorsion with concomitant cystectomy) were retrospectively collected from hospital electronic medical records and patient charts. Group comparisons by surgical approach, surgical procedure, torsion side, and PCOS status were conducted as secondary and exploratory analyses.

Serum AMH levels were measured in the same institutional laboratory using a fully automated electrochemiluminescence immunoassay analyzer in accordance with the manufacturer's instructions, employing the Roche Elecsys AMH assay (Roche Diagnostics, Mannheim, Germany). Changes in ovarian reserve were assessed by calculating the differences between preoperative and postoperative measurements at 3 and 6 months, defined as ΔAMH (3 months–preoperative) and ΔAMH (6 months–preoperative), respectively. The primary outcome of this study was longitudinal changes in serum AMH levels, assessed preoperatively and at 3 and 6 months after surgical detorsion. Changes from baseline were evaluated to characterize the trajectory of ovarian reserve recovery.

All surgical procedures were performed at the same tertiary referral center by experienced gynecologic surgeons. Although the operations were not conducted by a single surgeon, a standardized institutional protocol for the surgical management of ovarian torsion was followed in all cases. This protocol included uniform preoperative preparation and disinfection procedures, standardized detorsion techniques, and consistent postoperative management. The surgical approach and decision to perform concomitant procedures were based on predefined institutional criteria and intraoperative findings.

All statistical analyses were performed using IBM SPSS Statistics for Windows, version 27.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as median and interquartile range (IQR). Changes in AMH levels over time were analyzed using the Friedman test, and pairwise comparisons between time points were performed using the Wilcoxon signed-rank test. Between-group comparisons were conducted using the Mann-Whitney U test or Fisher's exact test, as appropriate. A p-value < 0.05 was considered statistically significant. Subgroup analyses were considered exploratory; therefore, no adjustment for multiple comparisons was applied. To control for multiple testing in the main pairwise comparisons of longitudinal AMH measurements, p-values were adjusted using the Holm-Bonferroni method. In addition to univariable analyses, a multivariable linear regression model was constructed to assess the association between symptom duration and AMH recovery at 6 months. The model was adjusted for age, baseline AMH level, and PCOS status as clinically relevant potential confounders.

3. Results

A total of 34 patients were included in the study. The median age was 27.5 years (IQR: 21.0–32.0), and 26.5% of patients (n = 9) had PCOS. The median symptom duration from pain onset to surgical intervention was 8.5 hours (IQR: 6.0–12.0). Torsion was located on the right adnexa in 64.7% of cases (n = 22) and on the left in 35.3% (n = 12). A laparoscopic approach was used in 67.6% of patients (n = 23), whereas 32.4% (n = 11) underwent laparotomy. Detorsion with concomitant cystectomy was performed in 29.4% of patients (n = 10), while the remaining patients underwent

Table 2. Longitudinal changes in serum anti-Müllerian hormone (AMH) and statistical comparisons.

Time point/Comparison	AMH (ng/mL), median (IQR)	Median paired change (ng/mL)	95% CI	*p* value
Preoperative	3.00 (2.10–5.00)	-	-	-
Postoperative 3 months	4.00 (2.60–4.88)	0.30	0.00–0.60	0.021
Postoperative 6 months	5.00 (3.60–6.00)	1.25	1.00–1.70	<0.001
3 months → 6 months	-	1.15	0.88–1.46	<0.001

Abbreviations: IQR, interquartile range.

Table 3. Multivariable linear regression analysis of factors associated with AMH recovery at 6 months.

Variable	β (B coefficient)	Standard error	95% CI	*p* value
Symptom duration (hours)	−0.050	0.022	−0.094 to −0.005	0.029
Age (years)	0.015	0.017	−0.020 to 0.050	0.384
Baseline AMH (ng/mL)	−0.134	0.074	−0.286 to 0.018	0.082
PCOS (yes vs. no)	0.168	0.253	−0.349 to 0.685	0.512

detorsion alone. No major or minor postoperative complications were observed (Table 1).

Longitudinal analysis demonstrated a significant change in serum AMH levels over time (overall $p < 0.001$). Median AMH levels increased from 3.00 ng/mL (IQR: 2.10–5.00) in the preoperative period to 4.00 ng/mL (IQR: 2.60–4.88) at 3 months and 5.00 ng/mL (IQR: 3.60–6.00) at 6 months postoperatively. When changes from baseline were evaluated, the median paired increase in AMH from the preoperative period to 3 months was +0.30 ng/mL (95% CI: 0.00 to 0.60; $p = 0.021$). A more pronounced increase was observed at 6 months, with a median paired change of +1.25 ng/mL from baseline (95% CI: 1.00 to 1.70; $p < 0.001$). In addition, AMH levels continued to increase between 3 and 6 months, with a median paired change of +1.15 ng/mL (95% CI: 0.88 to 1.46; $p < 0.001$), indicating a progressive recovery of ovarian reserve over time. All pairwise comparisons remained statistically significant after Holm-Bonferroni adjustment (Table 2).

In multivariable linear regression analysis adjusting for age, baseline AMH level, and PCOS status, longer symptom duration remained independently associated with reduced AMH recovery at 6 months. Each additional hour of symptom duration was associated with a decrease of 0.05 ng/mL in AMH recovery (β = −0.050; 95% CI: −0.094 to −0.005; $p = 0.029$). Age, baseline AMH, and PCOS status were not significantly associated with AMH recovery in the adjusted model (Table 3).

In subgroup analyses by PCOS status, median preoperative AMH levels were 3.00 ng/mL (IQR: 2.00–4.00) in PCOS-positive patients and 4.00 ng/mL (IQR: 2.80–5.00) in PCOS-negative patients. At 3 months postoperatively, median AMH levels were 3.00 ng/mL (IQR: 1.70–4.00) in the PCOS-positive group and 4.00 ng/mL (IQR: 2.60–5.00) in the PCOS-negative group, while at 6 months they were 4.00 ng/mL (IQR: 3.10–6.00) and 5.90 ng/mL (IQR: 4.00–6.30), respectively. No statistically significant differences were observed between PCOS-positive and PCOS-negative patients in terms of preoperative AMH, ΔAMH (3 months–preoperative), or ΔAMH (6 months–preoperative) (Table 4).

When outcomes were evaluated by surgical approach, AMH levels were analyzed separately in patients who underwent laparoscopy or laparotomy at preoperative, and 6-month time points. In both groups, AMH levels changed over time. However, no statistically significant differences were found between the groups in terms of preoperative AMH, postoperative AMH values, or ΔAMH measurements. Similarly, comparisons between patients who underwent detorsion alone and those who underwent detorsion with cystectomy revealed no significant differences in preoperative AMH, postoperative AMH levels, or ΔAMH values. No significant differences in AMH levels or ΔAMH measurements were observed between patients with right-sided and left-sided adnexal torsion (Table 5).

4. Discussion

In this study, we demonstrated that serum AMH levels in adult patients who underwent detorsion for ovarian torsion changed significantly over the preoperative, 3-month, and 6-month follow-up period, indicating that recovery of ovarian reserve is a time-dependent process. Our findings suggest that evaluating ovarian reserve after detorsion using a single postoperative measurement may be insufficient and that monitoring the longitudinal trajectory of AMH provides a more informative assessment. In addition, symptom duration appears to be associated with the biochemical recovery of ovarian reserve. This study enables comparison of our results with previously published adult ovarian torsion data.

Although detorsion is now widely accepted as a fertility-preserving approach, quantitative evaluation of ovarian reserve using biochemical markers has been investigated in only a limited number of studies. Yasa et al. [10] reported preservation of AMH levels and antral follicle count after laparoscopic detorsion. In our cohort,

Table 4. Serum AMH levels change according to PCOS status.

Variable	PCOS (+) (n = 9)	PCOS (–) (n = 25)	*p* value
Preoperative AMH (ng/mL)	3.00 (2.00–4.00)	4.00 (2.80–5.00)	0.159
Postoperative 3 months AMH	3.00 (1.70–4.00)	4.00 (2.60–5.00)	0.241
Postoperative 6 months AMH	4.00 (3.10–6.00)	5.90 (4.00–6.30)	0.198
Δ AMH (3 months – preoperative)	0.00 (−0.30–0.80)	0.50 (−0.30–1.00)	0.412
Δ AMH (6 months – preoperative)	1.10 (0.60–1.60)	1.30 (1.00–2.10)	0.284

Table 5. Serum AMH levels according to surgical approach, surgical procedure, and torsion side.

Factor	Group	Preoperative AMH (ng/mL), median (IQR)	Postoperative 6-month AMH (ng/mL), median (IQR)	Δ AMH (6 months–pre), median (IQR)	*p* value
Surgical approach	Laparoscopy (n = 23)	3.00 (2.10–5.00)	5.20 (3.80–6.20)	1.30 (1.00–2.10)	0.417
	Laparotomy (n = 11)	3.10 (2.00–4.80)	4.80 (3.20–5.90)	1.10 (0.80–1.60)	—
Surgical procedure	Detorsion only (n = 24)	3.20 (2.10–5.10)	5.10 (3.80–6.10)	1.30 (1.00–2.00)	0.512
	Detorsion + cystectomy (n = 10)	3.00 (2.00–4.60)	4.90 (3.30–5.80)	1.20 (0.90–1.80)	—
Side of torsion	Right (n = 22)	3.10 (2.10–5.00)	5.00 (3.70–6.00)	1.25 (1.00–2.00)	0.689
	Left (n = 12)	3.00 (2.00–4.90)	4.90 (3.40–5.80)	1.20 (0.90–1.70)	—

the increase in AMH at 3 months followed by a more pronounced rise at 6 months suggests that ovarian reserve recovery may not be fully captured in the early postoperative period. This finding supports the clinical relevance of longer-term follow-up and indicates that early postoperative assessments may underestimate functional recovery.

Conversely, experimental and translational studies have shown that ischemia–reperfusion injury during torsion can reduce the follicular pool and decrease ovarian reserve markers [11]. The observed increase in AMH in clinical series may therefore reflect the combined effects of patient selection, duration of ischemia, reperfusion response, residual follicular reserve, and timing of follow-up assessments. Accordingly, our results should not be interpreted as evidence that ovarian reserve is uniformly preserved in all cases, but rather that recovery is dynamic and influenced by both temporal and patient-specific factors.

Given the relatively small overall sample size and the limited number of patients within individual subgroups, all subgroup analyses in this study should be interpreted as exploratory and hypothesis-generating. In particular, the lack of statistically significant differences in subgroup comparisons, such as those based on PCOS status or surgical characteristics, should not be interpreted as definitive evidence of no effect. These findings may reflect insufficient statistical power rather than the true absence of an association and therefore warrant cautious interpretation.

One of the most clinically relevant findings of this study is the inverse relationship between symptom duration and early postoperative AMH recovery, as well as the significantly lower AMH gains observed at both 3 and 6 months in patients with symptom duration longer than 8.5 hours. Given that time to surgical intervention is widely regarded as a critical determinant of ovarian viability in torsion, our data support the importance of timely intervention not only for anatomical preservation but also for functional ovarian reserve outcomes [12].

Although imaging plays a central role in evaluating suspected torsion, the sensitivity and specificity of sonographic signs are variable and may contribute to diagnostic delays. Systematic reviews and meta-analyses have shown that findings such as the whirlpool sign and reduced Doppler flow have high specificity but only moderate sensitivity [13]. This implies that normal Doppler flow does not reliably exclude torsion, underscoring the importance of maintaining a high index of clinical suspicion. Emerging approaches such as contrast-enhanced ultrasound protocols have been proposed to improve diagnostic accuracy, reflecting ongoing efforts to reduce delays in surgical management [14]. Our findings suggest that diagnostic delay may be associated with reduced biochemical recovery of ovarian reserve.

PCOS is characterized by elevated baseline AMH levels and increased ovarian volume, and several reports have suggested an increased risk of torsion in this population [15]. In our study, PCOS-positive patients showed a trend toward a more limited early postoperative increase in AMH, although no statistically significant differences were observed between groups. Given the small sample size, this observation should be considered hypothesis-generating.

Future studies incorporating baseline ovarian phenotype, antral follicle count, and detailed torsion characteristics may help clarify whether PCOS modifies the trajectory of ovarian reserve recovery after detorsion.

Minimally invasive surgery is commonly preferred in ovarian torsion, and laparoscopy is generally considered advantageous when feasible [16]. However, whether the surgical approach itself influences ovarian reserve recovery or whether ischemia duration and tissue injury are the dominant determinants remains unclear. In our cohort, no significant differences in AMH recovery were observed between laparoscopic and open approaches, nor between patients undergoing detorsion alone and those undergoing detorsion with cystectomy. The strongest association with reserve recovery was observed with symptom duration, suggesting that biological injury related to ischemia may outweigh technical surgical factors. Larger studies incorporating operative details and histopathological parameters are needed to clarify these relationships further.

Despite increasing advocacy for ovarian preservation, oophorectomy is still frequently performed in cases of torsion, as reflected in national database analyses [17]. Contemporary studies and editorial perspectives have questioned this practice and support abandoning routine oophorectomy in favor of conservative management whenever feasible [18,19]. The longitudinal increase in AMH observed in our cohort aligns with this paradigm and provides biochemical evidence supporting ovarian-sparing surgery. Nevertheless, retrospective design and potential selection bias must be acknowledged when interpreting these findings.

The search for noninvasive biomarkers to facilitate the diagnosis of ovarian torsion remains ongoing. Systematic reviews indicate that currently proposed candidate biomarkers have not yet demonstrated sufficient accuracy for routine clinical use [20]. While our study does not address diagnostic biomarker development, it highlights the utility of AMH as a tool for assessing functional recovery after detorsion. AMH may serve as an objective biochemical marker of ovarian preservation following surgical intervention.

Experimental studies targeting ischemia–reperfusion injury have explored various pharmacologic and supportive strategies to protect ovarian tissue. Agents such as metformin, hyperbaric oxygen, and erythropoietin have demonstrated potential protective effects in animal models [21,22]. Similarly, emerging therapies including medical ozone and platelet-rich plasma have been investigated in experimental and early clinical settings [23,24]. These data reinforce the concept that torsion involves complex biological injury processes beyond mechanical obstruction. Translation of such interventions into clinical practice, however, will require robust prospective clinical trials.

The retrospective design of this study and the requirement for complete AMH measurements at all predefined time points introduce the potential risk that the selected patients in the analysis may differ from those with better follow-up adherence, potentially influencing the observed trajectory of AMH recovery. Consequently, the magnitude of ovarian reserve recovery may be overestimated if patients with incomplete follow-up experienced poorer outcomes. These limitations should be considered when interpreting the results.

Limitations

This study has several limitations that should be acknowledged. First, the retrospective design introduces the potential for selection bias and limits the ability to draw causal inferences. Second, the relatively small sample size, particularly within subgroup analyses, may have reduced statistical power and increased the risk of type II error, limiting the ability to detect potentially meaningful differences between groups. In addition, the sample size did not permit adequately powered cross-stratified analyses combining surgical route and procedure, thereby restricting conclusions regarding possible interaction effects. Third, although serum AMH is a widely accepted biomarker of ovarian reserve, its levels may be influenced by age, assay variability, and individual ovarian phenotype, which were not fully controlled for in this study. Ovarian reserve was assessed using a single biochemical marker, without complementary imaging parameters such as antral follicle count.

Furthermore, longer-term follow-up beyond six months was unavailable, precluding evaluation of the durability of ovarian reserve recovery over time. Although a standardized surgical protocol was applied, the involvement of multiple surgeons may have introduced variability in surgical technique. Finally, several factors that could influence postoperative ovarian reserve were not evaluated, including ovarian cyst type or size, the degree of ovarian torsion, and preoperative ovarian conditions other than PCOS.

5. Conclusions

Recovery of ovarian reserve after detorsion is feasible and appears to be time-dependent. The inverse association between symptom duration and AMH recovery underscores the critical importance of early diagnosis and prompt surgical intervention in preserving not only ovarian anatomy but also functional ovarian reserve.

Availability of Data and Materials

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Author Contributions

TS: study conception and design, data collection, and manuscript drafting. ES: data analysis and interpretation.

ŞP: surgical data verification and clinical interpretation. HS: substantial contributions to the acquisition, interpretation, analysis of the data, and critical revision of the manuscript for important intellectual content. All authors contributed to critical revision of the manuscript for important intellectual content. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

Ethical approval for this study was obtained from the Sancaktepe Şehit Prof. Dr. İlhan Varank Training and Research Hospital Scientific Research Ethics Committee (Approval No: 90). The study was conducted in accordance with the Declaration of Helsinki. Due to the retrospective design of the study, the requirement for written informed consent was waived by the Ethics Committee.

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Conflicts of Interest

The authors declare no conflicts of interest.

Declaration of AI and AI-Assisted Technologies in the Writing Process

During the preparation of this work, the authors used ChatGPT-5.0 solely to check spelling and grammar. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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