

The Role of D-Dimer and Ischemia Modified Albumin (IMA) in Adnexal Torsion: A Literature Review

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Abstract

Adnexal torsion is a gynaecological emergency in which timely diagnosis is critical to preserve ovarian function. This review examines the emerging roles of D-dimer and ischemia-modified albumin (IMA) as diagnostic biomarkers in ovarian (adnexal) torsion. A systematic search of recent literature (2015–2025) identified both animal experiments and clinical studies evaluating these markers. D-dimer, a fibrin degradation product, rises significantly in ovarian torsion due to thrombosis and tissue necrosis, while IMA increases in response to ischemia-induced albumin modification. Key studies show that D-dimer and IMA levels are significantly elevated in torsion versus controls, with diagnostic sensitivities and specificities reaching 67–82% and 78–100% for D-dimer, and ~90% each for IMA. Both markers demonstrate strong positive likelihood ratios (>10) for torsion. IMA levels also correlate with the severity of ovarian ischemic damage, suggesting a prognostic value. However, their accuracy can be influenced by confounders such as pregnancy and inflammatory conditions. In practice, these biomarkers could complement imaging (e.g. ultrasound) to improve early detection of torsion and guide urgent intervention. Further large-scale studies are needed to validate their clinical utility and to determine whether combining markers in a diagnostic panel could reliably distinguish torsion from other acute pelvic pathologies.

Keywords Adnexal torsion; Ovarian torsion; D-dimer; Ischaemia-Modified Albumin (IMA); Biomarkers; Diagnostic accuracy; Ischaemia-reperfusion injury; Sensitivity and specificity; Emergency gynaecology.

INTRODUCTION

Adnexal torsion, also termed ovarian torsion when confined to the ovary, occurs when an ovary (often with an ovarian cyst or mass) twists around its supporting ligaments, sometimes along with the fallopian tube. This twisting strangulates the ovarian blood vessels, leading to acute ischemia. Ovarian torsion is relatively uncommon (incidence ~9.9 per 100,000 women of reproductive age per year) but represents a true emergency in gynaecological practice. Prompt surgical intervention is required to untwist the adnexa and restore perfusion or to remove a necrotic ovary, with the goal of preventing irreversible ischemic damage and preserving fertility. However, diagnosing torsion can be challenging because its clinical presentation (sudden onset pelvic pain, nausea, etc.) and imaging findings overlap with other acute conditions (e.g. ovarian cyst accidents, appendicitis). Ultrasound with

Doppler is the mainstay of diagnosis, but its sensitivity is variable and operator-dependent (reported as low as 23–66% in some series). There is currently no single laboratory test specific for ovarian torsion. Thus, there is significant interest in identifying adjunct biomarkers that reflect the underlying pathophysiology of torsion and could aid in its early detection.

D-dimer and ischemia-modified albumin (IMA) have emerged as two promising candidates in this context. D-dimer is a fibrin degradation product commonly used to detect thrombotic events; it is extremely sensitive to intravascular thrombosis.

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In ovarian torsion, the twisting of the vascular pedicle leads to venous congestion, thrombosis, and subsequent ischemic necrosis of ovarian tissue. It has been hypothesized that this process could elevate systemic D-dimer levels, similar to other ischemic conditions involving thrombosis. IMA, on the other hand, is a biomarker of tissue ischemia. During ischemia, albumin's N-terminus undergoes structural changes due to oxidative stress, reducing its metal-binding capacity; the *albumin cobalt-binding test* detects this modified albumin as "IMA". IMA has been established as an early marker of ischemia in other fields (e.g. cardiac ischemia) and increases within minutes of an ischemic event. In ovarian torsion, the acute loss of blood flow and subsequent reperfusion injury generate oxidative stress, which could rapidly elevate IMA levels in the serum.

Over the past decade, multiple experimental and clinical studies have evaluated whether D-dimer and IMA can serve as reliable diagnostic markers for ovarian torsion. This literature review provides a comprehensive overview of those studies. We assess the diagnostic accuracy of D-dimer and IMA (sensitivity, specificity, likelihood ratios), their potential prognostic value (e.g. correlation with the extent of ovarian damage or viability), the pathophysiological rationale for their use, and any implications for management. By synthesizing data from recent research, we aim to clarify the utility and limitations of D-dimer and IMA in the diagnosis of adnexal torsion and highlight directions for future investigation.

METHODS

A literature search was conducted to identify peer-reviewed studies published in the last ten years (2015–2025) that investigated D-dimer and/or ischemia-modified albumin as biomarkers in ovarian/adnexal torsion. The search strategy included electronic databases (PubMed, MEDLINE, Scopus, and Web of Science) using keywords such as "ovarian torsion biomarker," "adnexal torsion D-dimer," "ischemia-modified albumin torsion," and related terms. Reference lists of relevant papers were also reviewed to capture additional studies. Inclusion criteria were: clinical studies (prospective or retrospective) or experimental animal studies focusing on the diagnostic or prognostic utility of D-dimer or IMA in ovarian torsion. We included studies involving human patients (of any age) with surgically confirmed torsion and appropriate control groups (e.g. patients with other diagnoses or healthy volunteers), as well as controlled animal experiments replicating ovarian torsion. We excluded case reports, editorials, and studies where torsion was not the primary focus or where biomarkers were measured only qualitatively.

Study selection was performed in two stages. First, titles and abstracts were screened to identify potentially relevant articles. Next, full texts of those articles were obtained and assessed against the inclusion criteria. Data extracted from each study included study design, sample size, patient population characteristics, details of biomarker measurement (assay type and timing), and key outcomes such as biomarker levels in torsion vs controls, diagnostic performance (sensitivity, specificity, positive/negative predictive values), and any correlations with clinical outcomes or pathology. Given the heterogeneity of study designs and markers, a formal meta-analysis was not performed in this review. Instead, results are described narratively and summarised in tables where appropriate. The quality of evidence was considered in terms of sample size, control of biases (e.g. blinding, selection criteria), and consistency of findings across studies.

RESULTS

Diagnostic Accuracy of D-Dimer

Several studies have evaluated plasma D-dimer levels in women with adnexal torsion, with generally consistent findings that D-dimer is significantly elevated in torsion compared to non-torsion cases. In a case-control study by Incebiyik et al. (2015), 14 women with surgically confirmed torsion were compared to 20 women operated on for benign ovarian cysts. The mean plasma D-dimer in the torsion group was 2.20 µg/mL versus 0.43 µg/mL in controls, a more than five-fold difference ($p = 0.002$). Using a cut-off of 0.65 µg/mL, D-dimer achieved 71.4% sensitivity and 85% specificity for diagnosing torsion in this study. Similarly, Topçu et al. (2015) investigated D-dimer in an obstetric population, focusing on pregnant women with pelvic pain and ovarian cysts. In 17 pregnant patients with confirmed adnexal torsion (versus 34 pregnant controls whose pain resolved without torsion), 77% had an abnormally elevated D-dimer on admission, compared to only 21% of the non-torsion group ($p < 0.01$). This corresponded to a markedly higher likelihood of torsion when D-dimer was elevated. In fact, combining an elevated D-dimer with an ovarian cyst >5 cm in size yielded an overall diagnostic sensitivity of 82% for torsion in the pregnant cohort. These human studies underscore that D-dimer tends to be positive in a majority of torsion cases, though not in all, and that it has relatively high specificity (around 80–85%) in non-pregnant populations.

Notably, one study by Gu et al. (2018) highlighted the value of D-dimer when used alongside imaging. Gu and colleagues applied a diagnostic protocol combining the ultrasonic whirlpool sign (a specific Doppler ultrasound finding of twisted ovarian pedicle) with a plasma D-dimer assay in

women with suspected torsion. In their series, a D-dimer cut-off of 248 ng/mL had 100% specificity for torsion (no false positives) but moderate sensitivity (around 68%) when used alone. The whirlpool sign on ultrasound had sensitivity ~71% and specificity ~92% by itself. Importantly, when both the whirlpool sign and D-dimer >248 ng/mL were present, the sensitivity rose to 96.4% and specificity to 100%, essentially confirming the diagnosis in all such cases. This combined approach illustrates how a biomarker can complement imaging: D-dimer can help rule-in torsion when positive (given its high specificity in that study), and improve confidence in diagnosis when an ultrasound sign is equivocal. The positive likelihood ratio (LR+) for D-dimer in torsion has been reported to be well above 10 in aggregate analyses, meaning a positive result provides strong evidence to “rule in” torsion. In a 2024 systematic review, serum D-dimer was identified as one of the most promising biomarkers for early detection of ovarian torsion, with reported sensitivities across studies ranging ~16–82% and specificities 78–100%. Although sensitivities were variable, D-dimer stood out for often achieving the highest specificity among markers (in one study, 100% specificity).

It should be noted that D-dimer levels can be influenced by various factors, which may affect its diagnostic accuracy. Pregnancy itself is associated with rising D-dimer levels as gestation progresses, and conditions like malignancy or recent surgery can also elevate D-dimer. Gu et al. (2018) in their protocol excluded patients with confounding factors (e.g. hypercoagulable states, pregnancy, cancer) to achieve 100% specificity. While this exclusion improved test performance, it limits clinical applicability since torsion often occurs in pregnant women and those with ovarian masses (some of which may be malignant). Thus, if D-dimer is to be used in practice, cut-offs may need adjustment (for example, pregnancy-specific reference ranges) and clinicians must consider the clinical context. Despite these caveats, the current evidence suggests that a markedly elevated D-dimer in a woman with acute pelvic pain strongly heightens the suspicion of torsion, whereas a normal D-dimer cannot completely exclude torsion but may be somewhat reassuring. Indeed, authors of the systematic review posited that D-dimer could potentially be used as a rule-out test for torsion, analogous to its use in ruling out venous thromboembolism, if appropriate thresholds and protocols are established.

Diagnostic Accuracy of Ischemia-Modified Albumin (IMA)

Ischemia-modified albumin has been investigated as a marker of acute ovarian ischemia, mainly in experimental

settings but also in a clinical study. In theory, IMA offers the advantage of being an early indicator of ischemia: it rises within minutes of an ischemic insult, even before frank tissue necrosis occurs, by detecting changes in albumin due to oxidative stress. Animal studies have consistently shown that ovarian torsion leads to increased IMA levels. For example, Karatas Gurgun et al. (2017) induced ovarian torsion in rats and observed a substantial rise in serum IMA in torsioned rats compared to sham-operated controls, although this increase reached statistical significance in some experiments but not others. Three out of four animal studies in a recent review demonstrated significantly higher IMA in torsion versus control groups ($p \leq 0.001$). Additionally, longer or more severe torsion appears to produce greater IMA elevations: an experimental study by Lazăr et al. (2018) found that extending the ischemia duration and allowing reperfusion injury led to progressively higher IMA levels, whereas shorter ischemic intervals yielded smaller changes. This trend aligns with the expectation that IMA reflects the magnitude of ischemic damage.

Clinically, the pivotal human study on IMA in ovarian torsion is by Güven et al. (2015). This was a prospective case-control study of 34 women presenting with acute pelvic pain (20 with surgical-confirmed torsion and 14 with other causes of pain), along with 40 healthy controls. The serum IMA was measured upon presentation, before any intervention. Güven et al. found that IMA levels were significantly higher in the torsion patients than in both the non-torsion pelvic pain group and healthy controls ($p < 0.001$). Importantly, IMA was the only biomarker among a panel of oxidative stress markers in that study that could reliably distinguish torsion from other causes of pain. Using receiver-operating characteristic (ROC) analysis, the optimal cut-off for serum IMA was determined to be 0.7045 absorbance units (measured by the albumin-cobalt binding test). At this threshold, IMA demonstrated 90.0% sensitivity and 92.31% specificity for diagnosing ovarian torsion. In other words, IMA correctly identified 90% of torsion cases and correctly excluded torsion in 92% of controls – a very high diagnostic accuracy. The positive likelihood ratio for IMA based on this performance is above 11, which, similar to D-dimer, indicates strong diagnostic evidence when the test is positive. In fact, a 2024 meta-analysis noted that IMA was one of only two biomarkers (the other being D-dimer) to achieve a pooled LR+ > 10 for ovarian torsion detection.

Beyond diagnosis, IMA may carry prognostic information regarding the extent of ovarian injury. In an elegant experimental study, Kucuk et al. (2016) examined the correlation between serum IMA levels and histopathologic

damage in a rat model of ovarian torsion. Rats were subjected to 3 hours of ovarian ischemia, followed by surgical detorsion and 3 hours of reperfusion, to simulate a clinical scenario of torsion and subsequent surgical intervention. The severity of ovarian tissue necrosis and inflammation was scored by pathologists, and this was compared to the serum IMA concentration. The results showed a *strong positive correlation* (Spearman $\rho \approx +0.99$, $p < 0.001$) between IMA level and histologic injury score. In other words, higher IMA values closely paralleled more severe tissue damage. This finding suggests that IMA might not only signal the presence of torsion, but also reflect how far the ischemic process has progressed – essentially indicating how sick the ovary is. Clinically, this could imply that extremely high IMA levels might predict a non-viable ovary or impending necrosis, whereas moderately elevated levels might accompany torsion caught earlier. However, human data on such prognostic use are not yet available; all current clinical studies measured IMA at a single time-point and correlated only with diagnosis, not with outcomes like ovarian salvage.

Taken together, current evidence supports IMA as a highly sensitive and specific indicator of ovarian torsion

in the acute phase. It appears to directly mirror the pathophysiological impact of ischemia on tissues. One practical limitation is that IMA testing is not as readily available as D-dimer in routine laboratories, as it requires a special assay (the albumin cobalt binding test). Moreover, IMA can be elevated in other scenarios involving ischemia or oxidative stress. Patients with chronic inflammatory diseases, cardiovascular ischemia, or even certain metabolic conditions might have elevated baseline IMA. Thus, while an elevated IMA is strongly indicative of ovarian ischemia in an appropriate clinical context, it must be interpreted cautiously if such comorbidities exist. So far, however, in the gynecologic emergency setting, no other causes of abrupt IMA elevation have been identified aside from ischemic events like torsion.

Comparative Evaluation and Synthesis of Findings

Both D-dimer and IMA show promise as adjunct diagnostic markers in ovarian torsion, but they have different strengths that could be complementary. Table 1 summarises key diagnostic performance metrics from representative studies of each marker in human patients.

Table 1. Selected studies reporting the diagnostic performance of D-dimer and IMA in ovarian torsion.

Marker	Study (Year) & Population	Cut-off / Criteria	Sensitivity	Specificity	Notable Findings
D-dimer	Incebiyik et al., 2015 (14 torsions vs 20 cyst patients)	0.65 $\mu\text{g/mL}$ (plasma)	71.4%	85%	D-dimer higher in torsion (2.20 vs 0.43 $\mu\text{g/mL}$, $p=0.002$); proposed as supplemental test
D-dimer	Topçu et al., 2015 (17 torsion vs 34 controls; all pregnant)	Gestation-adjusted normal range	77-82% ¹	~80-88% ²	77% of torsion patients had elevated D-dimer vs 21% of controls ($p<0.01$). D-dimer + cyst >5 cm gave 82% sens; adding clinical signs (nausea/vomiting & CRP) raised spec to ~85-88%.
D-dimer	Gu et al., 2018 (suspected torsion cases, n=28)	248 ng/mL (plasma)	67.9%	100%	Used in combination with ultrasound “whirlpool sign.” D-dimer alone had no false positives; combined with ultrasound, sens increased to ~96%, spec 100%
IMA	Güven et al., 2015 (20 torsion, 14 other pelvic pain, 40 healthy)	0.7045 absorbance units	90.0%	92.3%	IMA significantly higher in torsion vs controls ($p<0.001$). Highest diagnostic accuracy among tested oxidative stress markers. LR+ ~11.7

As shown in Table 1, the sensitivity of D-dimer for torsion in individual studies ranges roughly from ~68% up to ~82%. This indicates that a substantial fraction of torsion cases may not have elevated D-dimer, possibly early in the torsion process or in smaller torsions. IMA, in the one clinical study, demonstrated a higher sensitivity of 90%, suggesting it might be a more consistently positive marker in torsion. Specificity, conversely, is where D-dimer particularly shines: even in the worst case it was ~78–85%, and it reached 100% in a controlled study. A positive D-dimer, especially above a certain high threshold, is therefore highly suggestive of torsion and unlikely to be a false alarm (except in the presence of confounders). IMA's specificity of ~92% is also quite high, although one must recall that many inflammatory or ischemic conditions were not present in that study's control group – specificity could be slightly lower in a general ER population with varied diagnoses. Both markers yielded *positive likelihood ratios* well above 10 in pooled analyses, making them among the top performers of all biomarkers tested for torsion. By comparison, other proposed markers like interleukin-6 (IL-6) and tumor necrosis factor alpha (TNF- α) have shown high sensitivity in some studies, and another novel marker, SCUBE1, achieved a specificity of 93.3% (second only to D-dimer). However, none of these have consistently outperformed D-dimer or IMA in both sensitivity and specificity. Indeed, a recent systematic review concluded that the most promising blood tests for early torsion detection are serum D-dimer, IMA, IL-6, and TNF- α , with D-dimer and IMA being distinctive for their high likelihood ratios and strong statistical separation between torsion and controls.

From a pathophysiologic perspective, D-dimer and IMA offer complementary information: D-dimer reflects the coagulative and necrotic aspect of torsion (i.e. thrombosis and tissue breakdown), while IMA reflects the ischemic and oxidative stress aspect. It is conceivable that using them in combination could enhance diagnostic accuracy. For instance, a patient with a classic clinical picture of torsion but normal D-dimer might still have elevated IMA if ischemia has begun but thrombosis is minimal or very acute. Conversely, a patient with modest IMA elevation but a high D-dimer might indicate an infarcted ovary with extensive thrombosis. There is not yet a clinical study examining both markers together in the same patients, but future research could explore a multi-marker panel or algorithm.

DISCUSSION

The diagnosis of ovarian torsion remains challenging, and delays in diagnosis can lead to loss of ovarian function or

even life-threatening complications. This literature review finds that D-dimer and ischemia-modified albumin are both promising biomarkers that could support clinical decision-making in suspected adnexal torsion. D-dimer, a routinely available test, has demonstrated a notable ability to “rule in” ovarian torsion when markedly elevated. Its specificity in torsion can be very high – even 100% in one study when confounding factors were excluded. This means a positive D-dimer (above an appropriate threshold) in a patient with acute pelvic pain and an ultrasound finding of an ovarian mass strongly points toward torsion as the diagnosis. In practical terms, a positive D-dimer could prompt a gynaecologist not to dismiss equivocal ultrasound results and to proceed to diagnostic laparoscopy sooner rather than later. On the other hand, D-dimer's sensitivity is only moderate. A normal D-dimer does not exclude torsion with high confidence, especially since some torsion patients will not have had enough time for fibrin deposition and breakdown to generate D-dimer. Therefore, a negative result must be interpreted cautiously; imaging and clinical judgment remain paramount. One notable potential use of D-dimer might be in rule-out strategies: analogous to how a low D-dimer is used to rule out deep vein thrombosis in low-risk patients, a normal D-dimer might help reassure when the pre-test probability of torsion is low to moderate (for example, a less classic clinical presentation). However, any such strategy would have to account for patient factors like pregnancy, which raises baseline D-dimer and reduces the test's specificity.

Ischemia-modified albumin (IMA) emerges from this review as a very strong candidate for an early torsion marker. It has a sound physiological basis: ovarian torsion is essentially a sudden ischemic event, and IMA is an ischemia-specific indicator. The evidence indicates that IMA elevates in torsion even at early time points (within a couple of hours of vascular occlusion, as seen in animal models). Clinically, the high sensitivity and specificity reported by Güven et al. are encouraging, suggesting that IMA could differentiate torsion from other causes of acute pelvic pain better than general inflammatory markers like C-reactive protein or leukocytosis (which are often normal or non-specific in torsion). Moreover, the correlation of IMA with tissue damage severity raises an intriguing possibility: IMA might guide not just diagnosis but also management decisions. For instance, if a very high IMA level suggests significant ovarian ischemia, one might infer that the torsion has been prolonged – possibly decreasing the likelihood that the ovary can be salvaged by untwisting. In contrast, a modestly elevated IMA might suggest a shorter duration torsion, in which case emergent detorsion could still rescue the ovary. In

the future, serial IMA measurements might even be used to monitor reperfusion after surgical detorsion, to gauge if tissue oxygenation is restored. These prognostic aspects remain speculative but warrant further study.

Another important discussion point is how these biomarkers fit into clinical practice alongside imaging. Ultrasound, particularly with Doppler, is the current standard for evaluating suspected torsion. The classic finding is the absence of ovarian blood flow or the presence of the twisted pedicle ("whirlpool sign"). However, ultrasound has limitations: torsion can be intermittent, Doppler flow may appear present early on (due to dual blood supply or partial torsion), and radiologists' experience varies. Biomarkers like D-dimer and IMA could act as adjuncts – not replacing imaging, but supporting it. A scenario can be envisioned in which a patient has indeterminate

ultrasound results; a significantly elevated D-dimer or IMA could tip the balance towards proceeding with surgical exploration despite uncertainty. Conversely, if imaging is equivocal and biomarkers are normal, one might observe carefully and repeat imaging rather than immediate surgery, especially if clinical signs are mild. Ultimately, the goal is to reduce missed torsion diagnoses and also avoid unnecessary surgeries for mimicking conditions. In the systematic review by Naylor et al. (2024), none of the investigated biomarkers were yet deemed clinically useful on their own, largely due to small sample sizes and lack of validation. However, D-dimer and IMA were highlighted as promising, and the authors suggested that future efforts focus on combining markers into a diagnostic panel or score to improve reliability.

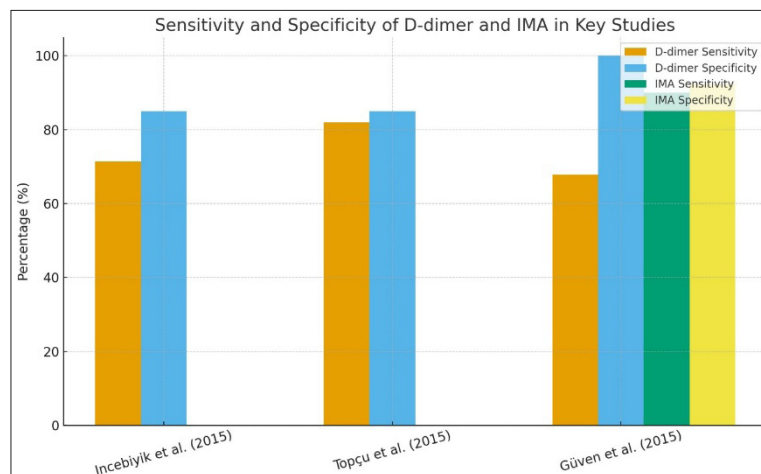


Figure 1. Summarises sensitivity and specificity values across key studies. D-dimer demonstrates excellent specificity, while IMA shows consistently high sensitivity, suggesting complementary diagnostic potential.

The pathophysiological mechanisms underlying the elevation of D-dimer and IMA in torsion also suggest some potential therapeutic implications. The rise in D-dimer reflects coagulation activation in the strangulated ovary. This implies that thrombosis and fibrinolysis are part of the torsion injury pathway. It raises an interesting question: could anticoagulant or fibrinolytic therapies play a role in management? In general, the treatment for torsion is surgical, but one could speculate that adjunct therapies might one day help limit damage (for example, heparin to reduce microthrombosis during detorsion). This is not standard practice currently, and such interventions would need careful study due to bleeding risks. On the other hand, the elevation of IMA underscores the role of oxidative stress and reperfusion injury. Animal studies have tested interventions like *antioxidants* or *controlled reperfusion* techniques. One study found that a controlled, gradual reperfusion after detorsion (as

opposed to abrupt restoration of blood flow) prevented the surge in IMA levels, suggesting less oxidative damage occurred. This aligns with general surgical principles that gradual detorsion or use of vasoactive agents can mitigate reperfusion injury. Clinicians might consider applying such strategies (for instance, untwisting the ovary intermittently or administering antioxidants like vitamin C) especially in cases where the torsion duration is uncertain but the ovary appears viable. Again, these approaches remain experimental, but the biomarkers in question (IMA in particular) could serve as monitoring tools for the effectiveness of such interventions in reducing ischemia-reperfusion injury.

Despite the encouraging data, it is important to acknowledge limitations in the current evidence. Most human studies on D-dimer and IMA in torsion have relatively small sample sizes (often on the order of 15–30 torsion cases). Torsion is rare, which makes large trials

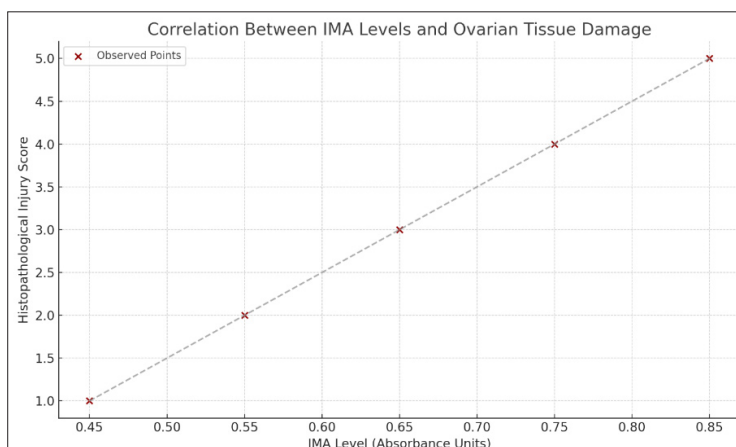


Figure 2. IMA levels correlate strongly with histopathological damage, supporting its potential use as a prognostic biomarker reflecting the severity of ischemia.

difficult, but multicentre collaborations will be needed to truly establish diagnostic accuracy and optimal cut-off values. There is also potential publication bias – studies with positive findings (showing a significant biomarker elevation) are more likely to be published than those with negative or inconclusive results. Additionally, nearly all clinical studies used a case-control design (comparing torsion patients to elective surgery patients or healthy individuals). This does not fully mimic real-world scenarios where the differential diagnosis is acute (e.g. torsion vs appendicitis vs renal colic). Future studies should ideally compare biomarker levels in torsion versus other emergency conditions causing similar symptoms.

For example, one study found IL-6 was elevated in torsion compared to well patients, but not necessarily higher than in appendicitis. It would be worthwhile to know if D-dimer or IMA could distinguish torsion from pelvic inflammatory disease or a ruptured ovarian cyst in an ER population. Early indications suggest D-dimer might be more specific in torsion than in generalized inflammation (appendicitis usually doesn't raise D-dimer significantly unless sepsis or thrombus is present), and IMA might remain relatively specific to ischemia (for instance, one wouldn't expect IMA to rise in a simple ovarian cyst rupture without vascular compromise). These hypotheses need direct testing.

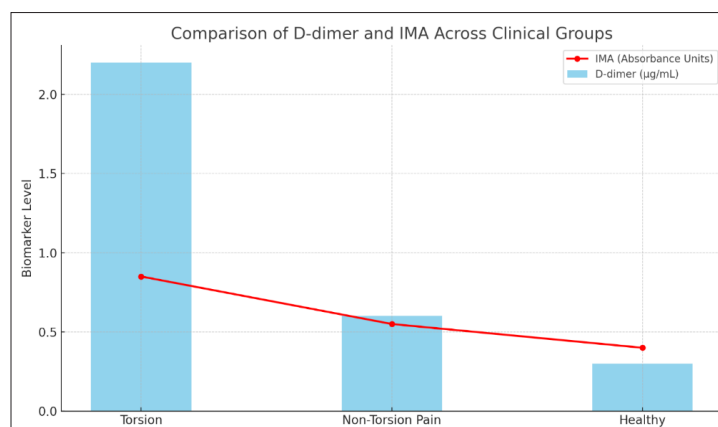


Figure 3. IMA correlates strongly with histopathological severity of ovarian tissue damage in experimental torsion-detorsion models. This supports a potential prognostic role, reflecting the burden of ischaemia more directly than traditional inflammatory markers.

STRENGTHS, LIMITATIONS, AND FUTURE DIRECTIONS

While the cumulative evidence supports the potential utility of D-dimer and IMA, important limitations remain. Most studies to date involve relatively small sample sizes, reflecting the inherent difficulty of recruiting large torsion cohorts. Variability in assay methodology, timing

of sample collection, and clinical heterogeneity further complicate comparisons across studies. Importantly, neither biomarker has yet been evaluated in sufficiently powered, prospective, real-world diagnostic accuracy trials that include the full spectrum of differential diagnoses encountered in emergency settings.

Future research should therefore aim to validate these

findings in multicentre prospective studies and explore multimarker algorithms that combine D-dimer, IMA, and potentially additional inflammatory or endothelial dysfunction markers. Such approaches may ultimately yield diagnostic models with superior accuracy to any single biomarker alone. Furthermore, longitudinal perioperative measurement of IMA could help clarify its role as a prognostic marker for ovarian viability and guide the future development of therapeutic strategies to mitigate reperfusion injury following detorsion.

CONCLUSION

In conclusion, D-dimer and ischemia-modified albumin have emerged as valuable biochemical markers in the context of ovarian torsion, reflecting distinct facets of the underlying pathophysiology. D-dimer rises with the thrombotic and necrotic processes of torsion, whereas IMA is an early signal of tissue ischemia. Evidence from the past decade indicates that both markers can improve the diagnostic accuracy for torsion when used alongside clinical and imaging findings. D-dimer has shown high specificity and could help confirm torsion, especially in equivocal cases, while IMA boasts a combination of high sensitivity and specificity in initial studies, making it a potentially powerful diagnostic tool. Moreover, IMA's correlation with tissue damage hints at a role in prognostication – it might help gauge the urgency and likely outcome (ovarian viability) of the torsion event.

For gynaecological practice, the integration of these biomarkers could mean more timely diagnoses and interventions. A patient presenting with acute pelvic pain might in the future receive a “torsion panel” blood test (including D-dimer, IMA, and perhaps selected inflammatory markers), which, if positive, would expedite surgical exploration even if ultrasound findings are uncertain. This could reduce the rate of missed torsion cases and consequent ovarian loss. Conversely, a negative biomarker panel in a low-risk scenario might avert unnecessary diagnostic surgery. However, before such applications become reality, further research is necessary. Large prospective studies and cost-benefit analyses should establish definitive sensitivity, specificity, and optimal cut-offs for diverse populations (non-pregnant, pregnant, pediatric, etc.), and clarify how these tests perform against mimicking conditions. Additionally, standardisation of IMA assays and broader availability will be needed. In parallel, exploring the therapeutic implications – such as using the insights from D-dimer and IMA about thrombosis and oxidative injury – could lead to adjunct treatments that improve ovarian salvage rates (for example, antioxidant therapy at detorsion).

In summary, D-dimer and IMA offer a window into the ischemic and hemorrhagic havoc wrought by adnexal torsion. They show great potential to enhance our diagnostic armamentarium for this emergency. By continuing to refine and validate these biomarkers, we move closer to the dual goal of earlier diagnosis and better outcomes for patients with ovarian torsion – preserving not only an ovary but also future fertility and endocrine function. The current literature, though promising, is the beginning; ongoing studies and innovations will determine how these biochemical markers can be best harnessed in everyday gynaecological emergency care.

Conflicts of interest

The authors declare no conflicts of interest.

Acknowledgements

We would like to thank the doctors and staff from the various institutes for their continuous support and guidance.

Authors' contributions

VB drafted the manuscript. LT and ZA supervised its preparation. FP and GP conducted the literature review.

All authors have read and approved the final version of the manuscript.

Funding

This research did not receive any specific grants from funding agencies in the public, commercial, or not-for-profit sectors.

Availability of data and materials

Not applicable.

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Cite this article: V. Bassi, F. Perriard, G. Palumbo, *et al.* *The Role of D-Dimer and Ischemia Modified Albumin (IMA) in Adnexal Torsion: A Literature Review.* International Journal of Research in Medical and Clinical Sciences. 2026; 4(1): 01-09.

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