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QUANTITATIVE DOPPLER ULTRASOUND MARKERS AND VASCULARITY SCORING FOR DIFFERENTIATING UTERINE LEIOMYOMA PHENOTYPES AND SUSPECTED SARCOMA

Goziyeva M.A., Goziyev M.SH., Toshpulatov B.B
Andijan State Medical Institute

Abstract: Background: Doppler ultrasound complements grayscale imaging by providing hemodynamic information that may improve the characterization of uterine masses. However, variability in acquisition and subjective interpretation limit reproducibility.
Aim: To propose a structured, quantitative Doppler-based framework (vascularity scoring + resistance indices) for differentiating common leiomyoma phenotypes and guiding escalation for suspected malignancy, based on a dissertation-derived clinical series.
Methods: A cohort of 115 women evaluated for pelvic tumors underwent transvaginal ultrasound (TVUS) with color Doppler mapping (CDM)/energy Doppler and pulsed Doppler. Intra-tumoral vascularity was graded by the number of color signals (≤5, 5–10, >10) and by distribution (central vs peripheral). Doppler indices (RI/IR, Vmax, Vmin, TAMX, and S/D) were sampled in uterine arteries, arcuate arteries, and intra-tumoral vessels when feasible. Indeterminate or high-risk presentations were escalated to CT and/or MRI.
Results: Doppler profiles differed across simple myoma, myoma with ischemic/degenerative changes, leiomyoma associated with adenomyosis, and proliferative myoma, with a gradient toward richer central vascularity and lower resistance indices in proliferative lesions. In the comparative analysis (proliferative myoma n=60 vs uterine sarcoma n=5), sarcomas demonstrated heterogeneous, low-resistance intra-tumoral flow and intense mixed vascularity, but overlap existed. The integrated imaging strategy (TVUS+CDM with selective CT/MRI) achieved an overall diagnostic effectiveness reported as high in the dissertation (up to 97.7%).
Conclusions: Quantitative vascularity grading and standardized Doppler index reporting can reduce subjectivity and improve triage of uterine masses. Because Doppler features overlap between proliferative leiomyoma and sarcoma, suspicious patterns should prompt MRI and multidisciplinary evaluation rather than “rule-out” decisions based on ultrasound alone.

Keywords: Doppler ultrasound; color Doppler; vascularity scoring; leiomyoma; uterine sarcoma; structured report; transvaginal ultrasound

Introduction

While grayscale TVUS remains the cornerstone of pelvic imaging, Doppler assessment can reveal vascular patterns reflecting cellularity, degeneration, and angiogenesis. Leiomyomas can be simple, ischemic/degenerative, or proliferative/cellular, each potentially exhibiting distinct hemodynamic signatures. Uterine sarcomas are rare but aggressive; their imaging appearance may mimic atypical leiomyomas. In practice, the greatest value of Doppler may be in standardizing documentation and triggering escalation to MRI in high-risk cases.
This manuscript focuses on the quantitative Doppler component of a dissertation-based diagnostic workflow and formulates a structured reporting template suitable for routine use.

Materials and Methods

Design: Retrospective analysis summarized from a Master’s dissertation (single center).
Participants: 115 women; mean age reported as 49.3 ± 1.5 years. Diagnostic groups included uterine myoma, adnexal tumors (benign/malignant), inflammatory adnexal disease, adenomyosis, suspected sarcoma, and pelvic tumors of unclear origin.

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Ultrasound technique: TVUS with grayscale evaluation followed by CDM/energy Doppler and pulsed Doppler measurements of uterine arteries, arcuate arteries, and intra-tumoral vessels. Waveforms were acquired with stable angles and consistent sampling.
Vascularity scoring: Intra-tumoral color signals were counted and graded as poor (≤5), moderate (5–10), or intense (>10). Vascular distribution was recorded as predominantly peripheral, predominantly central, or mixed.
Escalation to cross-sectional imaging: CT and/or MRI was used when TVUS+CDM findings were inconclusive or suspicious.
Outcomes: The primary outcome was descriptive differentiation of hemodynamic profiles across myometrial pathology variants and in the proliferative myoma vs sarcoma comparison.

Results

Table 1 presents dissertation-derived Doppler parameters across myometrial pathology variants.

Показатель	**Простая миома**	**Отёк/ишемия узла**	**Миома + аденомиоз**	**Пролиферирующая миома**
IRmed, маточная артерия	0,80±0,06	0,75±0,05	0,75±0,05	0,71±0,07
IRmed, аркуатные артерии	0,67±0,04	0,71±0,04	0,72±0,04	0,55±0,11
IRmin, аркуатные артерии	0,62±0,04	0,67±0,04	0,63±0,06	0,52±0,08
Диапазон IRmin	0,56–0,87	0,52–0,83	0,50–0,86	0,33–0,69
VAmax (см/с)	18,3	18,6	19,8	25,6
VAavg (см/с)	13,9	15,7	13,7	17,4
Диапазон VA (см/с)	5–33	9–31	5–27	10–58
Локализация кровотока	Периферический (бедный)	Периферический (умер./инт.)	Периферический (бедный/умер.)	Центральный + периферический (интенсивный)
IRmin, внутри узла	0,59±0,06	0,59±0,07	0,57±0,05	0,40±0,06
IRmed, внутри узла	0,65±0,07	0,65±0,08	0,61±0,06	0,50±0,09
Диапазон IR (узел)	0,50–0,82	0,40–0,81	0,45–0,80	0,17–0,58
VAmax в узле (см/с)	18,7	25,4	20,3	28,9
VAavg в	13,9	16,6	14,5	17,4

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узле (см/с)				
Диапазон VA (узел)	4–38	4–42	9–43	7–87
VBmax (см/с)	—	9,0	11,5	12,8
Диапазон VB (см/с)	—	5–13	7–15	8–23

Table 1. Doppler hemodynamics across myometrial pathology variants (dissertation dataset).

Table 2 compares Doppler indices between proliferative myoma and uterine sarcoma.

Показатель	**Пролиферирующая миома (n=60)**	**Саркома матки (n=5)**
Купирование кровотока	Интенсивный периферический + центральный, «мозаичность»	Интенсивный периферический + центральный, «мозаичность»
IRmin, внутри узла	0,40±0,06	0,38±0,07
IRmed, внутри узла	0,50±0,09	0,47±0,09
Диапазон IR (узел)	0,17–0,58	0,29–0,64
VAmax, внутри узла (см/с)	28,9	17,0
VAavg, внутри узла (см/с)	17,4	11,3
Диапазон VA, внутри узла (см/с)	7–87	4–30
VBmax, внутри узла (см/с)	12,8	—
Диапазон VB, внутри узла (см/с)	8–23	—
IRmin, аркуатные артерии	0,53±0,09	0,45±0,10
IRmed, аркуатные артерии	0,57±0,09	0,52±0,08
Диапазон IR, аркуатные	0,33–0,69	0,33–0,72
VAmax, аркуатные (см/с)	25,6	16,8
VAavg, аркуатные (см/с)	17,4	11,3
Диапазон VA, аркуатные (см/с)	10–58	5–29
IRmed, маточные артерии	0,72±0,07	0,70±0,04

Table 2. Doppler indices: proliferative myoma (n=60) vs uterine sarcoma (n=5) (dissertation dataset).

Interpretation Framework for Clinical Use

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Based on the dissertation observations, the following interpretive rules may improve consistency and triage. These are intended as operational guidance rather than definitive diagnostic thresholds:

- Always document both morphology (grayscale) and hemodynamics (vascularity score + distribution + at least one RI/IR measurement).
- Low vascularity (≤5 signals) with predominantly peripheral flow and higher resistance indices is more typical for simple leiomyoma or ischemic/degenerative lesions.
- Moderate-to-intense vascularity (≥5 signals) with mixed or central flow and comparatively lower resistance indices suggests a more cellular/proliferative phenotype or inflammatory hyperemia; correlate clinically.
- A heterogeneous mass with intense mixed vascularity (>10 signals), central chaotic vessels, and very low-resistance waveforms should be treated as suspicious; proceed to pelvic MRI and multidisciplinary evaluation.
- Do not use Doppler alone to exclude uterine sarcoma: overlap with proliferative leiomyoma is expected; clinical red flags (postmenopausal growth, atypical bleeding, systemic symptoms) and MRI are critical.

Structured Doppler Reporting Template (Proposed)

1) Lesion mapping: number, size (3D), location (submucosal/intramural/subserosal/cervical), relationship to endometrium and serosa.
2) Grayscale phenotype: margins, echogenicity, heterogeneity, cystic/necrotic areas, calcifications, shadowing.
3) Vascularity score: ≤5 / 5–10 / >10 color signals.
4) Vascular distribution: peripheral / central / mixed.
5) Doppler indices (report vessel + values): uterine artery RI/IR; arcuate artery RI/IR; intra-tumoral RI/IR (if measurable); Vmax/Vmin if available.
6) Impression: most likely phenotype (simple/degenerative/proliferative vs suspicious). Specify triggers for MRI/CT.
7) Recommended next step: follow-up interval, MRI referral, oncogynecology consultation, or surgical planning.

Discussion

The dissertation dataset supports a practical view of Doppler ultrasound as a "standardization and triage" tool: it improves documentation of vascular features that may correlate with cellularity and degeneration, and it can signal when MRI is warranted. In proliferative leiomyoma, the increased vascularity and lower resistance indices likely reflect higher cellularity and perfusion. Sarcoma may present with low-resistance chaotic flow, but the key limitation is overlap—especially in large, vascular, or degenerating leiomyomas.

The dissertation reports that adding CDM plus selective CT/MRI can increase overall diagnostic effectiveness (reported up to 97.7%). In modern practice, such integrated pathways align with current guideline themes: avoid overconfidence in a single imaging parameter, standardize reporting, and escalate early in suspicious presentations.

Limitations

Single-center design, heterogeneous diagnostic groups, and a small sarcoma sample limit inferential statistics and external generalizability. Raw individual-level data were not available in this manuscript format; therefore, ROC analysis and definitive cut-offs could not be derived.

Conclusion

Quantitative vascularity scoring combined with standardized Doppler indices provides a reproducible framework for characterizing uterine masses on TVUS. Because Doppler overlap

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exists between proliferative leiomyoma and sarcoma, suspicious patterns should trigger pelvic MRI and multidisciplinary decision-making.

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