Short Communication

Maria Linda Rocha, Thomas Menter, Sandra Zekic Tomas, Barbara Ciolka, Eumenia Castro, Helder Oliveira Coelho, Heather Keir, Bettina Neumayer, Rosete Nogueira, Maria Orsaria, Martyna Trzeszcz, Jo-Anne Ewald, Carmen Severens-Rijvers and Gitta Turowski*

Reproducibility of the Amsterdam consensus criteria for maternal vascular malperfusion (MVM): a multicenter evaluation of perinatal pathologists

https://doi.org/10.1515/jpm-2025-0518
Received September 13, 2025; accepted December 29, 2025; published online February 3, 2026

Abstract

Objectives: Maternal vascular malperfusion (MVM) refers to dysfunctional uteroplacental circulation and is associated with increased risk of adverse maternal and fetal outcomes. The diagnosis of MVM is one of the most common pathological diagnoses in term placentas. The aim of the study was to test the interrater reliability of the MVM Amsterdam criteria.

Methods: A group of 12 international perinatal pathologists reviewed digital histological sections of placentas (n=29; 20 MVM/ 9 non-MVM controls), applying published Amsterdam workshop consensus criteria. Kappa statistics were used for interobserver agreement analysis.

Results: Agreement levels on final MVM diagnosis according to Amsterdam consensus were calculated as slight to fair (K-values of 0.187 and 0.260, $p<0.001$). Substantial agreement was reached one time for infarcts (K-value of 0.707, $p<0.001$). Complementary tested criteria achieved none to moderate agreement.

Maria L. Rocha and Thomas Menter contributed equally to this work and share first authorship.

Carmen Severens-Rijvers and Gitta Turowski share senior authorship.

***Corresponding author: Gitta Turowski**, MD, PhD, Department of Pathology, Center for Pediatric and Pregnancy related Pathology, Oslo University Hospital, Kirkeveien 166, 0450, Oslo, Norway, E-mail: UXTUGI@ous-hf.no

Maria Linda Rocha, Institute of Pathology, University Medicine Rostock, Rostock, Germany; and Institute of Functional Anatomy, Charité - Universitätsmedizin Berlin, Berlin, Germany. https://orcid.org/0000-0001-7086-8698

Thomas Menter, Pathology, Institute of Medical Genetics and Pathology, University Hospital Basel, University of Basel, Basel, Switzerland. https://orcid.org/0000-0002-0847-6156

Sandra Zekic Tomas, Department of Pathology, University Hospital Centre Split, Split, Croatia. https://orcid.org/0000-0003-2964-5171

Barbara Ciolka, Pathology Department, Royal Infirmary of Edinburgh, Edinburgh, UK

Eumenia Castro, Department of Pathology and Immunology, University of Wisconsin School of Medicine and Public Health, Madison, WI, USA

Helder Oliveira Coelho, Anatomic Pathology Unit, Hospital de Cascais, Lisboa, Portugal; Escola Superior de Saúde de Lisboa - Polytechnic University of Lisbon, Department of Exact Sciences, Life Sciences, Social Sciences and Humanities, Lisboa, Portugal; and Nova Medical School, Histology & Embryology Unit, Lisbon, Portugal. https://orcid.org/0000-0002-5342-8081

Heather Keir, Anatomic Pathology, Texas Children's Hospital, Baylor College of Medicine, Houston, TX, USA

Bettina Neumayer, Institute of Pathology, University Clinics Salzburg, Paracelsus Medical University, Salzburg, Austria. https://orcid.org/0009-0001-2697-5629

Rosete Nogueira, School of Medicine, University of Minho, Braga, Portugal; Life and Health Sciences Research Institute (ICVS), Braga and ICVS/3B's, Braga, Portugal; Government Associate Laboratory, Minho University, Braga/Guimarães, Portugal; and Embryofetal Pathology Laboratory, LAP, Unilabs, Porto, Portugal. https://orcid.org/0000-0001-9231-1639

Maria Orsaria, Institute of Pathology, Azienda Sanitaria Universitaria Friuli Centrale (ASUFC), Udine, Italy. https://orcid.org/0000-0001-9978-8130

Martyna Trzeszcz, Department of Pathology and Clinical Cytopathology, University Hospital Wroclaw, Wroclaw, Poland. https://orcid.org/0000-0002-9971-1093

Jo-Anne Ewald and Carmen Severens-Rijvers, Department of Pathology, Maastricht University Medical Center (MUMC+), Maastricht, The Netherlands; and GROW School for Oncology and Developmental Biology, Maastricht University, Maastricht, The Netherlands

Conclusions: Our results highlight the need to refine current MVM criteria to support consistent international diagnosis.

Keywords: Amsterdam consensus; maternal vascular malperfusion; placenta; perinatal pathology; reproducibility; interobserver variability

Introduction

Indications for submitting placentas, standardized protocols for macroscopic sectioning, agreement on terms and criteria of histopathological diagnostics, and an understandable report for the clinician were suggested by experts in the field [1–3]. The Amsterdam consensus, published by an international group of perinatal pathologists in 2016, classified and defined four major patterns of placental injury, commonly accepted by pathological and clinical specialists in the field [3–5] (Table 1). The main categories encompass maternal vascular malperfusion, fetal vascular malperfusion (FVM), acute chorioamnionitis, and villitis of unknown etiology (VUE) [3, 4]. MVM relates to gross findings including placental hypoplasia, infarction, and retroplacental hemorrhage as well as histopathological changes comprising aberrant maternal vasculature and altered villous morphology [5]. The underlying pathophysiological mechanisms are still not fully understood but refer to impaired uteroplacental circulation. This condition is linked to fetal growth restriction, recurrent preterm birth, stillbirth/perinatal death, and long-term associated risks for the mother and the offspring [6–8]. Maternal associated systemic obstetric diseases (e. g. preeclampsia) and autoimmune diseases (e. g. systemic lupus erythematosus, antiphospholipid syndrome) are reported. The risk of recurrence in subsequent pregnancies and long-term cardiovascular and metabolic risk factors are increased [5–7].

Nevertheless, nearly a decade after publication, the Amsterdam recommendations have been variably implemented (Table 1), and pattern-specific morphological features continue to pose diagnostic challenges, even for experts in the field [7, 9].

Within an established, continuously active working group of international perinatal pathologists, the discussion on placental findings was challenging and provoked uncertainties and controversies. This prompted the group to test the reproducibility of the MVM criteria as proposed by the Amsterdam workshop consensus.

Materials and methods

Participants

Table 1 lists the group members' experience level in perinatal pathology.

Cases

The selection of 29 placentas (gestational age (GA) 24+2 to 41+2 weeks) from the archives of the pathological institutes (Oslo, Basel, Maastricht, Berlin) was consensus-based and guided by representation of Amsterdam criteria [3]. The study included (n=20) MVM cases and those with normal or other histopathological changes (n=9). The analysis was conducted in two equal consecutive sessions. One representative anonymized slide of central placental tissue of each case was scanned and assessed digitally. No clinical data or prior diagnoses were shared except GA. No case discussions took place between the test periods.

Assessed criteria

Eight morphological criteria were assessed for the diagnosis of MVM, including those defined by the Amsterdam consensus: accelerated villous maturation, increased syncytiotrophoblastic knots, decidual arteriopathy, and infarcts. Additional criteria evaluated were calcifications, inter-/perivillous fibrin depositions, villous stromal hypercellularity and fibrosis (see Supplementary 1). Complementary criteria were assessed alongside the Amsterdam consensus features to explore potential adjunctive markers of MVM. For each case, a binary decision was recorded for each parameter, and a final determination of MVM presence was made. Distal villous hypoplasia, which is recognized as more reliably diagnosed before GA of 32 weeks, was excluded due to its diagnostic limitations in the cohort's gestational age distribution (7/29 <GA of 32 weeks). A final column was provided to list desirable clinicopathologic information to strengthen the diagnosis of MVM.

Statistical evaluation

Individual results were compiled in a Microsoft Excel sheet (Microsoft Corp., Seattle, WA) and further analyzed using SPSS 22.0 (SPSS Software, Chicago, IL) for interobserver agreements. Cohen's kappa value was interpreted as follows: ≤0: no agreement; 0.10–0.20: slight agreement; 0.21–0.40: fair agreement; 0.41–0.60: moderate agreement; 0.61–0.80: substantial agreement; 0.81–0.99: near-perfect agreement; 1: perfect agreement.

Table 1: Workplace-related parameters and status of Amsterdam implementation (2024).

	Years of experience in perinatal pathology	Practicing exclusively as perinatal/ pediatric pathologist	Approx. ratio of placentas sent in for examination, %	Approx. number of perinatal pathologists in the country	Approx. ratio of all practicing pathologists in the country, %	Year of official institutional implementation of Amsterdam consensus	Implementation of Amsterdam consensus into national guidelines
Basel, Switzerland	5	No	7	10	1–2	2018	Yes[a]
Berlin, Germany	12	No	2.5	20	1.1	2024	No[b]
Edinburgh, United Kingdom	7	Yes	3.35	55	3.8	2021	yes
Braga/Porto, Portugal	33	Yes	20	10	5	2016	No[e]
Houston, TX, United States	5	Yes	50	400	1.8	2018	Yes
Lisboa, Portugal	9	No	9.5	10	5	2016	No[e]
Madison, WI, United States	22	Yes	72	400	1.8	2016	Yes
Maastricht, The Netherlands	8	No	30	25	6	2018	Yes
Olso, Norway	25	No	20	10	3.4	2016	Yes
Salzburg, Austria	7	No	22	5	1	2024	Yes
Split, Croatia	14	No	23	10	7	2018	No[c]
Udine, Italy	10	No	31	30	1.5	2024	Yes[d]

[a]PMID, 39465447. [b]Guideline manuscript (AWMF) submitted, revision not yet finalized. [c]Proposition to accept Amsterdam consensus not yet accepted by Croatian Pathology Society. [d]National consensus recommendations on placenta, AFIP guidelines included: Raccomandazioni operative per la diagnostica della placenta umana. SIAPeC – SIGO, AOGOI, AGUI, AGITE (2023). [e]Proposition to accept Amsterdam consensus and AFIP guidelines on placental pathology classification

Results

Overall agreement

K-values of 0.297 (p<0.001) and 0.386 (p<0.001) were determined in the first and second section, respectively, and show only fair agreement on the criteria tested.

Agreement on final MVM diagnosis

For the presence of MVM according to Amsterdam, K-values of 0.260 (p<0.001) and 0.187 (p<0.001) were reached in the first and second sections, indicating fair or slight agreement (Table 2).

Agreement on single criteria

Accelerated villous maturation (K-values of 0.290 and 0.210, p<0.001) and decidual arteriopathy (K-values of 0.213 and 0.361, p<0.001) reached fair agreement levels each. Increased syncytiotrophoblastic knots obtained none to slight agreement levels (K-values of 0.051 and 0.159, p<0.001). Infarction reached none to slight as well as substantial agreement (K-value of 0.005, p 0.882, and K-value of 0.707 p<0.001) depending on the session. The complementary tested criteria showed lower agreement (Table 2).

Agreement on additional information

The most frequently requested clinical or gross pathological information by the group members included maternal history and placental weight (each 41.8 %), fetal/birth weight (31.6 %), and evidence of an infectious/inflammatory event (7.9 %).

Discussion

Our study tested interobserver reliability on final MVM diagnosis and MVM criteria according to the Amsterdam consensus statement with variable agreement; only infarction reached substantial agreement (Table 2). The observed discrepancy in interobserver agreement for infarcts between the two evaluation sessions is likely multifactorial. Variation in case composition between sessions may have influenced diagnostic reproducibility, as subtle or chronic infarctions are inherently more difficult to distinguish from

Table 2: Agreement levels on morphologic criteria.

	Morphological criterion	p-Value	Cohen's kappa coefficient[b]	Strength of agreement
MVM criterion according to Amsterdam consensus	Accelerated villous maturation	<0.001	0.290	Fair
		<0.001	0.210	Fair
	Increased syncytiotrophoblastic knots	0.140	0.051	None to slight
		<0.001	0.159	Slight
	Decidual arteriopathy	<0.001	0.213	Fair
		<0.001	0.361	Fair
	Infarct(s)	0.882	0.005	None to slight
		<0.001	0.707	Substantial
	MVM diagnosis (final)	<0.001	0.260	Fair
		<0.001	0.187	Slight
Additional tested criterion[a]	Increased calcification	<0.001	0.288	Fair
		<0.001	0.477	Moderate
	Increased inter-/ perivillous fibrin	<0.001	0.120	Slight
	depositions	<0.001	0.228	Fair
	Stromal fibrosis	0.728	0.013	None to slight
		0.503	0.026	None to slight
	Stromal hypercellularity	<0.001	0.137	Slight
		0.276	−0.039	None

Each criterion was assessed in two independent rounds of testing (1st line ≙ first section, 2nd line ≙ second section). [a]No defined Amsterdam consensus MVM criterion. [b]Interpretation of Cohen's kappa value: ≤0: no agreement; 0.10–0.20: slight agreement; 0.21–0.40: fair agreement; 0.41–0.60: moderate agreement; 0.61–0.80: substantial agreement; 0.81–0.99: near-perfect agreement; 1: perfect agreement.

dense inter- or perivillous fibrin than acute, well-demarcated lesions. Likewise, very early infarcts, especially if not all criteria are fulfilled, may have led to differences in the interpretation.

Decidual arteriopathy (DA) reached fair agreement. This could be due to the fact that DA is a collective term that encompasses different findings, such as acute atherosis, fibrinoid necrosis, mural hypertrophy, chronic perivasculitis, absence of vascular remodeling of spiral arteries among others [3], and not all criteria were always fulfilled. Patchy distribution may also have contributed to interobserver variability.

Accelerated villous maturation (AVM) attained fair agreement. The definition provided by Amsterdam is broad, and there are no precise reference values based on gestational age, so the interpretative cut-off point is likely to have varied. Increased syncytiotrophoblastic knots, a subcriterion of distal villous hypoplasia (DVH), that often accompanies AVM, resulted in none to slight agreement, despite proposed reference values [10]. As distal villous hypoplasia (DVH), which is recognized as more reliably diagnosed before GA of 32 weeks [3], increased syncytial knots may be difficult to distinguish from a physiological increase in preterm and term placentas, taking the cohorts' composition into consideration (22/29 cases >32 weeks of GA). Complementary tested criteria as increased inter-/perivillous fibrin depositions, which are often associated with AVM [3], and have been suggested by other experts, obtained slight to fair agreement [6, 11, 12]. Here too, the boundaries between the physiological and pathological ranges, in relation to the respective week of pregnancy, are blurred and have not yet been sufficiently defined. While placental calcifications are considered within a range of normal aging to a certain extent at term and above, the early occurrence of placental calcifications (<36 weeks) can be a morphological correlate of underlying placental dysfunction. The agreement levels were slightly better but require further analysis.

The restricted number of cases in our study and the availability of only one central histological section per case represent limitations which might have impact on generalizability. Future large-scale studies also incorporating clinical data and gross findings could make a valuable contribution to a better understanding and greater consistency.

A recent work showed an association of MVM with adverse fetal outcome when reduced placental weight (<10th percentile), AVM, DA, infarcts, DVH, and increased multinucleated basal plate trophoblast were evident [9]. In another pattern-based study on preeclampsia, two different classes of MVM were identified, with low-grade MVM including villous lesions only, while high-grade MVM encompassed both villous and maternal vascular lesions [13]. Moreover, the MVM pattern associated with a status of inflammation or infection has rarely been addressed to date [8].

Regarding the incidence of MVM (32.8 % at term, 50.6 % at preterm), recurrence risk and potential maternal and neonatal or long-term offspring outcomes [6–8], it is crucial that pathologists are consistent in their diagnosis. When applying standardized definitions of Amsterdam, the overall agreement in our study was only slight to fair with considerable differences in the interpretations. Currently, there is no agreement on 'must-haves' and additional criteria for subclassifications, grading and staging of MVM [4, 6, 7].

The Amsterdam workshop consensus, published in 2016, aimed to create a unified placental classification system, based on suggested pathological patterns and criteria [3, 4], and to achieve higher interrater agreement and reliability [6]. After almost 10 years, the importance of revision is clear; the criteria require refinement.

The necessity of clinical data, more stringent placental submission according to indication and following guidelines by obstetricians and midwives [1, 14] (Table 1), and the need for diagnosis by trained perinatal pathologists should be emphasized [15].

Research ethics: Not applicable.
Informed consent: Not applicable.
Author contributions: MLR: manuscript – original draft, conceptualization, resources, investigation, data curation, statistical analysis, visualization, project administration; TM: manuscript – original draft, conceptualization, methodology, resources, investigation, data curation, project administration; SZT: investigation, manuscript – editing, supervision; BC: investigation, manuscript – editing; EC: investigation, manuscript – editing; HOC: investigation, manuscript – editing; HK: investigation, manuscript – review & editing, supervision; BN: investigation, manuscript – editing; RN: investigation, manuscript – editing; MO: investigation, manuscript – editing; MT: manuscript – editing; JAE: statistical analysis; CSR: conceptualization, resources, investigation, data curation, manuscript – review & editing; GT: conceptualization, resources, investigation, manuscript – review & editing, supervision. All authors have accepted responsibility for the entire content of this manuscript and approved its submission.
Use of Large Language Models, AI and Machine Learning Tools: None declared.
Conflict of interest: The authors state no conflict of interest.
Research funding: None declared.
Data availability: Upon request from the corresponding author.

References

1. Langston C, Kaplan C, Macpherson T, Manci E, Peevy K, Clark B, et al. Practice guideline for examination of the placenta: developed by the placental pathology practice guideline development task force of the college of American pathologists. Arch Pathol Lab Med 1997;121: 449–76.
2. Turowski G, Berge LN, Helgadottir LB, Jacobsen E-M, Roald B. A new, clinically oriented, unifying and simple placental classification system. Placenta 2012;33:1026–35.
3. Khong TY, Mooney EE, Ariel I, Balmus NCM, Boyd TK, Brundler MA, et al. Sampling and definitions of placental lesions: Amsterdam placental workshop group consensus statement. Arch Pathol Lab Med 2016;140: 698–713.
4. Redline RW, Ravishankar S, Bagby CM, Saab ST, Zarei S. Four major patterns of placental injury: a stepwise guide for understanding and implementing the 2016 Amsterdam consensus. Mod Pathol 2021;34: 1074–92.
5. Ernst LM. Maternal vascular malperfusion of the placental bed. APMIS 2018;126:551–60.
6. Redline RW, Roberts DJ, Parast MM, Ernst LM, Morgan TK, Greene MF, et al. Placental pathology is necessary to understand common pregnancy complications and achieve an improved taxonomy of obstetrical disease. Am J Obstet Gynecol 2023;228:187–202.
7. Slack JC, Parra-Herran C. Life after Amsterdam: placental pathology consensus recommendations and beyond. Surg Pathol Clin 2022;15: 175–96.
8. Catov JM, Scifres CM, Caritis SN, Bertolet M, Larkin J, Parks WT. Neonatal outcomes following preterm birth classified according to placental features. Am J Obstet Gynecol 2017;216:411.e1–411.e14.
9. Davis DL, Lechner AC, Chapel DB, Slack JC, Carreon CK, Quade BJ, et al. Outcome-based risk stratification model for the diagnosis of placental maternal vascular malperfusion. Mod Pathol 2024;37:100370.
10. Loukeris K, Sela R, Baergen RN. Syncytial knots as a reflection of placental maturity: reference values for 20 to 40 weeks' gestational age. Pediatr Dev Pathol 2010;13:305–9.
11. Baergen RN, Burton GJ, Kaplan CG, editors. Benirschke's Pathology of the Human Placenta, 7th ed. Cham: Springer International Publishing; 2022.
12. Faye-Petersen OM, Ernst LM. Maternal floor infarction and massive perivillous fibrin deposition. Surg Pathol Clin 2013;6:101–14.
13. Freedman AA, Suresh S, Ernst LM. Patterns of placental pathology associated with preeclampsia. Placenta 2023;139:85–91.
14. Roberts DJ, Baergen RN, Boyd TK, Carreon CK, Duncan VE, Ernst LM, et al. Criteria for placental examination for obstetrical and neonatal providers. Am J Obstet Gynecol 2023;228:497–508.e4.
15. Ernst LM, Basic E, Freedman AA, Price E, Suresh S. Comparison of placental pathology reports from spontaneous preterm births finalized by general surgical pathologists versus perinatal pathologist. Am J Surg Pathol 2023;47:1116–21.

Supplementary Material: This article contains supplementary material (https://doi.org/10.1515/jpm-2025-0518).