



Research article

Primary parvovirus B19 infection in immunocompetent pregnancies:

Clinical features and outcomes of 16 prospective cases

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Abstract: Parvovirus B19 (B19V) is a contagious virus. It is responsible for a wide range of clinical manifestations, from spontaneously resolving illness to potentially fatal and severe conditions in at risk individuals such as pregnant women. This study would enable the investigation of clinical and biological manifestations as well as adverse fetal outcomes in pregnant women with recent infection. We reported a series of 16 pregnant women with primary B19V infection. Diagnosis was clinical, serological, and molecular. Real-time PCR molecular analysis was performed on all pregnant women with recent B19V infection. Viral DNA was detected in 3 women. Mothers with recent B19V infection were symptomatic in 68.75% (11/16) of cases, and 62.5% (10/16) had developed arthralgia associated with a rash. Anemia was present in half the women with recent infection, with only one case of thrombocytopenia. Postnatal follow-up of the infected mothers showed that 13 women gave birth to healthy new borns. Two patients experienced a spontaneous abortion, and another gave birth to a premature infant. Given the complications of B19V infection, the assessment of maternal infection is important and should be considered within the framework of the fetal and maternal health policy in Morocco.

Keywords: clinical manifestations; fetal outcomes; maternal infection; Parvovirus B19 (B19V); Spontaneous abortion

1. Introduction

Parvovirus B19 (B19V) is ubiquitous and contagious. It is a small, single-stranded, non-enveloped DNA virus belonging to the genus *Erythroparvovirus* in the Parvoviridae family [1]. The clinical manifestations and severity of B19V infection in pregnant women do not differ from those commonly observed in healthy individuals. Most pregnant women infected with the B19V are asymptomatic or present with mild, non-specific symptoms [2,3]. Infection should be suspected in any patient presenting with a skin rash, regardless of its distribution, and especially if the patient is a young woman, diagnosed in spring or summer with moderate fever or flu-like symptoms and joint pain [4]. In fact, there is no relationship between the presence of maternal symptoms, the risk of vertical transmission of the B19V, and the development of fetal complications. During pregnancy, infection by the B19V may be asymptomatic in 55 to 76% of cases, or associated with polyarthralgias or skin rashes [5]. The rate of transmission of maternal B19V infection to the fetus is between 17% and 33%, and most fetuses have spontaneous resolution of infection without adverse perinatal outcome [6]. The risk of fetal infection can occur at any stage of pregnancy. It is highest if the primary infection occurs before 20 weeks of gestation (WG). However, most fetal complications occur between 8 and 12 WG after maternal infection with B19V [7]. However, the repercussions are more severe the earlier the infection happens (during the first and second trimesters of pregnancy) [8]. Regarding the detection of anti-B19 IgM, it is important to emphasize that the absence of these antibodies in a serum sample from a suspected pregnant woman cannot rule out fetal B19V infection, since fetal manifestations can occur several weeks after maternal infection, when signs of acute infection may have disappeared [9]. To date, there is no research on B19V infection in pregnant women in Morocco. As such, we are the first to explore the use of serology and molecular biology to detect this virus in pregnant women in the Marrakesh-Safi region.

Our objectives of this study are:

- To study the clinical, biological, and virological manifestations of B19V infection in pregnant women with recent infection.
- To assess the risk of fetal complications in pregnant women recently infected with B19V based on gestational age and the results of serological and molecular analysis.
- To assess the association between recent maternal B19V infection and the risk of low birth weight.
- To conduct short-and long-term follow-up of children born to mothers infected with the virus.

2. Methods and materials

2.1. Study design

We conducted a retrospective cohort study in the Marrakech-Safi region of Morocco, including pregnant women who consulted the obstetrics and gynecology department of the University Hospital of Marrakech and had an acute B19V infection during the period from January to July, 2023. These observations were identified after a clinical, serological and, molecular examination.

2.2. Inclusion and exclusion criteria

The total number of pregnant women recruited during the period of study was 430. A total of 16 of these 430 developed acute B19 infection. We included all pregnant women with a recent B19V

infection (positive anti-B19 IgM), with a positive or negative result for anti-B19 IgG, whether symptomatic or asymptomatic. Any pregnant woman undergoing seroconversion to the B19V and not recently infected was excluded (negative anti-B19 IgM).

2.3. Study methodology

For each patient included in the study, a series of clinical and biological parameters were recorded. Biological data were obtained from blood tests performed on the patient a few days prior to her gynecological consultation. Clinical data and the pathological status of each patient were taken into account at the time of admission.

The parameters common to all pregnant women with a recent infection were:

- Clinical parameters:
Presence of a skin rash, arthralgia, flu-like symptoms, fever, malaise, or fatigue.
- Biological parameters:
 - Presence of anemia.
 - Presence of thrombocytopenia.
- Parameters related to immune or pathological status:
 - Presence or absence of immune suppression in pregnant women recently infected with the B19V.
 - Presence or absence of certain acute or chronic diseases.
- Serological parameters:
 - Value of the positive anti-B19 IgM index.
 - Value of the anti-B19 IgG index (negative or positive).

Other socio demographic, medical, and obstetric information was also collected.

Patients were followed prospectively with targeted fetal ultrasound examinations until delivery to detect signs of fetal hydrops, intra uterine fetal death, spontaneous abortion, etc.

Newborns of mothers infected with the B19V were also followed.

2.4. Analytical methods

2.4.1. Serological analysis

The presence of B19V IgG and IgM antibodies was determined using Parvovirus VIRCLIA® Chemiluminescence MONOTEST kits (Viracell Microbiologist, Granada, Spain). This test is quantitative. An antibody index less than 0.9 was considered negative, an index between 0.9–1.1 was considered equivocal, and an index greater than or equal 1.1 was considered positive.

2.4.2. Molecular analysis

Viral DNA Extraction: Viral DNA extraction from the B19V was performed using the QIAamp DNA Mini Kit (Qiagen). This system enables the isolation and purification of viral nucleic acids using silica membrane technology (QIAamp).

Real-time PCR amplification: Viral DNA amplification was performed using the Real Star® Parvovirus B19 PCR kit1.0 (Altona Diagnostics, Germany). This test is based on Real-time PCR Technology to detect and quantify B19V DNA.

The kit is a heterologous amplification system with an internal control (IC) to ensure the integrity of the kit reagents and to detect any PCR inhibition.

2.5. Statistical analysis

Collected data were analyzed using statistical package for social science (SPSS) version 26. Categorical variables were summarized as proportions while continuous variables were summarized as median with interquartile range. A *P* value of <0.05 was considered statistically significant.

3. Results

3.1. Patient characteristics

Sixteen cases were identified. The mean age at diagnosis was 26.6 years (range: 17–36), and 25% of patients were under 36 years old. In our study, 62.5% (10/16) of pregnant women with recent B19V infections were from rural areas. Ten cases (10/16) were diagnosed during the spring period.

3.2. Real-time PCR results: Prevalence of Parvovirus B19 DNA

The prevalence of B19V DNA for all pregnant women with recent infection was 18.75% (3/16).

3.3. Clinical manifestations

Most of the recently infected pregnant women were symptomatic for B19V, representing 68.75% (11/16) of cases. This infection was responsible for non-specific poly arthralgias in 62.5% (10/16) of cases, associated with a rash on the body (limbs, back, and abdomen) in 68.75% (11/16) of cases and on the face in 43.75% (7/16) of cases. Feeling of fatigue was observed in 7 infected women. Fever and the development of flu-like symptoms were observed in 1 woman (Figures 1 and 2).

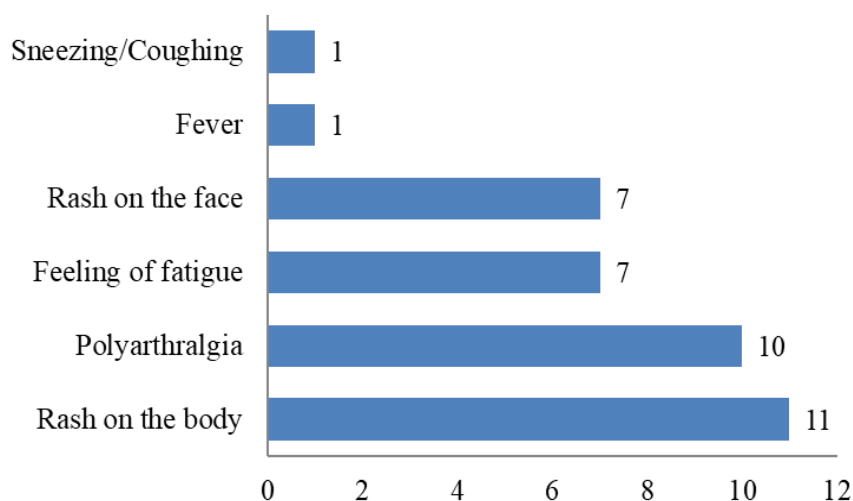


Figure 1. Clinical manifestations of Parvovirus B19 in recently infected pregnant women.

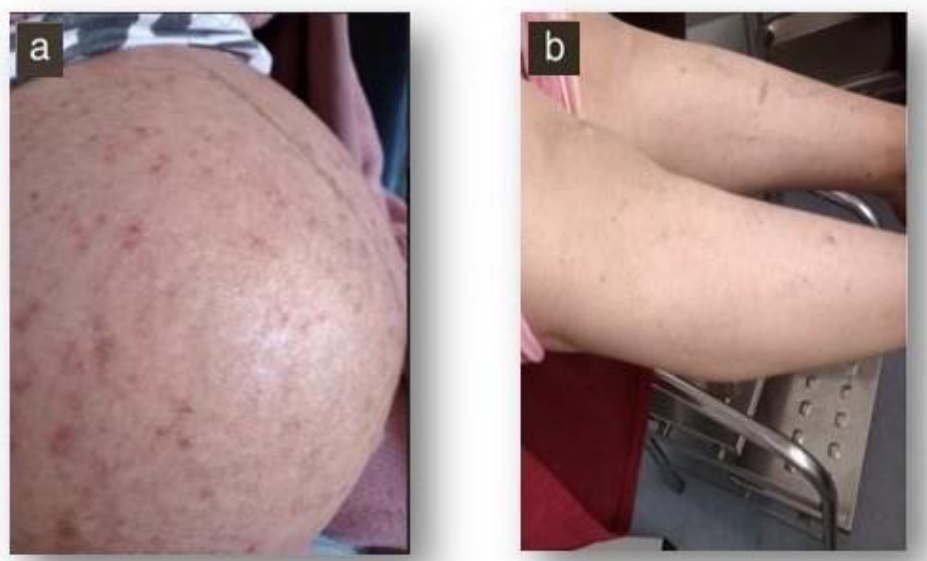


Figure 2. Skin manifestations of Parvovirus B19 infection in pregnant women. (a) and (b) Skin rashes associated with recent B19 infection on the abdomen and feet of a pregnant woman in her ninth month of pregnancy.

3.4. Biological profile, immune, and pathological status of pregnant women in primary infection

Anemia ranging from mild to moderate (between 8 and 11 g/dL) to severe (<8 g/dL) was found in half of the pregnant women with a recent infection, with one case of thrombocytopenia ($55\,000/\text{mm}^3$), 2 cases of gestational diabetes, and 1 case of insulin-dependent diabetes. None of the pregnant women with recent B19V infection were immune compromised. Four cases had pregnancy-induced hypertension, 2 cases had preeclampsia, 1 case had hyperthyroidism, and 1 case had depression.

3.5. Sources of Parvovirus B19 infections in pregnant women

Of the 11 pregnant women who were either symptomatic ($n = 11$) or asymptomatic ($n = 5$), the main source of B19V infection was contact with children who exhibited the same symptoms as their mothers, either simultaneously or beforehand. One woman with a recent infection was infected at her workplace while working as a nanny. The source of infection was unknown in five other cases (Table 1).

Table 1. Sources of infection for pregnant women recently infected with Parvovirus B19.

Source of infection	Number of cases
*Symptomatic pregnant women	11
• Children presenting the same symptoms:	
✓ Simultaneously	3
✓ Long before	6
• Nature of the work (nanny)	1
• Source unknown	1
*Asymptomatic pregnant women	5
• Children	1
• Source unknown	4

3.6. Study of the clinical evolution of fetuses and pregnancy outcomes in women with recent Parvovirus B19 infection

Serological and molecular data, as well as the clinical outcomes of fetuses of mothers infected with B19V, are presented in Table 2. Prospective follow-up of 16 cases of pregnant women with recent B19V infection showed that: 13 had healthy infants, with the exception of 4 babies born with transient perinatal anemia; 2 patients experienced spontaneous abortion; and 1 woman gave birth to a premature infant at 24 WG. None of the fetuses developed non-immune hydrops fetalis. The premature infant died a few days after delivery. The overall fetal loss rate in this prospective follow-up group of infected pregnant women was 12.5% (2/16) (Table 2).

Table 2. Summary table of serological and virological data and pregnancy outcomes in pregnant women with recent Parvovirus B19 infection.

Case	Maternal age	Gestational Age (weeks)	medical conditions	Hb (g/dL)	Platelet (/mm ³)	B19V results			Pregnancy outcome
						IgM	IgG	DNA	
1	23	12		9	331 000	pos	neg	neg	Birth of a premature baby at 24 WG
2	31	13		<8	55 000	pos	pos	neg	Spontaneous abortion at 14 WG
3	22	15	Gestational diabetes	12	290 000	pos	pos	neg	Spontaneous abortion at 17 WG
4	24	20	Pregnancy-induced hypertension	<8	189 000	pos	pos	neg	Live birth at 38 WG
5	20	27	Insulin-dependent diabetes	13	223 000	pos	neg	pos	Live birth at 38 WG
6	22	34	Hyperthyroidism	8	400 000	pos	pos	neg	Live birth at 39WG
7	25	35		15	170 000	pos	pos	neg	Live birth at 39 WG
8	33	35	Pregnancy-induced hypertension	12	200 000	pos	pos	neg	Live birth at 40 WG
9	32	36	Gestational diabetes	10.5	167 000	pos	pos	pos	Live birth at 40 WG
10	36	38	Hyperthyroidism	14	250 000	pos	pos	neg	Live birth at 40WG
11	30	38	Preeclampsia	12	340 000	pos	pos	neg	Live birth at 41 WG
12	21	39	Insulin-dependent diabetes	8	190 000	pos	pos	neg	Live birth at 41WG
13	23	41	Depression	12	159 000	pos	neg	neg	Live birth at 41 WG
14	24	41	Pregnancy-induced hypertension	13	300 000	pos	neg	neg	Live birth at 41 WG
15	30	41	Preeclampsia	9	420 000	pos	pos	neg	Live birth at 41 WG
16	32	41	Pregnancy-induced hypertension	10	190 000	pos	neg	pos	Live birth at 41WG

3.7. Study of the association between recent Parvovirus B19 infection and low birth weight

Our results showed that there is no significant association between recent maternal infection with the B19V and the birth weight of newborns (p -value = 0.837, $\chi^2 = 0.042$, 95% CI = 0.750 (0.048–2.648)). These newborns have a birth weight between 2 and 3 kg.

3.8. Study of short-and long-term complications in children born to mothers infected with Parvovirus B19

The study of short-and long-term sequelae in children born to mothers infected with the B19V

showed no growth delays and no development of neurological or cardiac disease until the age of less than one year.

4. Discussion

In this article, we report the clinical, biological, and molecular manifestations of recent B19V infection in 16 immunocompetent pregnant women. According to our literature review, we are the first to report on this topic in Morocco.

The predominant clinical manifestations observed and caused by the B19V in our series were arthralgia associated with a rash on the limbs, face, and body. A feeling of fatigue or malaise was also noted. Most of the women were symptomatic. Indeed, during pregnancy, B19V infection can be asymptomatic in 30 to 50% of cases or associated with symptoms such as arthralgia (46%), rash (38%), and fever (19%) [10].

Several studies have confirmed our results. A study by Parra et al. 2014, and Bonvicini et al. 2011, revealed that joint and skin involvement are the primary clinical manifestations in pregnant women [4,9].

In the 16 cases of pregnant women with recent infection, moderate anemia was found in half of the women, with only 1 case of thrombocytopenia. It was difficult to systematically link these biological manifestations to a pathogenic effect related to B19V. Transient cases of anemia and thrombocytopenia have been reported in the literature in healthy individuals following B19V infection [11,12].

In our study, among the 16 cases of pregnant women recently infected with B19V, four cases suffered from pregnancy-induced hypertension, 2 cases were in preeclampsia, 1 case had gestational diabetes and hyperthyroidism, and 1 case had depression. A study by Jensen et al. 2000, involving a cohort of 3596 pregnant women in Denmark, showed that pregnant women who suffered from certain serious diseases such as high blood pressure, insulin-dependent diabetes and /or kidney disease were the most susceptible to acute infection with the B19V [13].

The source of infection for pregnant women with the B19V in our study was contact with children exhibiting the same symptoms as their infected mothers, either simultaneously or later, the main symptom of which was the appearance of a rash on the children's face or body. Several studies have shown that the rash is more prevalent in children than in adults [14], and that the clinical manifestations of B19V infection in pregnant women differ from those in non-pregnant women and more closely resemble the clinical manifestations in children [15].

Of the 16 pregnant women with serological evidence of recent B19V infection, viral DNA was positive by Real-time PCR in 3 women. Indeed, 18.75% (3/16) of the pregnant women included in this study possessed the B19V genome as well as anti-B19 IgM antibodies.

Contradictory results were obtained by Adam et al. 2015, in a study of 500 pregnant women, in which only 1 case was IgM positive and no cases were PCR positive [16]. Another study by Karami et al. 2020 revealed that the IgM seroprevalence was 2%, and viral DNA was not detected by real-time PCR [17].

Other studies conducted in Sudan and Iran, similar to our results, showed that the prevalence of viral DNA was 2.1% (N = 97) and 0.73% (N = 824), respectively [18,19].

These remarkable differences in the prevalence of B19 virus DNA in pregnant women in different regions of the world could be explained by the sample size, the type of primers chosen, and the molecular technique used [20]. Another point to consider is that this work was probably conducted during a non-epidemic period for the B19 virus; hence, the limited number of primary infection cases detected [21,22].

In this study, 16 pregnant women with recent B19V infection underwent serial ultrasound

examinations to detect fetal anemia, ascites, or fetal death. Newborns also underwent clinical examinations to monitor pregnancy outcomes. The results were as follows: 13 pregnant women delivered healthy infants, 2 experienced spontaneous abortions, and 1 woman delivered a premature infant at 24 WG. No intrauterine deaths were observed, and none of the fetuses developed hydrops fetalis.

The women with symptomatic B19V identified in this study did not show fetal signs of vertical Transmission during their pregnancies, highlighting the lack of correlation between maternal Symptoms and adverse fetal outcomes [23].

The majority (2/3) of pregnant women who tested positive by Real-time PCR in our study were in the third trimester of pregnancy. Favorably, B19V infection in this trimester was associated with a low Rate of fetal complications. However, the risk of adverse fetal outcomes is increased if the mother is infected during the first two trimesters of pregnancy [7,24].

Several studies confirm our results, showing that transplacental B19V infection is most often asymptomatic and dependent on gestational age [25]. According to Enders M et al. 2012, asymptomatic intrauterine infection following B19V infection was the most frequent outcome, particularly after maternal infection in the second half of pregnancy [7].

These diverse and varied results obtained worldwide regarding the study of adverse pregnancy outcomes following B19V infection differ according to inclusion criteria, gestational age at the time of infection, the number of pregnant women included, the study duration, the presence or absence of a B19V epidemic, and the diagnostic methods used [26].

Evaluating the risk of low birth weight in the 13 cases of newborns born to mothers infected with B19V was deemed necessary because the virus may or may not cross the placental barrier, but infection of placental trophoblasts without fetal infection can affect fetal development [27].

There was no noticeable effect in our study between recent B19V infection and birth weight. Similar results were obtained by Sarfraz et al., 2009 and Marhamati et al., 2021, who reported that acquired or recent maternal B19V infection was not significantly associated with birth weight [28, 29].

Studies of the long-term effects of maternal B19V infection on children suggest that most children do not experience long-term sequelae, but further research is needed [30,31].

In our series, no short-or long-term adverse effects were observed in children born to mothers with recent infection.

In a survey conducted by Miller et al., 1998, no increased risk of serious or adverse outcomes was found in children whose mothers had been infected with B19V during pregnancy up to the age of one year [32]. In contrast, Nagel et al., 1993 observed abnormal neurological development in 5 of 16 infants who received intrauterine blood transfusions due to B19V infection [33].

B19V infection, in the absence of hydrops fetalis or significant fetal anemia, does not appear to cause long-term neurological morbidity, but severe anemia and fetal hydrops fetalis can lead to long-term neurological sequelae [33,34].

Maternal infection with B19V follows seasonal and annual variations. It is most often asymptomatic. However, the clinical presentation of a recent B19V infection is polymorphic.

In conclusion, the prevalence of viral DNA in cases of pregnant women with a recent infection was 18.75%. Our results showed that cases of spontaneous abortion in women with a recent infection were likely related to a recent B19V infection. No cases of intrauterine fetal death or non-immune hydrops fetalis were detected in recently infected women. These results highlight the importance of assessing the immune status of the B19V in pregnant women to closely monitor pregnant women with a recent infection and manage potential complications.

5. Future recommendations

Ensure systematic screening for B19V in pregnant women in cases of suspected exposure, development of symptoms suggestive of a B19V infection (flu-like syndrome, fever, malaise, arthralgia, skin rash, etc.), or following the discovery of fetoplacental hydrops by ultrasound. Conduct regular clinical, biological, molecular, and ultrasound monitoring of women presenting with symptoms related to the B19V. Accurate etiological diagnosis of any skin rash in pregnant women is important not only for treating the illness but also for differentiating B19V and suspected measles or rubella.

6. Limitations

The number of pregnant women in this study is limited, so increasing the sample size would help in obtaining more representative results. A large-scale, multicenter study should be considered and conducted to compare epidemiological data and to elucidate the possible relationship between B19V viral infections and adverse pregnancy outcomes, particularly in cases of non-immune fetal hydrops or intrauterine fetal death.

Use of AI tools declaration

The authors declare that they not used Artificial Intelligence (AI) tools in the creation of this article to improve the language quality of their content.

Conflict of interest

The authors declare no competing interests

Author contributions

MB: Extracting, drafting, analysis of data, statistical analysis of the manuscript. KW: Design and revision. SA: Investigation, Methodology. YEK and LA: Methodology and supervision. KH and AS: Resources, Supervision. SZ: Conceptualization, Methodology, Writing and review.

Ethics approval and consent to participate

The study was approved by the institution's research and ethics committee and the informed written consent was signed by all pregnant women who participated in the study. The code of ethics is no.17/2022 issued by the ethics committee of the university hospital in Marrakesh, Morocco.

Data availability

The data sets used and analysed in the current study are available from the corresponding author up on reasonable request.

References

1. Cotmore SF, Agbandje-McKenna M, Canuti M, et al. (2019) ICTV virus taxonomy profile: *Parvoviridae*. *J Gen Virol* 100: 367–368. <https://doi.org/10.1099/jgv.0.001212>
2. Gigi CE, Anumba DOC (2021) Parvovirus B19 infection in pregnancy—A review. *Eur J Obstet Gynecol Reprod Biol* 264: 358–362. <https://doi.org/10.1016/j.ejogrb.2021.07.046>
3. Zakrzewska K, Arvia R, Bua G, et al. (2023) Parvovirus B19: Insights and implication for pathogenesis, prevention and therapy. *Asp Mol Med* 1: 1–11. <https://doi.org/10.1016/j.amolm.2023.100007>
4. Parra D, Mekki Y, Durieu I, et al. (2014) Manifestations cliniques et biologiques de la primo-infection à Parvovirus B19 chez l'adulte immunocompétent: Étude rétrospective de 26 observations. *Rev Med Interne* 35: 289–296. <https://doi.org/10.1016/j.revmed.2013.04.015>
5. Bonvicini F, Bua G, Gallinella G (2017) Parvovirus B19 infection in pregnancy awareness and opportunities. *Curr Opin Virol* 27: 8–14. <https://doi.org/10.1016/j.coviro.2017.10.003>
6. Ornoy A, Ergaz Z (2017) Parvovirus B19 infection during pregnancy and risks to the fetus. *Birth Defects Res* 109: 311–323. <https://doi.org/10.1002/bdra.23588>
7. Enders M, Klingel K, Weidner A, et al. (2012) Risk of fetal hydrops and non-hydropsic late intrauterine fetal death after gestational parvovirus B19 infection. *J Clin Virol* 49: 163–168. <https://doi.org/10.1016/j.jcv.2010.07.014>
8. Bascietto F, Liberati M, Murgano D, et al. (2018) Outcome of fetuses with congenital parvovirus B19 infection: Systematic review and meta-analysis. *Ultrasound Obstet Gynecol* 52: 569–576. <https://doi.org/10.1002/uog.19092>
9. Bonvicini F, Puccetti C, Salfi NCM, et al. (2011) Gestational and fetal outcomes in B19 maternal infection: A problem of diagnosis. *J Clin Microbiol* 49: 3514–3518. <https://doi.org/10.1128/JCM.00854-11>
10. Puccetti C, Contoli M, Bonvicini F, et al. (2012) Parvovirus B19 in pregnancy: Possible consequences of vertical transmission. *Prenat Diagn* 32: 897–902. <https://doi.org/10.1002/pd.3930>
11. Segata M, Chaoui R, Khalek N, et al. (2007) Fetal thrombocytopenia secondary to parvovirus infection. *Am J Obstet Gynecol* 196: 61.E1–61.E4. <https://doi.org/10.1016/j.ajog.2006.08.041>
12. Oiwa H, Shimada T, Hashimoto M, et al. (2011) Clinical findings in parvovirus B19 infection in 30 adult patients in Kyoto. *Mod Rheumatol* 21: 24–31. <https://doi.org/10.3109/s10165-010-0338-y>
13. Jensen P, Thorsen P, Jeune B, et al. (2000) An epidemic of parvovirus B19 in a population of 3596 pregnant women: A study of sociodemographic and medical risk factors. *BJOG Int J Obstet Gynaecol* 107: 637–643. <https://doi.org/10.1111/j.1471-0528.2000.tb13306.x>
14. Van Beers-Tas M, Heidema J (2013) Review: Pathogenesis of parvovirus infections in children. *Virol Mycol* 2: 1–5. <https://doi.org/10.4172/2161-0517.1000110>
15. Chisaka H, Ito K, Niikura H, et al. (2006) Clinical manifestations and outcomes of parvovirus B19 infection during pregnancy in Japan. *Tohoku J Exp Med* 209: 277–283. <https://doi.org/10.1620/tjem.209.277>
16. Adam O, Makkawi T, Reber U, et al. (2015) The seroprevalence of parvovirus B19 infection in pregnant women in Sudan. *Epidemiol Infect* 143: 242–248. <https://doi.org/10.1017/S0950268814000600>

17. Karami A, Hoseini SL, Ramazani A, et al. (2020) Prevalence of parvovirus B19 infection by serology and PCR in pregnant women referring to obstetrics and gynecology clinic. *J Natl Med Assoc* 112: 91–96. <https://doi.org/10.1016/j.jnma.2018.12.001>
18. Abdelkabeer TH, Mohammed NE, Khider JS, et al. (2022) Detection of parvovirus B19 DNA in pregnant Sudanese women attending the military hospital using Nested PCR technique. *Al-Kindy Coll Med J* 18: 144–147. <https://doi.org/10.47723/kcmj.v18i2.788>
19. Taherkhani R, Farshadpour F, Norozi M (2022) Molecular evaluation of human parvovirus B19 infection and associated risk factors among pregnant women in Bushehr province, Southern Iran. *Am J Trop Med Hyg* 106: 1539–1546. <https://doi.org/10.4269/ajtmh.21-1088>
20. Servant-Delmas A, Morinet F (2016) Update of the human parvovirus B19 biology. *Transfus Clin Biol* 23: 5–12. <https://doi.org/10.1016/j.traccli.2015.11.006>
21. Elnifro E, Nisha AK, Almabsoot M, et al. (2009) Seroprevalence of parvovirus B19 among pregnant women in Tripoli, Libya. *J Infect Dev Ctries* 3: 218–220. <https://doi.org/10.3855/jidc.38>
22. Seetha D, Pillai HR, Nori SRC, et al. (2021) Molecular genetic characterization of human parvovirus B19 prevalent in Kerala State, India. *Virol J* 18: 96. <https://doi.org/10.1186/s12985-021-01569-1>
23. Beigi RH, Wiesenfeld HC, Landers DV, et al. (2008) High rate of severe fetal outcomes associated with maternal parvovirus B19 infection in pregnancy. *Infect Dis Obstet Gynecol* 2008: 524601. <https://doi.org/10.1155/2008/524601>
24. Lassen J, Jensen AKV, Bager P, et al. (2012) Parvovirus B19 infection in the first trimester of pregnancy and risk of fetal loss: A population-based case-control study. *Am J Epidemiol* 176: 803–807. <https://doi.org/10.1093/aje/kws177>
25. Kaşifoğlu N, Us T (2016) Parvovirus B19 infections in pregnant women and neonates: Review. *Turk Klin J Gynecol Obstet* 26: 103–108. <https://doi.org/10.5336/gynobstet.2013-38434>
26. Riipinen A, Väisänen E, Nuutila M, et al. (2008) Parvovirus B19 infection in fetal deaths. *Clin Infect Dis* 47: 1519–1525. <https://doi.org/10.1086/593190>
27. Barlinn R, Trogstad L, Rollag H, et al. (2020) Parvovirus B19 DNAemia in pregnant women in relation to perinatal death: A nested case-control study within a large population-based pregnancy cohort. *Acta Obstet Gynecol Scand* 99: 856–864. <https://doi.org/10.1111/aogs.13801>
28. Sarfraz A, Samuelsen S, Bruu AL, et al. (2009) Maternal human parvovirus B19 infection and the risk of fetal death and low birthweight: A case-control study within 35940 pregnant women. *BJOG Int J Obstet Gynaecol* 116: 1492–1498. <https://doi.org/10.1111/j.1471-0528.2009.02211.x>
29. Marhamati N, Shirvani F, Azimi L, et al. (2021) Molecular detection of human parvovirus B19 in umbilical cord blood: Case study of Tehran, Iran. *Gene Rep* 23: 101183. <https://doi.org/10.1016/j.genrep.2021.101183>
30. De Jong EP, Walther FJ, Kroes ACM, et al. (2011) Parvovirus B19 infection in pregnancy: New insights and management. *Prenat Diagn* 31: 419–425. <https://doi.org/10.1002/pd.2714>
31. Lamont RF, Sobel JD, Vaisbuch E, et al. (2011) Parvovirus B19 infection in human pregnancy. *BJOG Int J Obstet Gynaecol* 118: 175–186. <https://doi.org/10.1002/pd.2714>
32. Miller E, Fairley CK, Cohen BJ, et al. (1998) Immediate and long term outcome of human parvovirus B19 infection in pregnancy. *BJOG Int J Obstet Gynaecol* 105: 174–178. <https://doi.org/10.1111/j.1471-0528.1998.tb10048.x>
33. Nagel HTC, de HaanTR, Vandenbussche FPHA, et al. (2007) Long-term outcome after fetal transfusion for hydrops associated with parvovirus B19 infection. *Obstet Gynecol* 109: 42–47. <https://doi.org/10.1097/01.AOG.0000249611.67873.94>

34. Malm C, Fridell E, Jansson K (1993) Heart failure after parvovirus B19 infection. *Orig Publ* 341: 1408–1409. [https://doi.org/10.1016/0140-6736\(93\)90973-K](https://doi.org/10.1016/0140-6736(93)90973-K)



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