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Seroprevalence of human cytomegalovirus and its impact on hematological, biochemical and genetic factors among aborted women in Baghdad

A Thesis

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By

Ahmed Shehab Ahmed

Supervised by

Prof. Dr. Ibrahim Hadi Mohammed

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بِسْمِ اللَّهِ الرَّحْمَٰنِ الرَّحِيمِ

﴿ وَلَقَدْ آتَيْنَا دَاوُودَ وَسُلَيْمَانَ عِلْمًا ۖ وَقَالَا الْحَمْدُ لِلَّهِ الَّذِي فَضَّلَنَا عَلَىٰ كَثِيرٍ مِّنْ عِبَادِهِ الْمُؤْمِنِينَ ﴾

﴿صَدَقَ اللَّهُ الْعَظِيمُ﴾

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Abstract

Human cytomegalovirus (HCMV) is typically asymptomatic in healthy individuals; however, morbidity and mortality rates increase significantly among immunocompromised patients. Moreover, the virus can cause various health complications in pregnant women and their fetuses, potentially leading to abortion. The present study aimed to compare women who experienced abortion and were infected with HCMV in Baghdad province with the healthy pregnant women and to investigate the effect of the virus on several important hematological parameters, in addition to its association with selected social and demographic characteristics. An enzyme-linked immunosorbent assay (ELISA) was performed to determine the seroprevalence of immunoglobulin M (IgM) and immunoglobulin G (IgG). The study included 180 participants: 130 women with abortion and 50 healthy pregnant women as a control group, between December 2024 and March 2025. Results showed that the mean age of the aborted women group was 30.76 ± 0.61 years, compared to 30.22 ± 1.005 years in the control group (P = 0.642). The percentage of positive anti-HCMV antibody in aborted women was 25.4% for IgM and 100% for IgG, respectively, compared to the control group's 0.0%, a significant difference (P = 0.001). The prevalence of anti-HCMV IgM and IgG Ab was higher among patients aged 19–35 years, with rates of 96.9% and 73.8%, respectively, also showing a significant difference compared with controls (P = 0.001). With regard to residential area, 64.9% of the miscarried women lived in urban regions with low socioeconomic status. A total of 68.5% were housewives, 73.1% had attended primary school, and 54.6% were in consanguineous marriages. Additionally, 4.6% reported contact with animals. Levels of hemoglobin (Hb), red blood cells (RBCs), and platelets (PLT) were lower in the miscarried group (9.43 g/dL, 3.28 × 10^6/µL, and 103.93 × 10^3/µL, respectively) compared with the control group (12.93 g/dL, 4.35 × 10^6/µL, and 256.04 × 10^3/µL, respectively), with statistically significant differences

(*P* = 0.001). Conversely, white blood cell (WBC) counts were significantly higher among miscarried women (13.08 × 10^3/µL) compared with controls (6.05 × 10^3/µL). Furthermore, 53.1% of the miscarried women had the O^+ blood group. Levels of C-reactive protein (CRP) were elevated in the patient group (10.00 mg/L) compared to the control group (2.21 mg/L), with a significant difference (*P* = 0.001). The erythrocyte sedimentation rate (ESR) was also higher in patients (61.39 mm/h) compared to controls (29.68 mm/h). Albumin levels were significantly reduced in patients (2.5 g/dL) compared with the control group (4.24 g/dL) (*P* = 0.001). In addition, levels of alanine aminotransferase (ALT), aspartate aminotransferase (AST), urea, and creatinine were markedly higher in the patient group (74.08 IU/L, 60.33 IU/L, 56.62 mg/dL, and 1.40 mg/dL, respectively) compared with the control group (30.19 IU/L, 27.47 IU/L, 28.65 mg/dL, and 0.91 mg/dL, respectively), all with significant differences (*P* = 0.001). Both systolic and diastolic blood pressure levels were lower among the miscarried group (105.75 mmHg and 63.18 mmHg, respectively) compared to controls (120.10 mmHg and 77.60 mmHg, respectively), with significant differences (*P* = 0.001). The prevalence of urinary tract infection (UTI) was 11.5% among the patient group, compared with 0.0% in controls (*P* = 0.001). Chronic diseases were also more frequent among patients (8.5%) than controls (0.0%) (*P* = 0.001). Finally, chromosomal analysis revealed no detectable aberration.

In conclusion, the present study determined that the seroprevalence of anti-CMV immunoglobulins M and G is widespread among women who have experienced abortion. Furthermore, CMV infection was associated with the patients' social status, including their educational level and place of residence. The study also concluded that numerous hematological parameters, enzymatic activities, and vital organ functions were directly affected by CMV infection.

Chapter One:

Introduction

1.Introduction:

Every year, about 23 million miscarriages are reported worldwide (Quenby *et al*., 2021). About 80% of miscarriages occur during the first twelve weeks (Melo *et al*., 2023). Because pregnant women have higher rates of virus-associated morbidity and mortality than their non pregnant counterparts, systemic maternal viral infections can also have an impact on the pregnancy and can be particularly harmful (Racicot & Mor, 2017). Under certain circumstances, infectious diseases have the potential to cause miscarriage or serious harm to the embryo and fetus (Wang *et al*., 2019).

The high prevalence of human cytomegalovirus (HCMV) infection in Iraqi women raises the possibility that the virus and repeated abortions are related (Kareem *et al*., 2022). CMV, a common virus that affects the majority of people, significantly increases morbidity and death, especially in those with weakened immune systems (Fowler *et al*., 2022). Worldwide, HCMV infection is widespread, and in affluent nations, the prevalence of some antibodies ranges from 60% to 90% (Altevogt *et al*., 2021).

In immunocompetent people, HCMV often produces asymptomatic infections; nevertheless, a mononucleosis-like illness may arise after a primary infection (Schattner, 2024). In immunocompromised people, an HCMV infection can cause serious illness. For instance, HCMV infection is a serious clinical problem in patients with acquired immunodeficiency syndrome (AIDS) (Zhao *et al*., 2020) and those receiving immunosuppressive treatment, such as recipients of solid organ and stem cell transplants (Stewart & Kotton, 2024). One of the main causes of birth abnormalities and developmental disorders is congenital CMV(cCMV) infection, which is brought on by mother-to-fetus transmission during pregnancy. Children born to pregnant women who have a primary infection are at the highest risk of impairment (Al Beloushi *et al*., 2024). HCMV infections can occur through vertical transmission from mother to fetus via the placenta, as well as through horizontal transmission following the

shedding of the virus in bodily fluids from HCMV-infected individuals. This horizontal transmission happens when susceptible individuals are exposed to these virus-laden fluids (Yue et al., 2022). Contact with infectious body fluids, including blood, saliva, urine, tears, seminal fluid, cervical secretions, and breast milk, can spread CMV(Tzialla *et al*., 2025). Furthermore, infection may occur after solid organ and stem cell donation (Zhou *et al*., 2021). Chromosome abnormalities caused by the HCMV are known to occur in infected cells, and this can result in congenital defects in infected fetuses (Siew *et al*., 2009).

Aims of the study:

1- Determine the seroprevalence rate of the HCMV IgM and IgG antibodies in invited women.

2- Investigate the relationship between HCMV and abortion.

3- Examine the relationship between the virus and various demographic, social, hematological, and biochemical factors.

4- Performing genetic tests, including chromosomal karyotype examination.

Chapter Two:

Litereture Review

2. Literature Review:

2.1 Abortion:

A spontaneous abortion or miscarriage occurs when a pregnancy ends before it reaches viability, with a birthweight of less than 500 g and less than 20 weeks of gestation (Quenby et al., 2021). Worldwide, there are about 23 million miscarriages reported each year (The Lancet, 2021). Because of their well-known proinflammatory condition, pregnant women are thought to be particularly susceptible to viral infections, particularly during the first trimester (Liu et al., 2020). The first trimester of pregnancy is renowned for its proinflammatory condition, making it a problematic period due to increased maternal vulnerability to viral infections (Burlacu et al., 2025). According to Ganatra et al. (2017), a fetus is generally deemed viable if it is more than 20 to 24 weeks gestation. The involuntary termination of an intrauterine pregnancy before 28 full weeks of gestation, in which the fetus was dead when expelled, was described as spontaneous abortion by the World Health Organization in 1970 (Najafipour et al., 2016).

2.1.1 Types of abortion:

Recurrent spontaneous abortion (RSA) is the term used to describe the spontaneous ending of two or more consecutive pregnancies before the fetus is capable of external life (20th week) (Deng et al., 2022). According to Babker et al. (2015), there are several different forms of spontaneous abortion, including threatened abortion, inevitable abortion, incomplete abortion, missed abortion, septic abortion, full abortion, and recurring spontaneous abortion. Between 8% to 20% of all known pregnancies terminate spontaneously. About 80% of spontaneous pregnancy losses occur during the first trimester, and the rate drops with each week of pregnancy (Pinar et al., 2018). There are numerous types of spontaneous abortion that can be classified based on pelvic ultrasonography results and inspection. A nonviable intrauterine pregnancy with a closed cervix and little or no

abdominal cramps or vaginal bleeding is described as a missed abortion, which is further divided into anembryonic gestation and embryonic demise (Alves et al., 2023; Majeed et al., 2025). Anembryonic gestation is a pregnancy in which the embryo does not develop. It is proven when the mean gestational sac diameter assessed by transvaginal ultrasonography is greater than 20 mm and no embryonic pole is detected. When an embryo has a crown-rump length of more than 5 mm and no heart activity, it is characterized as embryonic demise, and the pregnancy is considered nonviable (Ganatra et al., 2017). An incomplete abortion is another kind of abortion that includes cervical dilatation, cramping (contractions), vaginal bleeding, and incomplete passage of the fetus. When a woman has an incomplete abortion, she often reports vaginal bleeding and the passage of clots or tissue fragments (Wang et al., 2019). Though not as severe as a full-term labor, the cramping may be rhythmic or labor-like. The infant has already passed away and is either a part of the retained tissue or has already perished (Kalilani et al., 2015).

2.1.2 Causes of abortion:

2.1.2.1 Uterus malformations:

Formation defects, fusion flaws, and septal absorption defects are the three main types of uterine abnormalities, according to Akhtar et al. (2019). It has been difficult to determine the actual prevalence of uterine malformations because some abnormalities, such as an arcuate uterus, may be considered normal variations of uterine anatomy (Chan et al., 2011).

2.1.2.2 Placental problems:

The placenta is an organ that grows inside the womb during pregnancy. Uteroplacental vascular insufficiency, another name for placental malfunction, is an uncommon yet serious pregnancy ailment. The mother's bloodstream cannot supply the infant with adequate oxygen and

nourishment. Without this vital support, the baby will not be able to grow and flourish (Gaboon et al., 2015).

2.1.2.3 Immunological disorder:

During pregnancy, the fetus and the mother provide a variety of hormonal and metabolic variables that have a complex impact on the mother's immune system. Variations in cell numbers, morphologies, and their functional ability to release cytokines and other mediators are among the changes in the maternal immune response. Pro- and anti-inflammatory responses are dynamically modulated according to the stage of pregnancy (Rahnama, 2021). T cells and/or antibodies mediate self-reactive immune responses that cause tissue and organ damage in autoimmune diseases. The complicated links between autoimmunity and reproduction are shown by the effects of pregnancy on autoimmune illnesses and autoimmunity on pregnancy (Marder et al., 2016).

2.1.2.4 Bacterial infection:

The most prevalent cause of abortion-related disorders is an ascending bacterial infection, such as chlamydia, gonorrhea, mycoplasma, or bacterial vaginosis (BV), which begins in the lower genitals and spreads to the uterus via the cervix. If not treated, the infection may spread to the fallopian tubes, causing infertility (Hay, 2017).Variations in the normal vaginal flora, particularly a notable decline in lactobacilli counts, are indicative of bacterial vaginosis, the most common nonulcerative lower genital tract disease (Haddad et al., 2017). Understanding the pathogenic events linked to vaginitis requires an understanding of the normal vaginal flora. Ninety-five percent of typical vaginal flora is composed of Lactobacillus species, with the remaining five percent being facultative anaerobic and anaerobic microbe species (Petrov et al., 2021). The lactic acid, hydrogen peroxide, and antibiotic proteins produced by Lactobacillus species shield the vaginal flora from genital infections. Anaerobic and facultative anaerobic

microorganisms replace Lactobacillus species as their numbers decrease (Fourie et al., 2021).

2.1.2.5 Parasites infection:

One of the causes of abortion is toxoplasmosis, which is caused by the obligate intracellular parasite Toxoplasma gondii (T. gondii), which belongs to the phylum Sporozoa (Dubey, 2004). Global research indicates that between 14 and 77% of pregnant women are infected with T. gondii (Montoya, 2004). The frequency and severity of congenital toxoplasmosis are associated with gestational age. The first and second trimesters of pregnancy have the highest infection severity, which can lead to stillbirth or miscarriage, even though the third trimester has the highest risk of congenital toxoplasmosis (Li et al., 2014).

2.1.2.6 Viral infection:

During pregnancy, viral infections have been associated with poor pregnancy outcomes and birth defects in the offspring (Tognon et al., 2020). Although viruses seldom cross the placental barrier, when they do, they can result in severe birth defects such microcephaly or even the fetus's death (Silasi et al., 2015). It is well recognized that placental dysfunction caused by viral infection of cells at the maternal-fetal interface can result in pregnancy complications such as miscarriage, intrauterine growth restriction (IUGR), or preterm birth (PTB). Additionally, there is growing evidence that viral infection of the decidua and/or placenta may produce soluble immune factors that could affect fetal development by reaching the fetus (McGee et al., 2016). A common cause of maculopapular rash and fever is rubella. There aren't many consequences from the disease until a pregnant woman contracts it, especially in the first few weeks of pregnancy. A congenital rubella infection in the fetus may result in stillbirth, miscarriage, or congenital rubella infection (Abdullah et al., 2009). Women are at a higher risk of contracting the Cytomegalovirus, and the risk rises with age. CMV is

the primary cause of infection in 15–25% of pregnancies, and in as many as 40% of cases, it can be passed on to the fetus. 15% of these infections are asymptomatic, 15% are congenital illnesses with symptoms, and some cause miscarriages (Revello et al., 2015).

One of the most dangerous congenital conditions is CMV infection, which can cause neurologic symptoms and deafness in 10–14% of infected fetuses. In 34% of cases, premature birth results from a CMV infection during pregnancy. Perinatal infections, particularly during the first trimester, can cause acute fetal infections that manifest as neurologic, eye disease, and auditory symptoms. 2.4% of spontaneous abortions and fetal fatalities are caused by CMV infection (Gao et al., 2018). A common cause of miscarriages, CMV infection is also a prominent factor in recurrent abortions, especially in people with immunosuppression and acquired immunodeficiency syndrome (AIDS) (Buxmann et al., 2017). Screening for CMV during pregnancy is essential due to the detrimental effects of perinatal CMV infection. If a CMV infection is identified early in pregnancy, it may be possible to give a voluntary termination of pregnancy and prevent the delivery of a problematic newborn (Stoykova and Ivanova, 2016).

2.2 Human cytomegalovirus (HCMV):

The widespread virus known as CMV can cause severe end-organ dysfunction in immunocompromised children with congenital CMV illness, or it can cause no symptoms at all. The family of viruses known as herpesviruses, Herpesviridae, or human herpesvirus-5 (HHV-5) includes the human cytomegalovirus. Salivary gland infections are frequently linked to human cytomegaloviruses. In healthy individuals, CMV infections may not cause any symptoms, but in immunocompromised patients, they can be fatal (Gupta & Shorman 2025). The most common member of the herpes virus family is CMV. In affluent nations, the most frequent cause of congenital malformations brought on by viral intrauterine infection is HCMV (Ariani

& Chaichi, 2014). A significant portion of people get CMV during their lifetime, and it hides in leukocytes once the illness has subsided. Despite not being regarded as a health risk, this virus poses a serious risk to the health of unborn children in pregnant women. According to Altayeb et al. (2016), primary CMV infection affects 0.15–2.00 percent of pregnancies and can be passed on to the fetus in 40% of cases. Close contact with contagious people can result in infection. Transmission can occur horizontally (via sexual contact or contact with fluids including blood, breast milk, saliva, or maternal genital secretions) or vertically (transplacental from mother to fetus) (Parsons et al., 2021). Additionally, it can be spread by solid organ donation or stem cell transplantation (Badami, 2014). Human cytomegalovirus causes intrauterine infection in women who are most at risk of other infections during childbirth because of the virus's ability to harm the fetus, leading to spontaneous abortion or congenital abnormalities. According to Aigberua (2019), viruses can evade host protection in a number of ways.The illness is pervasive globally impacting persons with lower socioeconomic status and wider areas in developing nations (Zenebe et al., 2021). Women of reproductive age are at a significant risk of giving birth to children who have a congenital infection if the infection is contracted during pregnancy (Bialas et al., 2015). Unfortunately, HCMV IgM was shown to be much more common in pregnant women and unmarried women in six investigations conducted in Iraq. There are several elements that make HCMV a more serious health concern, such as the lack of a known vaccination and a particular antiviral medication. The majority of infections in women and babies are also asymptomatic, which means they are not identified at birth (Abbas & Egbe, 2021).

2.3 Taxonomy of HCMV:

Human cytomegalovirus, which infects both humans and animals, is classified based on comparative biology, physicochemical traits, and virion

morphology. Over the past two decades, genomic sequence analysis has largely replaced older methods for viral classification. According to the Baltimore system, HCMV belongs to Group I and is classified as follows: Group: dsDNA; Order: Herpesvirales; Family: Herpesviridae; Subfamily: Betaherpesvirinae; Genus: Cytomegalovirus; Species: Human Cytomegalovirus (Gugliesi et al., 2020). The International Committee on Taxonomy of Viruses (ICTV) states that human herpesvirus-5 (HHV-5) was a member of the Herpesviridae family and referred to as human cytomegalovirus (HCMV). Herpes simplex viruses 1 (HHV-1) and 2 (HHV-2), varicella-zoster virus (HHV-3), Epstein-Barr virus (HHV-4), and HHV-6, -7, and -8 are all members of this family. Together with cytomegaloviruses that were present in a variety of animal species, it belongs to the subfamily Betaherpesvirinae due to its affinity for salivary glands, slow development in cell culture, and strong species specificity. The most representative species of the genus Cytomegalovirus was human CMV, also referred to as cytomegalovirus. The potential of the virus to induce infected cells to enlarge—"cyto" meaning cell and "mega" meaning huge—was the basis for its name (Gatherer et al., 2021).

2.4 Genomic structure of HCMV:

One of the biggest categories of human viral diseases is HCMV.With a somewhat larger diameter of 200 to 300 nm and a more irregular envelope,the virion possesses a classic herpesvirus structure. A 125 nm icosahedral nucleocapsid made of five herpesvirus core proteins is found inside virions. According to Murphy and Shenk (2008), the nucleocapsid has a linear ds-DNA genome of about 235 kb (Figure 2-1). At least 27 viruse encoded protiens and numerous more small protiens are present in the tegument (or matrix) in which the nucleocapsid is embedded (Varnum et al., 2004).

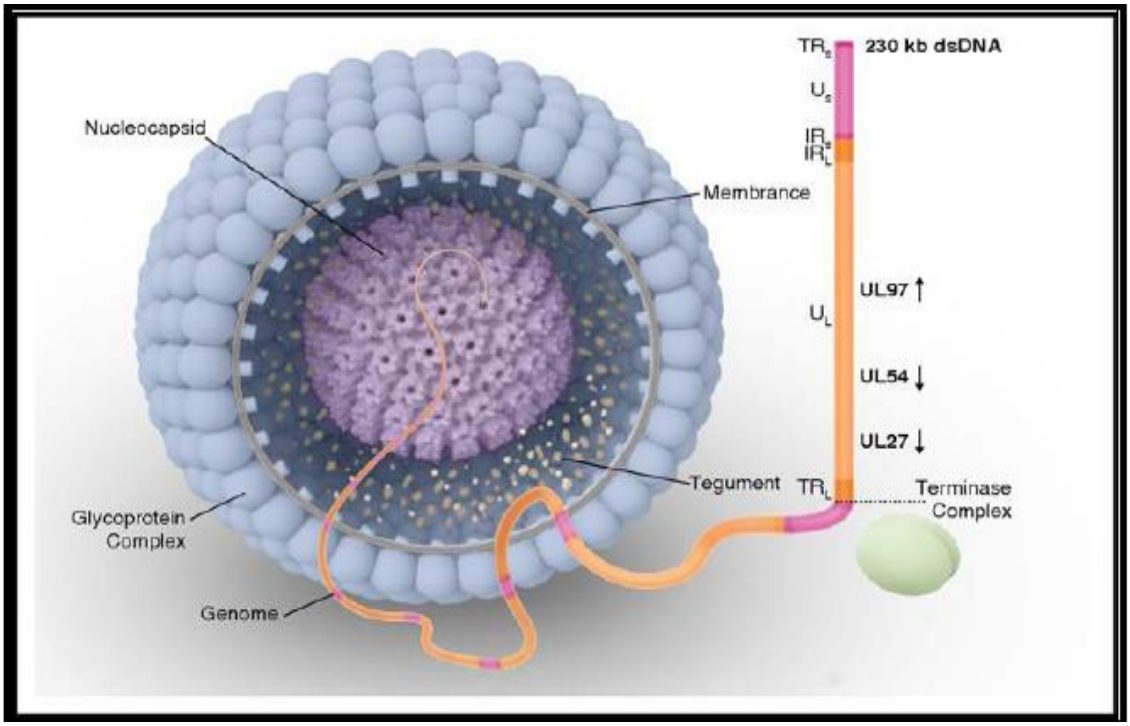

Figure (2-1): Structure of HCMV and genome organization (Murphy and Shenk, 2008).

With a genomic length of roughly 235 kbp, HCMV has the longest double stranded DNA (dsDNA) of any human herpesvirus.Of the approximately 200 genes, only a small fraction (14 microRNAs) express noncoding RNAs; the remaining genes encode proteins (Liu et al., 2019). With two separate sections—the *unique long* (*UL*) and *unique short* (*US*)—with inverted repeats on either side (terminal repeat long, internal repeat long (*TRL*, *IRL*), and internal repeat short, terminal repeat short (*IRS/TRS*), the HCMV genome exhibits the characteristic herpes virus class E genomic architecture. Numerous gene families, such as *RL11*, *UL14*, *UL18*, *UL25*, *UL82*, *UL120*, *US6*, *US7*, *US12*, and *US22*, are present in the HCMV genome. According to studies, there are more than 751 translated open reading frames (*ORFs*) in the HCMV genome (Stern Ginossar et al., 2012; Patro, 2019). Of them, 285 viral transcripts actively participate in the translation process (Balazs et al., 2017). Of them, 208 offer unique coding potential. Furthermore, according to Gatherer et al. (2011), a third of the virus poly-A transcripts from RNA are in charge of

protein encoding. Furthermore, it has been discovered to have 26 mature miRNAs and 16 pre-miRNAs in total (Ding et al., 2017; Zhang et al., 2020). 4 genome isomers can be produced by inserting *UL* and *US* sections between repetitions in either orientation (Cunningham et al., 2010). Core gene clusters that are mostly exclusive to the middle region of the *UL* can be located there (McSharry et al., 2012) (Figure 2-2).

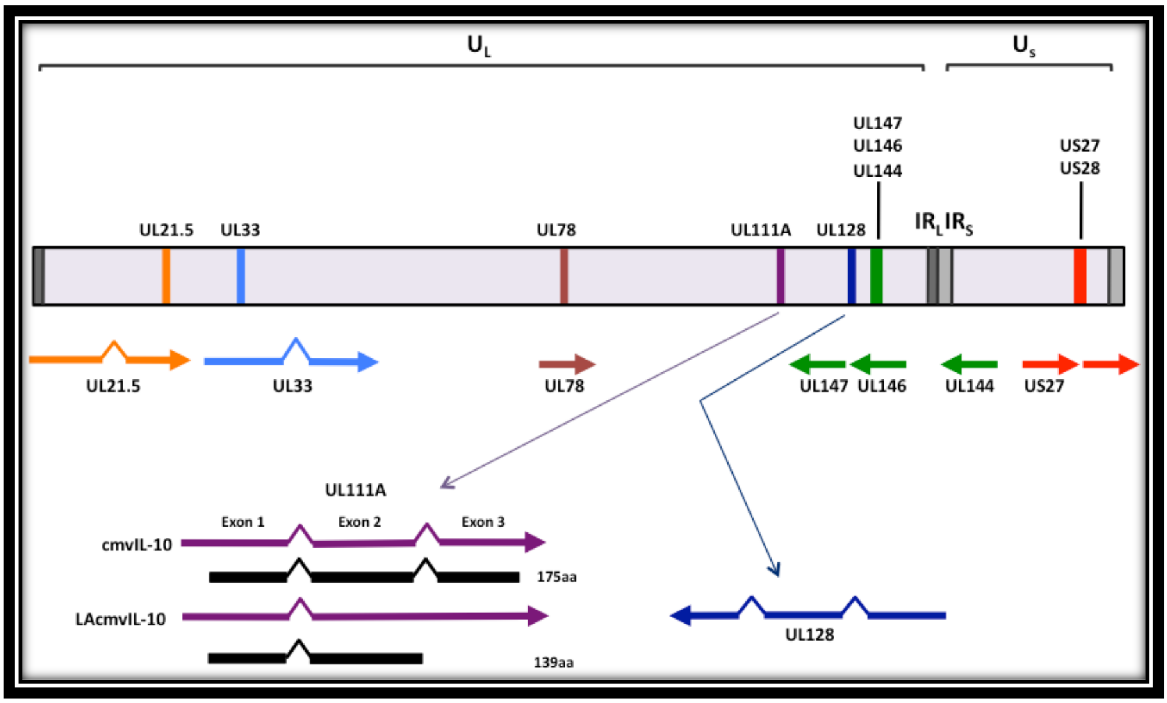

Figure (2-2): Elements of the HCMV genome (McSharry et al., 2012).

2.5 Life cycle HCMV:

2.5.1 Viral entry:

According to Crough and Khanna (2009), CMV virions enter host cells through a process called membrane fusion, where the glycoproteins on their lipid envelope fuse with the outer membrane of the host cell. According to Shenk et al. (2008), receptors on the viral envelope attach to complementary receptors on the host cell's membrane. The membranes may merge as a result of this initial connection, allowing the viral tegument and genomic DNA to enter the host cell and expose it to more interactions. When

the DNA-containing nucleocapsid moves to the nuclear pore complex, it is believed that a variety of tegument proteins play a role in the subsequent release of viral DNA into the nucleus (Graf et al., 2018) (Figure 2-3).

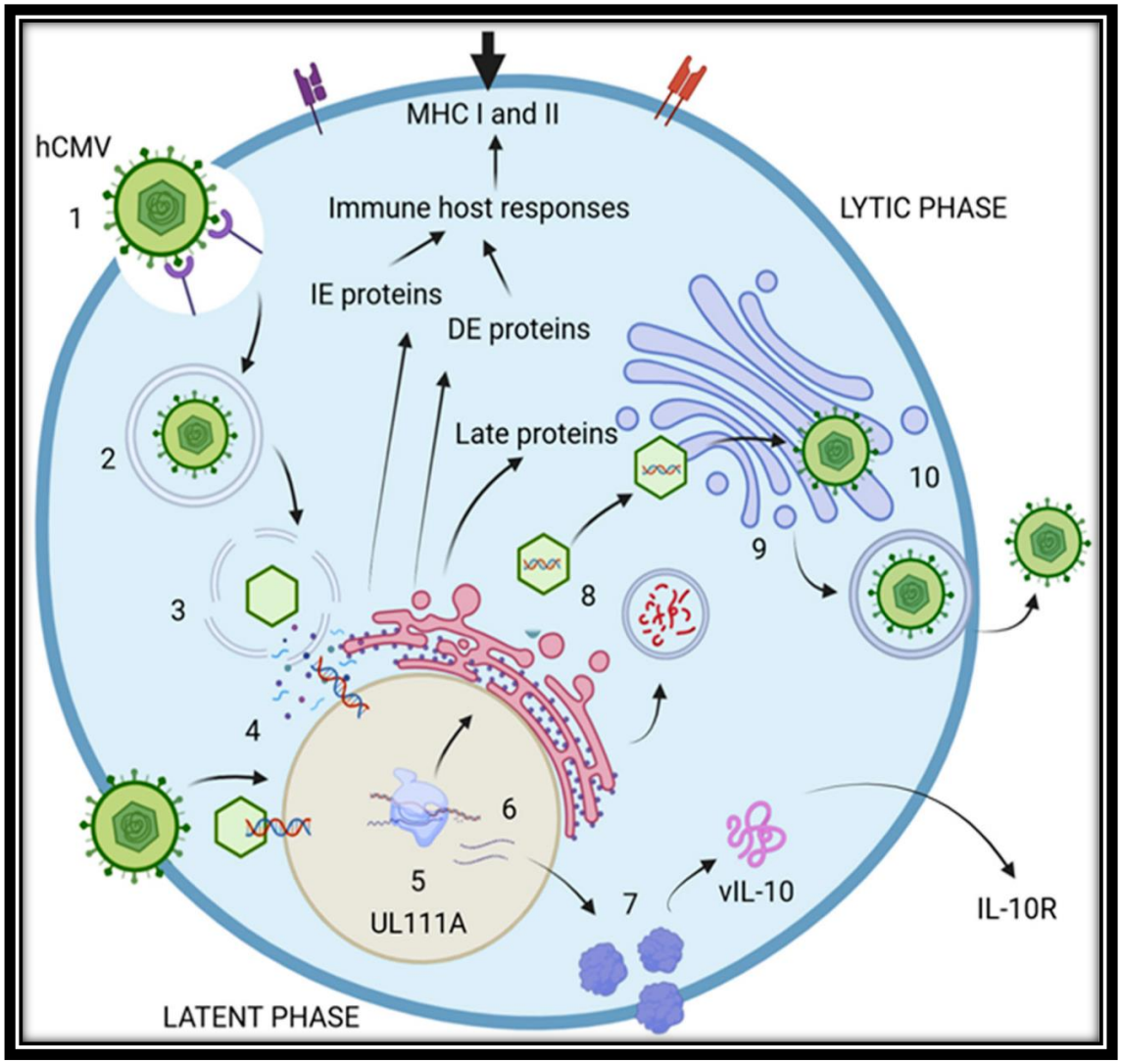

Figure (2-3): Life cycle of HCMV in a human cell (Pamela et al., 2025)

2.5.2 Replication of HCMV:

In CMV replication, gene expression is arranged chronologically. A set of immediate-early (*IE*) genes, primarily transcriptional regulators, are expressed when the virus enters the nucleus. These genes' expression determines the transcription of the early genes, which comprise the second temporal class and are mostly involved in DNA replication (Stinski, 2014). The polymerase gene (*pol* gene) is a member of this temporal class. After

DNA replication begins, late genes encoding viral structural and assembly proteins are expressed from the replicated genomes (Meier & Stinski, 2013).

2.5.3 Gene expression:

Viral immediate-early genes are activated once the viral genome enters the host cell's nucleus, facilitated by the pp71 tegument protein. This activation initiates the lytic stage of the viral life cycle and leads to the replication of the 236-kb double-stranded CMV DNA genome (Graf et al., 2018).

2.5.4 Gathering and releasing:

Following viral DNA replication, the expression of viral late genes is triggered by a number of early gene products, including several tegument proteins. Most of the late proteins of CMV are structures that help shape and escape newly infectious CMV virions. The exocytosis mechanism encloses vacuoles containing newly generated infectious virions via the host cell's transport system, and after the virions are packed, they are released into the extracellular space (Graf et al., 2018).

2.6 Tropism of HCMV:

The virus can infiltrate a broad range of tissue cells in vivo, including muscle cells, phagocytes, fibroblasts, epithelial cells, and neural cells. Because of this, the virus can affect several organ systems and cause a wide range of illnesses (Acquaye-Seedah et al., 2015).

2.7 Immunity to HCMV:

2.7.1 Host immunity to HCMV infection:

Many innate immune response hallmarks are stimulated by human cytomegalovirus (HCMV). Natural killer cells (NK cells) and dendritic cells (DC) secrete interferon alpha/beta (IFN α/β) through toll-like receptors. IFN α/β activates the genes in host cells that produce the enzymes that break down viral mRNA and stop the viral genome from translating (Lisnic et al.,

2015). Either alone or in conjunction with the complement, antibodies have the ability to neutralize the free virus. Cellular immunity is the primary HCMV control factor in an organism. Individuals who have anomalies in their cellular immune system are more likely to experience invasive or symptomatic infection and HCMV reactivation. According to Broadley *et al.* (2017), a healthy quantity of HCMV-specific $CD4^+$ and $CD8^+$ cells is essential for both virus reactivation and resistance to initial infection.

2.7.2 Immune evasion by HCMV:

By focusing on intrinsic, innate, and adaptive immune responses, a number of unique tegument proteins, including *Pp 65* and *Pp 71*, enable CMV to evade the host cell immune system. According to Graf et al. (2018), *Pp 65* is a crucial tegument protein that aids in the host's immune evasion. The human cytomegalovirus employs a number of tactics to impair the host's immune system. Throughout its life cycle, HCMV alters both the innate and adaptive immune responses (Terrazzini & Kern, 2014). NK cell function can be modulated and inhibited by at least seven genes in HCMV (Charpak Amikam et al., 2017). Certain HCMV proteins decrease the expression of Major Histocompatibility Complex (MHC) class I or class II proteins on the cell surface, which could help infected cells evade adaptive immune responses (Walker, 2021).

Immune evasion is anticipated to be facilitated by cytokines, chemokines, and chemokine receptors expressed by HCMV (Kaczorowski et al., 2017). Human cytomegalovirus Interleukin-10 (HCMV IL-10) is largely immunosuppressive, may bind to the same receptor, and signals through a comparable route, although being only 27% identical to human IL-10 (Lomaeva et al., 2022).

2.8 Latency of HCMV:

Human cytomegalovirus can develop latency across a range of cell types, in contrast to other herpes viruses that typically remain localized

(Groves et al., 2021). A lytic cycle, which entails a well-ordered transcriptional cascade that results in the formation of new particles, is initiated by infection of susceptible targets such as fibroblasts or epithelial cells. However, lytic gene output is rapidly suppressed and only a small number of latency-associated transcripts are detected when HCMV infects hematopoietic stem cells (HSC) (Goodrum, 2016). After then, the viral genome is kept intact as a stable episome that doesn't divide or create new virions. When HCMV-infected HSC differentiate into DCs and are stimulated to mature the virus, it is imperative that the virus replicate in order to maintain long-term presence, even though it is likely safer to keep viral protein production low during latency to evade immune surveillance (Yun et al., 2021). Latently infected cells may be able to evade detection by using virus-encoded miRNAs, which are generated throughout the lytic viral cycle. Recent research has shown that many, if not all, of the miRNAs encoded by HCMV are expressed during latency. The fact that miRNAs are non-antigenous for T cell identification is a significant advantage (Lee et al., 2021).

2.9 Pathogenesis of HCMV:

According to Griffiths and Reeves (2021), HCMV infections can happen to people who have never been exposed to the virus before (primary infection) or to people who have been exposed to it previously (repeat infection). Reactivation of an endogenous latent virus or reinfection with an exogenous virus can result in repeated infection. Conversely, recurrent infections are more likely to be asymptomatic and exhibit less severe symptoms than the initial infection. Following the initial, usually symptomatic HCMV infection, there is a prolonged, undetectable infection during which the virus persists in mononuclear cells without causing visible damage or clinical illnesses (de Melo Silva et al., 2020).

According to Jain et al. (2011), there is a clinical correlation betwee-n HCMV disease and immunological suppression, with severe presentatios observed in AIDS patients, infants, and other immunocompromised person-s. HCMV frequently infects children and healthy adults, and the prevalence of infection increases with age (Stockdale et al., 2018; Bate et al., 2010).

The likelihood of HCMV infection rises in individuals with hematological or oncological disorders who take anti-cancer medications with T-suppressive effects (Griffiths & Reeves, 2021). Jain et al. (2016) reported that 10% of newborns with acute lymphoblastic leukemia had an HCMV infection. Additionally, about 30% of patients who receive seropositive stem cell donors go on to get a primary HCMV infection, and infections with bacteria and fungi increase mortality (Sironi et al., 2015). Once inside the human body, HCMV spreads through leukocytes in the blood. Numerous hematological cell types, parenchymal cells, and connective tissue cells of any organ are among the various cell types that HCMV can infect within its host. Epithelial cells, endothelial cells, fibroblasts, and smooth muscle cells are the most often targeted cell types for virus propagation (Griffiths & Reeves, 2021). Once HCMV penetrates a cell and travels to the nucleus, it may result in intranuclear inclusion. The conventional one is surrounded by a halo of low reflection, giving the impression of "Owl eyes" (Brocks et al., 2014).

2.10 Infection in immunocompromised Hosts:

In allogeneic recipients, HCMV infection results in both direct repercussions, such as the virus killing cells, and indirect effects, such as acute and chronic rejection (Wu et al., 2016). In immunocompromised patients, human cytomegalovirus (HCMV) can be lethal; individuals with AIDS and malignant tumors undergoing chemotherapy or organ transplants are particularly vulnerable to HCMV infection (Zheng et al., 2019).

2.11 Congenital and neonatal infection:

High rates of morbidity and mortality in newborns are caused by congenital HCMV infection, which is the most prevalent infectious cause of deafness and a major contributor to neurodevelopmental problems in children (Zhang & Fang, 2019). Although the frequency varies significantly throughout research populations, 0.64 percent of surviving newborns have congenital HCMV infection, which can be caused by a primary maternal infection acquired during pregnancy or by reactivation of HCMV in a seropositive mother during pregnancy. According to Manicklal et al. (2013), there is a 30–40% likelihood of congenital infection and a 1–4% chance of primary infection in a mother who is seronegative.

Infection of a seronegative woman during the first trimester increases the risk and severity of HCMV illness. Congenital infection can still occur from reactivation of an HCMV infection during pregnancy, although the risk is lower since the mother's preexisting HCMV antibodies prevent intrauterine transmission (Götting et al., 2021). Pneumonitis, petechiae, hepatitis with jaundice and thrombocytopenia, intrauterine growth retardation, severe central nervous system damage with microcephaly, intracerebral calcifications, chorioretinitis, and sensorineural hearing loss (SNHL) are among the symptoms that 10 to 15% of congenitally infected babies exhibit at birth (Fowler et al., 2017). Sick neonates have a recorded mortality rate of 30%, and many more suffer significant neurological, visual, and auditory impairments (Zavattoni et al., 2016).

The most common prenatal viral infection, HCMV, can cause major long-term neurological consequences and even death in children who contract it. An estimated 0.7% of children worldwide are thought to have cHCMV, and 10% to 15% of infected fetuses present with signs of cHCMV infection at birth (Tanimura et al., 2021). About 9% of surviving babies with cCMV infection may experience severe neurological repercussions as a

result of the infection's clinical symptoms, which include low birth weight, fetal development restriction, and involvement of the Central nerves system (CNS) and other organs. According to Fowler and Boppana (2018), 10–15% of babies with asymptomatic cCMV infection may experience increasing SNHL and mental impairment, among other long-term neurological issues.

2.12 Epidemiology of HCMV:

The seropositivity rate in Iraq differs from province to province. According to a 2011 study by Majeed, which involved 270 women between the ages of 20 and 35, 90 of them tested positive for CMV, with 62 of those instances showing positive CMV IgM and 28 showing positive CMV IgG. Al-Shammary (2014) conducted a study in the Wasit Governorate involving 750 women, all of whom were either pregnant or had experienced an abortion. The detection of anti-CMV IgM antibodies in 345 cases (43.9%) confirmed the diagnosis. Baghdad city's IgG and IgM percentages were found to be 85% and 10%, respectively, by Al-Baiati et al. (2014). Among 145 pregnant women in Babylon province, 4.1% tested positive for IgM and 95.1% tested positive for IgG (Saleh et al., 2018). The seroprevalence of CMV-specific IgG in Erbil was 100% (Ali, 2020). The seropositivity was at 77.32% for women in the Al Hamza district in Babylon/Iraq (Abbas & Egbe, 2021). In Al Najaf city, the seroprevalence of CMV IgG was 95% (Hamoud et al., 2021). The seropositivity rate among women who had abortions and visited the public health center in Ibn Ghazwan and Basra Hospital in Basra City was 30.8% (Naame et al., 2021). According to a systematic review by Kareem et al. (2022), the prevalence of HCMV IgG and IgM was 0%-100% and 0%-93%, respectively, among Iraqi women. In another study conducted in Baqubah, Dyala, it was found that women who had abortions showed the highest rates of seropositivity to CMV, with 40% testing positive for IgM and 96.3% for IgG (Kalaf & Jameel 2023). CMV seroprevalence has reached

24.4% for patients who visited Al-Numan Teaching Hospital in Baghdad (Al-Khero et al., 2024).

The seroprevalence of CMV in pregnant women was well known to be between 42.3% and 68.3% in affluent nations but over 95% in underdeveloped nations (Yamamoto et al., 2013). Although CMV was found around the world, its frequency varies by region as well as social and economic status. About 85% of people were thought to have been exposed to this virus overall (Davis et al., 2017; Navti et al., 2021). Women, older adults, and individuals from lower socioeconomic groups have greater rates of seroprevalence (Robert & Ravit, 2018).

Reports indicate that the largest prevalence of CMV IgG is found in Africa (Yeroh et al., 2015). A study conducted in Lagos, Sokoto, and Bida, all in Nigeria, revealed CMV IgG rates of 98.7%, 97.2%, and 84.2% (Usman et al., 2017). The prevalence rate of IgG in women in Iran was estimated to be 90% based on the merging and meta-analysis of the findings of 15 studies with a total sample size of 5253 participants from 2008 to 2017 (Sharghi et al., 2019). The Eastern Mediterranean region had the highest estimated mean seroprevalence of 92%, while the regions of Europe had the lowest estimates at 65%. Upon examining several countries, Turkey exhibited the greatest seroprevalence rate, estimated at an average of 95%, while Ireland had a relatively low rate at an average of 38% (Zuhair et al., 2019). According to Kıncı et al. (2023), the seropositivity rates for anti-CMV IgG in Turkey were 98.5%.

2.13 Transmission of HCMV:

Globally, HCMV infections impact both men and women in every socioeconomic category and region (Ross et al., 2006). In the absence of any known nonhuman vectors, maintaining a sizable HCMV reservoir in human populations is an incredible parasitic achievement. This success is due to several factors, such as the relatively slow process of infection, which allows

the immune-competent host to live with the virus indefinitely; multiple viral excretion sites; intermittent viral reactivation and excretion; and the prolonged persistence of viral excretion after primary infection. Horizontal transfer can happen directly or indirectly through contact with saliva, cervical or vaginal secretions, sperm, tears, urine, blood, or breast milk (Weisblum et al., 2014). Usually, intimate or personal contact between people is necessary for viral transmission. As a result, HCMV has been linked to sexual transmission, breastfeeding, and baby care. Seropositive status is more likely in those with multiple sexual partners and a history of sexually transmitted diseases (STDs) (Fowotade et al., 2015). Breastfeeding may be a source of infection for the newborn since moms who are seropositive can release the virus in their breast milk. Daycare facilities facilitate the spread of HCMV by promoting close contact between children, many of whom expel the virus. One of the main sources of infection is children, especially toddlers (Pass et al., 1982). Adler and his associates found that 20% to 40% of daycare center youngsters were excreting HCMV in 1986. Saliva on hands and toys can spread the HCMV virus horizontally from child to child (Waters et al., 2019). Before, during, or after delivery, the HCMV can be vertically transferred from mother to kid. Although HCMV can exist in a dormant state, it can produce a variety of clinical illnesses in the correct conditions. CMV can spread horizontally through direct contact between individuals, as well as through the donation of blood, leukocytes, and platelets from infected donors (Sherief et al., 2021).

2.14 Transmission of HCMV in pregnancy:

HCMV infection during pregnancy is more complex than other illnesses since the virus can reactivate at childbearing age and be transferred to the fetus even if the mother is protected (Navti et al., 2021). Hematogenous diffusion across the placenta with subsequent infection of placental and amniotic tissue appears to be the most common mechanism of

virus transfer to the fetus, while other methods have also been hypothesized (Pass & Boppona, 1999). According to De Santis et al. (2020), the primary modes of vertical transmission include transplacental viral transmissions during gestation and fetal exposure to HCMV generated in the vagina during transit via the birth canal at delivery. Congenital infections have a greater impact on a newborn's development than intrapartum or postpartum infections, with the exception of neonates weighing less than 1500 g (Yeager et al., 1983). As illustrated in Figure 2-4, HCMV can pass through the placenta (Parker et al., 2020).

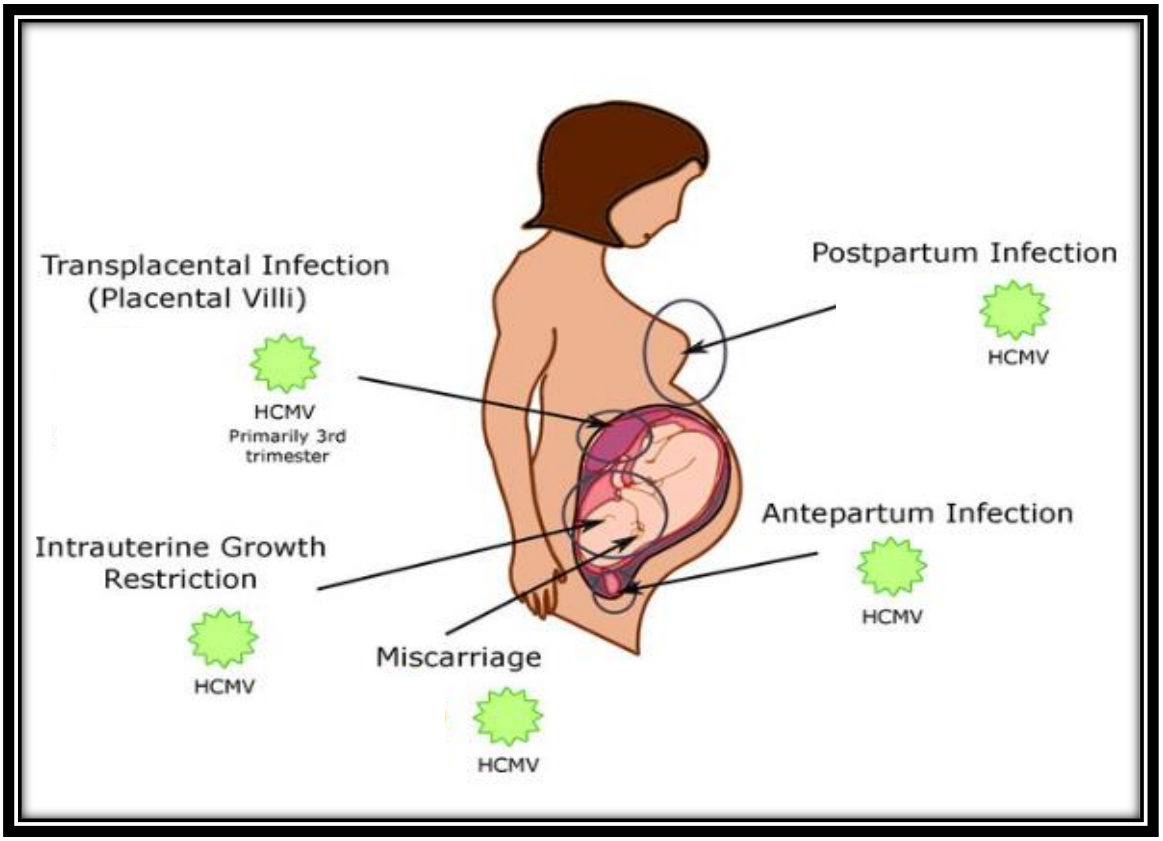

Figure (2-4): Human cytomealovirus passed from mother to kid via the placenta (Parker et al., 2020).

2.15 Pregnancy loss during CMV infection:

The results of several studies investigating the roles of 20 distinct viral infections in miscarriage are presented. Next, the causes of pregnancy loss caused by viral infections were examined. These processes included

placental tissue death, activation of an overactive maternal immune response, and alterations in trophoblast invasion and placental dysfunction. Understanding these pathways can help treat or prevent viral infections and ensure a successful pregnancy, as viruses can cause pregnancy loss in a number of ways (Heydarifard et al., 2022). In addition to immunocompromised individuals like organ transplant patients, it is a major cause of morbidity and mortality in pregnant women (Polz-Dacewicz et al., 2013). Most early pregnancy problems, including spontaneous or repeated miscarriages and several congenital abnormalities, are caused by HCMV. It has also been detected in women who have previously experienced stillbirths. An estimated 0.64% of babies are born with a cHCMV infection, and 11% of them exhibit symptoms (Yamamoto et al., 2013). Pregnancy and close contact with young children who are infected are the two main ways that HCMV is passed on to a developing fetus. Compared to secondary infections, primary infections spread more quickly. Maternal primary HCMV infection during pregnancy has been identified as the leading risk factor for congenital infection in developing countries. Numerous investigations on fetal congenital defects brought on by HCMV infection have been carried out worldwide. On the other hand, little is known about the association between HCMV sero-prevalence and women who have experienced a poor obstetrical outcome (Amna et al., 2021). HCMV infections are associated with deafness, stillbirth, newborn death, and cognitive and motor impairments. Small observational studies have investigated the use of HCMV hyperimmuneglobulin to prevent congenital infection in pregnant women with primary HCMV infection; however, the results have been conflicting or unclear (Hughes et al., 2021).

2.16 Symptoms of HCMV:

After delivery, HCMV infection is referred to as an acquired infection. When an adult or child is generally healthy, HCMV infection is usually not

aproblem. There is a 90% chance that it won't cause any symptoms or indicators of an infection. But occasionally, a flu-like or mononucleosis-like disease can occur, causing symptoms like weariness, swollen glands, a sore throat, and a fever (up to 39°C) lasting longer than two weeks (Marin et al., 2016). The signs and symptoms of HCMV infection may be dangerous for people with weakened immune systems, such as those with HIV, those getting steroid medication, those receiving chemotherapy or radiation therapy, those receiving organ or bone marrow transplants, and those receiving treatment (Kenneson & Cannon, 2007). When a person contracts HCMV for the first time or when an existing infection develops again, signs and symptoms may appear. People with compromised immune systems are at risk for a number of illnesses, including pneumonia, retinitis (an infection of the eye that can cause blindness), hepatitis (liver inflammation), esophagitis and colitis (gastrointestinal disorders), meningoencephalitis (an infection of the brain and its surrounding fluid), and even death (Duff, 2010).

2.17 Laboratory diagnosis of HCMV:

The isolation of the HCMV virus or the identification of viral proteins or nucleic acids in any physiological fluid or tissue material is considered an HCMV infection, according to Raymund et al. (2020). Improved methods for cCMV detection have been developed and validated in recent years. The gold standard for diagnosing neonates with cCMV was to look for an infectious virus in urine or saliva samples collected during the first two to three weeks of life. (Rawlinson et al., 2017).

2.17.1 Serological assay:

Primary HCMV infections during pregnancy are primarily assessed by serologic tests. HCMV sero-conversion, or the identification of HCMV IgG in a pregnant woman who was previously presumed to be nonimmune, is currently the gold standard for diagnosing primary infections. HCMV IgG antibody detection has been accomplished using a variety of techniques.

Examples ELISA, complement fixation, and indirect hemagglutination (Divya et al., 2017). The detection of IgM antibodies has been used as a marker for recent or acute infections. Although there are many other kinds of assays, the most widely used ones are ELISA. Although serology is useful in epidemiological studies, immunocompromised persons often do not exhibit measurable levels of it due to the limitations of IgM assays. In certain populations, IgG avidity assays are utilized to distinguish between primary and non-primary HCMV infections (Gliga et al., 2018). Based on the findings of these tests, IgG antibodies with low avidity are observed in the first few months following infection, and avidity increases as the immune response matures. Thus, a high level of anti-HCMV IgG anemia indicates a persistent infection. After treatment with denaturing chemicals, the avidity index, which quantifies the percentage of IgG bound to the antigen, is used to report avidity levels (Idris et al., 2016).

2.17.2 Detection of HCMV antigen:

Antigenemia is the condition in which leukocytes have decreased levels of the matrix phosphoprotein pp65. These proteins are often only expressed when the virus is spreading. Antigen testing can identify subclinical infection in high-risk people and is commonly used to initiate antiviral medication in transplant recipients (Katia et al., 2018). The assay's sensitivity is extremely high. The test is both qualitative and quantitative, and it has a good link with viremia and the severity of clinical illness in immunocompromised persons (Versalovic et al., 2011).

The antigenemia assay's drawbacks are its labor-intensive nature, low throughput, and lack of automation. The sensitivity of the experiment will be decreased with any delay, hence the samples need to be processed as soon as possible (within 6 hours). False results may arise because the antigenemia test relies on the presence of a sizable quantity of polymorphonuclear leukocytes, especially in neutropenic individuals (Reham et al., 2016).

2.17.3 Culture of the virus:

Culture can be performed utilizing the conventional plaque assay or the more rapid shell vial centrifugation culture system. Viral culture can be applied to blood, saliva, stool, urine, respiratory secretions, cerebrospinal fluid (CSF), and tissue biopsy specimens. The major obstacles to the use of viral culture are its low to moderate sensitivity and long turnaround time (Sigrid et al., 2019).

2.17.4 Electron microscopic detection:

Because the sensitivity of electron microscopy to evaluate HCMV sensitivity is dependent on the viral titer in the samples, electron microscopy is currently rarely utilized to diagnose HCMV in clinical virology laboratories (Span et al., 1993).

2.17.5 Histological detection:

Histopathology continues to be the gold standard for the diagnosis of tissue-invasive HCMV infection (Mills et al., 2013). Larger cells are where the consequences of infection are most noticeable, and the presence of distinctive intracellular inclusions surrounded by a halo of poor reflection gives the appearance of "owl eyes" (Powers et al., 2008).

2.17.6 DNA amplification:

DNA amplification requires the multiplication of primers specific to a specific area of the HCMV gene. Nucleic acid amplification methods are recommended for the prompt diagnosis of HCMV following organ transplantation (Maha et al., 2015). Despite the high sensitivity of this test, the clinical value of qualitative polymerase chain reactions (PCR) is limited since HCMV DNA can be detected in patients who are now ill or not. PCR amplification of viral DNA is a very sensitive technique for HCMV detection in various clinical samples (Lassina et al., 2016). It has also been demonstrated that quantitative PCR is helpful in monitoring how different patient groups react to antiviral drugs (Hirsch et al., 2013).

2.17.7 DNA sequencing:

DNA sequencing of PCR products amplified from antiviral target ge nes has emerged as the main genotypic method for identifying medication r esistance mutations since all nucleotide and amino acid changes within the amplified area may be identified.Sequencing both strands resolves the majo rity of uncertainty (Schindele et al., 2010). Originally employed to investigate HIV-1 and hepatitis B virus resistance mutations, more recent "deep" sequencing technologies enable the detection of far smaller subpopulations of mutants, as little as 1%. Initial research indicates that ultradeep sequencing enables the early identification of mutations that cause drug resistance (Ligat et al., 2017). The technology could be useful for studying how drug exposure histories affect the early generation of mutations that result in varying degrees of viral growth fitness and drug resistance, even if it is now too costly and unfeasible for diagnostic use. Based on this knowledge, strong antiviral regimens that lower the likelihood of drug resistance can be developed, and sentinel mutations can be targeted for the sensitive detection of impending resistance (Sijmons et al., 2015).

2.18 Prevention of HCMV:

Avoiding exposure is the only way to prevent HCMV infection as there is currently no effective vaccine. Although it is uncommon, intimate contact with contaminated fluids or, in rare instances, fomites is necessary for horizontal transmission of HCMV. Sexual intercourse and children who spread the virus are the main ways that women of reproductive age become infected (Boeckh, 2011). Furthermore, pregnant women should avoid direct contact with people who are prone to shed HCMV, such as adults with mononucleosis symptoms and toddlers attending group day care (Adler, 2011). The incidence of mother HCMV infection was successfully decreased by a prophylactic strategy that identified and educated pregnant women who were at higher risk for the initial infection, according to data from a

controlled experiment (Revello et al., 2015). According to the International cCMV Recommendations Group (Rawlinson et al., 2017), all pregnant women should get information on cCMV infection and self-defense.

2.19 Treatment of HCMV:

Antiviral medications are being used to treat an increasing number of viral infections that are impairing the host's health. Antiviral drugs primarily target the processes that viruses use to replicate. Zur et al. (2011) state that no viral genomes will replicate effectively if the medicine is effective and viral fitness is significantly decreased. However, selective pressure may hasten the development of resistance if the treatment is ineffective and certain genomes reproduce. Anti-HCMV drugs such as Ganciclovir (GCV), its oral prodrug valganciclovir (vGCV), FOS, and cidofovir (CDV) target the viral DNA polymerase.

Continued investigation into genetic foundations, diagnostic procedu res, and the creation of novel treatments are required due to drug toxicity a nd antiviral resistance (Lurain & Chou, 2010). Only neonates with severe or moderate symptoms of cCMV infection at birth should be evaluated for the use of antiviral drugs (Luck et al., 2017; Rawlinson et al., 2017). Intravenous ganciclovir and its oral bioavailable prodrug, vGCV, are the recommended antiviral drugs used as the first line of treatment. In most cases, oral vGCV is recommended to infants with non-life-threatening illnesses. Given twice daily for six months of age, the suggested dosage is 15 mg per kilogram each time (Kimberlin et al., 2015). As soon as a virologic test comes back positive, antiviral therapy must begin. This drug has been demonstrated to improve brain development and hearing when administered during the first month of life. However, even after the advised newborn stage, some studies have shown the advantages and safety issues of treating children with cCMV (Dorfman et al., 2020; Morioka et al., 2022).

2.20 Blood components:

Blood is an essential fluid that flows throughout the body and offers several important advantages. Its functions include respiration, excretion, nutrition, maintaining a normal acid-base balance, controlling water balance, regulating body temperature, and transporting hormones, vitamins, and salts, as well as transporting different essential vitamins that the body needs (Batra et al., 2020). Blood contains a variety of substances that serve several vital functions. It contains platelets, plasma, white blood cells, red blood cells, and more (Batra et al., 2020). When blood hemoglobin levels drop below a threshold or cutoff that is unique to age and sex, anemia is typically diagnosed (Pasricha et al., 2018). Maternal and newborn morbidity and death are linked to anemia during pregnancy, which is a worldwide health concern (Ohuma et al., 2023). Negative maternal and baby health outcomes are strongly predicted by both low and high maternal hemoglobin concentrations during pregnancy (Young et al., 2023).

Erythrocytes, leucocytes, and platelets are among the produced constituents that are suspended in blood (Pradesh, 2016). RBC functions include transporting oxygen from the lungs to the tissues, transporting carbon dioxide from the tissues to the lungs for expulsion, and maintaining the acid-base balance. RBCs in the human body typically range between 5 and 5.5 million/mm^3 (Dulińska, 2006). Thrombocytes, also known as platelets, are non-nucleated components of the cytoplasm of the bone marrow's megakaryocytes, which are very big cells (Conrads & Schmidt, 2000). Their primary role is to help with hemostasis, which includes both preventing bleeding and halting it when blood vessel damage results in blood leakage (Moliterno et al., 1998). Leukocytes are another component of blood that is generated. The creation of a) granulocytes and b) agranulocytes (lymphocytes and monocytes) is the result of three separate series. The human body's normal WBC range is 4000-10,000 WBC/mm^3 (Zhang, 1999;

Barchi, 2009). Leukocytes appear to play a major role in the body's defense against invasive species such as bacteria, viruses, parasites, and cancer cells. The neutrophils and monocytes are primarily responsible for attacking and eliminating germs and viruses in the bloodstream (Singh et al., 2022).

2.21 Blood group and the related diseases:

Human ABO blood type antigens exhibit distinct phenotypes and genetically generated glycoconjugate structures on the surface of red blood cells, which play an active role in the physiology and pathophysiology of the cells (Abegaz, 2021). An independent risk factor for pregnancy-related problems that result in substantial morbidity and mortality in expectant mothers and newborns has been identified as the ABO blood group type (Sajan et al., 2021). Numerous roles are performed by the glycoconjugate structures on red blood cells, such as serving as receptors for exogenous ligands, viruses, bacteria, parasites, and other functions (Cartron & Colin, 2001). Human blood circulation contains the majority of the A and B antigens that are released by cells. Consequently, nonsecretors are susceptible to a number of diseases (Naeini et al., 2010). An increased risk of contracting viral and non-viral infections is linked to both non-O and Rh-positive blood status (Butler et al., 2023).

2.22 C-Reactive protein:

In inflammatory regions, macrophages create a minimal quantity of, C-reactive protein (CRP) while hepatocytes produce the majority of it (Luan et al., 2021). The classic acute-phase reactant that has long been almost solely identified as an indicator of inflammation is CRP (Zeller et al., 2022). At least two protein conformations with different pathophysiological roles make up the CRP system. Two highly pro-inflammatory variants, pentameric (pCRP) and monomeric CRP (mCRP), are produced when the native, pCRP binds to active cell membranes, changing its shape. In a wide range of clinical situations, it has been demonstrated that the deposition of these pro-

inflammatory proteins contributes to localized tissue injury (Zeller et al., 2022). CRP levels are typically used as a measure of infection severity because they tend to rise after infection; the CRP curves for viral infections were the flattest and lowest. The highest CRP peaks were found in bacteremia, particularly Gram-negative infections treated with antibiotics, while non-bacteremic illnesses displayed intermediate levels. For example, in viral infections without antibiotics, peak CRP was 15.4 mg/L, whereas in Gram-negative bacteremia treated with antibiotics, it was 140.9 mg/L (Cherny et al., 2025).

2.23 Erythrocyte sedimentation rate (ESR):

When diagnosing and measuring inflammatory activity, the Westergren method's Erythrocyte Sedimentation Rate (ESR) is employed. A significant underlying illness is typically indicated by an extremely high ESR (>100 mm/hr). The three phases of the ESR phenomenon—aggregation, decantation, and packaging—are associated with certain physics principles, such as Stokes' law. Numerous physiological and clinical conditions, as well as RBC, plasma, and technical parameters, influence ESR as determined by the Westergren method (Kahar, 2022).

2.24 Liver function tests (Albumin, ALT, and AST):

The most significant plasma protein in terms of amount is albumin. E-xclusively produced in hepatocytes, it accounts for 75% of plasma colloid osmotic pressure. The liver can produce twice as much albumin when it is lost quickly. The albumin half-life is 14–20 days. Osmotic pressure, systemic inflammation, blood hormone levels, and dietary status all affect albumin production. (Kang, 2013).

Serum aminotransferases, It is the most sensitive indicator of acute liver damage. AST and alanine, respectively, catalyze the conversion of the α-amino group of L-aspartic acid to the α-keto group. AST is found in the cytoplasm and mitochondria of cells. The most common sites of spread are

the heart muscle, kidney, brain, lung, pancreas, leukocytes, erythrocytes, and skeletal muscle. The most common cytoplasmic enzyme, ALT, is located in hepatocytes. As a result, it is a more accurate indicator of liver damage than AST (Kang, 2013).

The region of hepatic injury can be identified with the aid of these tests, and a differential diagnosis can be organized using the elevation pattern (Lala et al., 2023).

2.25 Renal function tests:

The kidneys play a crucial role in removing waste products and toxins such as urea and creatinine. Renal function tests are valuable for identifying the presence of kidney disease, monitoring the kidneys' response to treatment, and assessing the progression of the illness (Gounden et al., 2024). The body typically produces creatinine at a fairly constant rate. This rate depends on muscle mass and results from the breakdown of creatine phosphate in muscle (Zuo et al., 2008). The urea cycle enzymes, which are mostly found in the liver but are also widely expressed at low levels in other tissues, produce urea. Many factors, including diet, hormones, and illnesses, can change the metabolic process. Fluids, particularly urine, are then used to get rid of urea (Wang et al., 2014).

2.26 Blood pressure:

One of the most fundamental aspects of patient care is arterial pressure measurement. The amount that the heart pumps into the arteries, the elasticity of the artery walls, and the speed at which blood exits the arteries all affect arterial pressure (Magder, 2018). In adults, systolic blood pressure typically ranges from 90 to 120 mmHg, while diastolic pressure ranges from 60 to 80 mmHg. These values are considered standard indicators of circulatory health (Whelton et al., 2018).

2.27 Chromosomal aberration and HCMV:

Chromosomal aberrations, or abnormalities, are changes to the structure or number of chromosomes. The main types of chromosomal aberrations are deletion, duplication, inversion, and translocation (Figure 2-5). Chromosome abnormalities caused by the HCMV are known to occur in infected cells, and this can result in congenital defects in infected fetuses. A family of conserved proteins found in herpesviruses includes HCMV *UL76*. The *UL76* family has been implicated in a number of activities, including lytic replication, reactivation of latent viruses, apoptosis induction, gene expression regulation, virulence determination, disruption of cell cycle progression, and possible nuclease activity (Siew et al., 2009). There is evidence that chromosomal abnormalities are caused by HCMV after infection. Premature chromatid condensation, chromosomal pulverization, selective chromosome breaks, and centrosome structural damage are some of these anomalies (Bystrevskaya et al., 1997; Fortunato & Spector, 2003). For host cells, CMV infection is genotoxic. Both the viral genome expression and the cell cycle stage of the cells at the time of infection influence the kinds and degree of damage (Abubakar et al., 1988). The damage is linked to virion-associated proteins and not newly generated viral protein creation, as ultraviolet (UV)-inactivated HCMV can specifically cause centrosome damage and site-specific breaks at places 1q42 and 1q21 on chromosome 1 (Fortunato et al., 2000; Fortunato & Spector, 2003; Nystad et al., 2008). Once injected into the cell at a very early stage of viral infection, virus-associated UL76 most likely contributes to the modification of gene expression (Wang et al., 2000). The induction of breaks is avoided by incubating the virus with a neutralizing antibody (Fortunato et al., 2000). Chromosome 1 can be specifically damaged by UV-inactivated viruses just as effectively as by untreated viruses. Therefore, viral adsorption and penetration are essential, but new viral gene expression is not. Congenitally

infected infants may suffer neurological abnormalities as a result of the HCMV-mediated production of site-specific damage in actively proliferating cells (Fortunato et al., 2000).

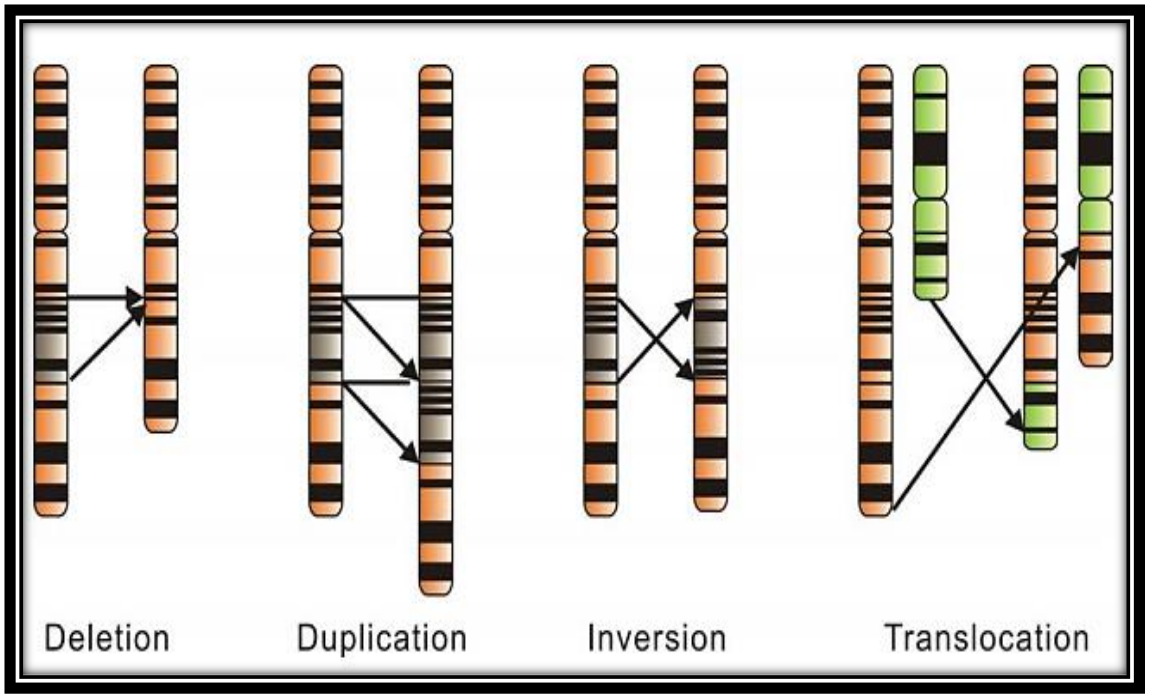

Figure (2-5): The chromosomal aberration (Bu & Cao, 2012).

Chapter Three:

Materials and Methods

3. Materials and Methods:

3.1. Materials:

3.1.1 Tools and instruments:

The tools and instruments employed in this study are summarized in Table 3-1.

Table 3-1: A list of the tools and laboratory instruments utilized in this investigation, along with their place of origin

No.	Item	Company	Country
1-	Autoclave	HIRAYAMA	Japan
2-	Centrifuge	SIGMA	Germany
3-	Cover glass	AmScope	China
4-	Deepfreeze (-20o C)	Helmar	France
5-	ELISA reader	Biotek	USA
6-	ELISA washer	Biotek	USA
7-	Eppendorf tubes (0.2-1.5 ml)	JET BIOFIL	Singapore
8-	Gloves	Jiangsu	China
9-	Incubator	Thermaks	Germany
10-	Micropipette, 10 µL, 100 µL, and 1000 µL	Human	Germany
11-	Microscope slides	AmScope	China
12-	Multichannel micropipette	Supertek	India
13-	Refrigerator (4°C)	Samsung	Korea
14-	Specimens transport box	IndiaMART	India
15-	Syringes	Imaheco	China
16-	Tips 100, and 1000 µL	Gilson	China

17-	Tubes Rack	Biometra	Germany
18-	Vacuum EDTA tubes	AFICO- DISP	Jordan
19-	Vacuum Gel tube	AFICO- DISP	Jordan
20-	Vortex	Quality Lab System	England
21-	Water Bath	Sigma	Germany
22-	AFLO Chemistry Analyzer Smart-150	Geno TEK	USA
23-	CBC Sysmex-350 Device	Sysmex Corporation	Jaban
24-	Roller Mixer Device	Labtron	UK
25-	ESR Auto Analyzer Device	Liner Chemicals S.L.U	Spain

3.1.2 Laboratory kits:

3.1.2.1 Immunological kits:

The immunological kits used for this investigation were presented in Table 3-2.

Table 3-2: Immunological kits utilized for current study

No.	Kit	Company	Country
1-	Anti-HCMV (IgM) antibody ELISA kit	Human	Germany
2-	Anti-HCMV (IgG) antibody ELISA kit	Human	Germany
3-	C-reactive protein kit	Nipigon	Canada

3.1.2.2 Biochemical kits:

The biochemical kits used for this investigation were presented in Table 3-3.

Table 3-3: Biochemical kits utilized for the current study

No.	Kit	Company	Country
1-	Albumin kit	Giesse	Italy
2-	Alanine Aminotransferase (ALT) kit	Giesse	Italy
3-	Aspartate Aminotransferase (AST) kit	Giesse	Italy
4-	Urea kit	Giesse	Italy
5-	Creatinine kit	Giesse	Italy

3.2 The contents of laboratory kits:

3.2.1 The contents of the immunological kits:

3.2.1.1 The contents of the anti-HCMV (IgM) Ab kit:

The contents of the anti-HCMV (IgM) Human (Germany) kit were presented in Table 3-4.

Table 3-4: Contents of an anti-HCMV IgM kit

No.	Component	Quantity
1-	Coated assay plate	1 x (96 wells)
2-	Wash Buffer (20x)	1 x 50 ml
3-	Sample Diluent	1 x 100 ml
4-	HRP-Conjugate Antibody	12 ml
5-	Positive Control	2.5 ml
6-	Negative Control	2.5 ml
7-	Stop Solution	1 x 15 ml
8-	Substrate A	1 vial x 5 ml
9-	Substrate B	1 vial x 5 ml
10-	Instruction Manual	1
11-	Plate Sealers	2

3.2.1.2 The Contents of the anti-HCMV (IgG) Ab kit:

The contents of the anti-HCMV (IgG) human (Germany) kit were presented in Table 3-5.

Table 3-5: Contents of an anti-HCMV IgG kit

No.	Component	Quantity
1-	Coated assay plate	1 x (96 wells)
2-	Wash Buffer (20x)	1 x 50 ml
3-	Sample Diluent	1 x 100 ml
4-	HRP-Conjugate Antibody	12 ml
5-	Positive Control	2.5 ml
6-	Negative Control	2.5 ml
7-	Stop Solution	1 x 15 ml
8-	Substrate A	1 vial x 5 ml
9-	Substrate B	1 vial x 5 ml
10-	Instruction Manual	1
11-	Plate Sealers	2

3.2.1.3 The Contents of the CRP Kit:

The contents of the CRP Nipigon (Canada) kit were presented in Table 3-6.

Table 3-6: Contents of the CRP kit

No.	Component	Quantity
1-	Latex reagent (liquid) CRP polyclonal latex (> 0.2g/L) 1% bovine serum albumin 100 mmol/L phosphate buffer.	1 x 2.5 mL
2-	Positive control (liquid) CRP (>30 mg/L) 1% bovine serum albumin 100mmol/L phosphate buffer.	1 x 0.25 mL

3-	Negative control (liquid) 1% bovine serum albumin 100 mmol/L phosphate buffer.	1 x 0.25 mL
4-	Black reaction plate	8 plates
5-	Stirring rod	2 strip

3.3 Biological and chemical materials:

The biological and chemical materials used for karyotype were presented in Table 3-7.

Table 3-7: Biological and chemical materials

No.	Materials	Manufacture company	Country
1-	Cell culture medium (RPMI-1640)	Chemical Point	Germany
2-	Fetal bovine serum (FBS)	Avonchem	UK
3-	Phytohemagglutinin (PHA) (Mitogens)	Medicago	Sweden
4-	Colchicine	Avonchem	UK
5-	potassium chloride (KCl)	Alpha Chemika	India
6-	Methanol (CH_3OH)	Chem-Lab	Belgium
7-	Acitic acid (CH_3COOH)	Chem-Lab	Belgium
8-	Giemsa stain	Bibo Biotech	China
9-	Trypsin enzyme	Bloom Tech	China
10-	Antibiotics	Avonchem	UK
11-	Mono-Potassium Phosphate (KH2PO4)	GCC	UK
12-	Di-Sodium Hydrogen-O-Phosphate (Na2HPO4)	Quali Kems	India

Table 3-8: Preparation of solutions and material used in karyotype

No.	Solution	Preparation method
1-	Complete Media	Fetal bovine serum was added to RPMI-1640 medium. After adjusting the pH to 7.2, a 0.22μm syringe filter unit was used to sterilize the medium. To make sure it was free of impurities, the medium was incubated for three days at 37°C. After that, it was transferred into sterile tubes, each holding five milliliters, and stored at -20°C.
2-	Fetal bovine serum (FBS)	This solution was prepared by the Avonchem Company
3-	Phytohem agglutinin (PHA)	The PHA is prepared by dissolving 2.5mg of PHA in 4ml of distilled water, taking 0.1ml of it and adding it with 0.6ml of distilled water, then adding 0.1ml of it to each culturing tube containing 5ml of culture media so that the final concentration reached 15μg/ml and store at -20°C.
4-	Colchicine	Dissolve 0.5mg of colchicine powder in 10ml of distilled water, preparing it immediately upon use and keeping it away from light.
5-	Hypotonic Solution	A hypotonic solution was prepared by dissolving 1.1175g of KCl in 200ml of distilled water until the solution had a concentration of 0.075M, and kept at 4°C until use.
6-	Fixative Solution	Prepared by simultaneous mixing of absolute methanol with cold acetic acid in a ratio of 1:3 v/v and used cold.

7-	Sorensen's Buffer Solution	Sorensen.buffer solution is prepared by dissolving.7.08g of Na2HPO4 with 6.7g of KH2PO4 salt in 1000ml of distilled water and keeping it at 4°C until use.
8-	Giemsa Stain	Dissolve 2g of Giemsa stain powder in 100ml of absolute methyl alcohol using a magnetic stirrer for 72 hrs, then filter the dye using Whattman No.1 filter paper. Keep in an airtight, opaque vial. This solution is stored in stock, and when used, dilute immediately by mixing 1ml of the dye with 4ml of Sorensen buffer.

3.4 Study groups:

The study involved 130 women aged 19–44 years with a history of abortion who attended Al-Elwiya Maternity Teaching Hospital in Baghdad, along with 50 healthy pregnant women of the same age range without prior abortion. After obtaining consent, data were collected through a questionnaire including the patient's name, age, residence, education, occupation, endogamy, animal contact, chronic diseases, smoking, birth defect, number of abortions, vaginal infections, and previous abortions, and gestational duration as detailed in Appendix 1. Samples were collected between December 2024 and March 2025.

3.5 Samples collection:

Each participant provided 5 ml of venous blood, 2 ml of which were placed in an EDTA tube for CBC less than 8 hours after sample collection using a Sysmex XN-350. 1 ml was stored in a lithium heparin tube at 4°C until used for the leukocyte chromosomal aberration assay. The remaining 2 ml were placed in gel tubes and allowed to clot for 15 minutes at room temperature (20–25°C). To collect serum samples, the clotted blood was

centrifuged at 2,500 rpm for 5 minutes. Serum samples were applied to the cassette according to the manufacturer's instructions (see Appendix 2). Antibody presence was indicated by the appearance of colored lines. Aborted women with positive results were included in the study, while those with negative results were excluded. Each serum sample was stored in two Eppendorf tubes at -20°C until used for HCV diagnosis in the study groups.

3.6 Exclusion criteria:

Healthy pregnant women in the control group included those with a history of previous abortions, women who tested positive for CMV-IgM and IgG, organ transplant recipients, and those diagnosed with HBV, HCV, or HIV. Additionally, it included women with a history of cancer, chronic anemia, high blood pressure, autoimmune diseases (AD), and kidney diseases.

3.7. Detection of HCMV by ELISA test:

3.7.1 Anti-HCMV IgM antibody:

3.7.1.1 Principle of the ELISA assay:

The traditional ELISA method serves as the foundation for the human CMV IgM ELISA. Cell culture-derived HCMV antigens (HCMV-Ag) are applied to the microtiter strip wells as a solid phase. During the first incubation step, specific antibodies (HCMV-IgM-Ab) from patients or controls bind to the antigens in the solid phase. Anti-HCMV IgM is included in the sample dilution buffer to stop RF interference and competition from particular IgM in the sample. Unbound components are rinsed off at the conclusion of the incubation period. The addition of anti-IgM conjugate (anti-HCMV IgM Ab, peroxidase conjugated) for the second incubation step causes it to bind selectively to IgM class antibodies, forming characteristic immunocomplexes. Following a further washing procedure to get rid of extra conjugate, Step 3 involves adding TMB/substrate. After the reaction is stopped, a blue color appears that eventually turns yellow. The concentration

of HCMV-IgM-Ab in the material is directly correlated with the color intensity.

3.7.1.2 Assay procedure:

Prior to use, all samples and reagents were allowed to come to room temperature. Before the assay, the samples were thawed and centrifuged one more time. ELISA was used to detect the human anti-CMV IgM in accordance with the Human (human.de) protocol:

1. The strips were placed in a strip holder, and an adequate number of wells were numbered, comprising one blank, two positive controls, and two negative controls. Neither samples nor horseradish peroxidase conjugat.
2. Each well received 100 µl of either the sample, positive control, or negative control.
3. After applying the adhesive strip to the microtiter plate, it was incubated at 25°C for 30 minutes.
4. Each well's liquid was aspirated and then cleaned four times. Following the final wash, the plate was inverted and tapped against fresh absorbent paper after being aspirated to remove any leftover wash buffer.
5. Each well (except for the blank well) received 100 µl of HRP-conjugated antibody, which was then sealed with a fresh plate sealer and allowed to sit at 25°C for 30 minutes.
6. In accordance with step 4, the wells were aspirated and cleaned five times.
7. After adding 100 µl of substrate A and B to each well, the wells were incubated for 15 minutes at 25°C under light protection.
8. After adding 100 µl of stop solution to each well, the plate was lightly pounded to guarantee complete mixing. The blue hue instantly turned to yellow.
9. The optical density of each well was measured within 10 minutes using a microplate reader set to 450 nm, with the blank well being taken as zero.

3.7.1.3 Calculation of results:

The sample and the control must be closely compared to calculate the valence of the anti-HCMV IgM antibody. The optical density (OD) values for the negative control were below 0.25, while the OD values for the positive control must exceed 0.4. The cutoff value was determined by adding the average negative control value to 0.2 times the positive control value. Samples with positive OD results are those that meet or exceed this cutoff v-alue, while samples with negative OD results fall below it.

3.7.2 Anti-HCMV IgG antibody:

3.7.2.1 Principle of the assay:

The traditional ELISA method serves as the foundation for the human CMV IgG ELISA. Cell culture-derived HCMV antigens (HCMV-Ag) were applied to the microtiter strip wells as a solid phase. During the first incubation step, specific antibodies (HCMV-IgG-Ab) from patients or controls bind to the antigens in the solid phase. Anti-human IgM is included in the sample dilution buffer to stop RF interference and competition from particular IgG in the sample. Unbound components are rinsed off at the conclusion of the incubation period. The addition of anti-IgG conjugate (anti-human IgG antibodies, peroxidase conjugated) for the second incubation step causes it to bind selectively to IgG class antibodies, forming characteristic immunocomplexes. Following a further washing procedure to get rid of extra conjugate, Step 3 involves adding TMB/substrate. After the reaction is stopped, a blue color appears that eventually turns yellow. The concentration of HCMV-IgG-Ab in the material is directly correlated with the color intensity.

3.7.2.2 Assay procedure:

Prior to use, all samples and reagents were allowed to come to room temperature. Samples were prepared according to the kit protocol before the

assay. ELISA was used to detect the human anti- CMV Ab IgG in accordance with the Human (human.de) protocol:

1.The strips were placed in a strip holder, and an adequate number of wells were numbered, comprising one blank, two positive controls and two negative controls. Neither samples nor horseradish peroxidase-conjugate were added to the blank well.

2. Each well received 100 µl of either the sample, positive control, or negative control.

3. After applying the adhesive strip to the microtiter plate, it was incubated at 25°C for 30 minutes.

4. Each well's liquid was aspirated and then cleaned four times.Following the final wash, the plate was inverted and tapped against fresh absorbent paper after being aspirated to remove any leftover wash buffer.

5. Each well (except from the blank well) received 100 µl of HRP-conjugate antibody, which was then sealed with a fresh plate sealer and allowed to sit at 25°C for 30 minutes.

6. In accordance with step 4, the wells were aspirated and cleaned five times.

7. After adding 100 µl of substrateA and B to each well, the wells were incubated for 15 minutes at 25°C under light protection.

8. After adding 100 µl of Stop solution to each well, the plate was lightly pounded to guarantee complete mixing. The blue hue instantly turned to yellow.

9. The optical density of each well was measured within 10 minutes using a microplate reader set to 450 nm, with the blank well being taken as zero.

3.7.2.3 Calculation of results:

To determine anti-HCMV IgG, samples and controls were matched. OD values below 0.25 indicated negative controls, and values above 0.75 indicated positive controls. The cutoff was defined as the negative control average plus 0.1 × positive control. Samples above or equal to the cutoff were positive; those below were negative.

3.8 Complete blood count(CBC) test:

3.8.1 Principle of the assay:

The Sysmex XN-350 is an automated hematology analyzer widely used in clinical laboratories for performing CBC tests. The device operates based on two fundamental principles:

3.8.1.1 Electrical impedance (Coulter principle):

This technique is applied for counting RBCs, WBCs, and PLTs. As cells pass through a small aperture within an electrical current, each cell generates a pulse. The number of pulses corresponds to the cell count, while the pulse size reflects the cell volume.

3.8.1.2 Photometric measurement:

The Hb concentration was measured photometrically. RBCs were lysed using a specific reagent, and the absorbance of the released hemoglobin was detected at a defined wavelength. The absorbance was directly proportional to the Hb concentration.

3.8.2 Assay procedure:

A CBC test was performed using a Sysmex XN-350 automated analyzer (Sysmex Corporation). Two milliliters of blood were collected into EDTA tubes, stored at 5 °C, and tested within 24 hours. Samples were brought to room temperature for 15 minutes, mixed on a roller for 2–5 minutes, and then aspirated into the analyzer to initiate the test.

3.8.3 Sysmex XN-350 solutions and their functions:

The solutions used in the Sysmex XN-350 and their functions were presented in Table 3-9.

Table 3-9: Solutions used in the Sysmex XN-350 and their functions

No.	Solution name	Purpose / Function
1-	RBC/HGB Diluent	Dilutes whole blood for accurate RBC counting and hemoglobin measurement. Prevents cell aggregation.
2-	WBC Diluent	Dilutes blood for WBC counting. Lysates RBCs while preserving WBCs for accurate measurement.
3-	Lyse Solution / RBC Lyse	Lysates red blood cells in WBC channels to remove interference and allow accurate WBC differentiation.
4-	Cleaning Solution	Cleans internal fluidics and measurement chambers to prevent clogs and contamination.
5-	Rinsing Solution	Rinses the system between samples to remove residual blood and prevent cross-contamination.
6-	PLT Diluent (Platelet Diluent)	Dilutes blood specifically for platelet counting to prevent clumping and ensure accuracy.
7-	Hemoglobin Reagent	Chemically reacts with hemoglobin to produce a measurable signal for photometric measurement.

3.9 C-reactive protein test:

3.9.1 Principle of the assay:

The latex reagent consisted of latex coated with CRP polyantibodies, calibrated to a CRP content of 6 mg/L for adults. Agglutination was observed with the naked eye when this concentration was exceeded. Serum samples were measured directly without dilution.

3.9.2 Assay procedure:

The reagent was allowed to reach room temperature before use, and positive and negative controls were examined. One drop (50 µL) of undiluted serum was added to the black reaction plate, followed by a drop of the latex reagent. The mixture was stirred and spread evenly across the reaction area, then the plate was gently shaken and observed under bright light for three minutes. The same procedure was applied to the controls. For the semi-quantitative assay, serum was diluted with physiological saline (0.9 g NaCl in distilled water to 100 mL), as described in Table 3-10.

Table 3–10: Semi-quantitative experiment for CRP

Dilution ratio	1:2	1:4	1:8
Serum	100 µL	_	_
Saline	100 µL	100 µL →100 µL	100 µL →100 µL
Sample volume	50 µL	50 µL	50 µL
mg/L	>12	>24	>48

3.10 Measurement ESR:

The LENA automated ESR analyzer was used to measure the ESR rate. In order to prevent clot formation, venous blood samples were obtained in EDTA tubes, carefully mixed, and then put straight into the device. Results are achieved in around 20 minutes and given in mm/h. The measurement concept is based on photometric detection of RBC aggregation and sedimentation over a specified period. Compared to the conventional Westergren method, this automated approach enhances laboratory throughput, reduces manual errors, and yields findings quickly and consistently.

3.11 Albumin(ALB) test:

3.11.1 Principle of the assay:

The albumin in the sample combines with bromocresol green (BCG) in a pH 3.8 buffered solution to produce a color shift. The amount of albumin in the serum or plasma directly correlates with the color intensity.

3.11.2 Kit components:

The contents of the albumin Giesse Diagnostics (Italy) kit were presented in Table Table 3-11.

Table 3-11: Contents of ALB Kit

No.	Content
1-	**Reagent (1) ALB (Volume = 50/100/250 ml)** - Succinic acid (83mmol/L), Bromocresol green (BCG) (167 µmol/L), Sodium hydroxide (50mmol/L), and Polyoxyethylene monolauryl-ether (1.00 g/L).
2-	**Standard ALB (Volume = 5 ml)** - Bovine Albumin 5.0 g/dL (725 µmol/L).

3.11.3 Reagent preparation:

Before use, the liquid reagent should be allowed to come to room temperature (15–25°C).

3.11.4 Procedure:

The assay was performed at a wavelength of 628 nm (range: 620–640 nm) with a light path of 1 cm and a temperature of 37°C. Readings were taken against the blank reagent using the increasing endpoint method, with a sample-to-reagent ratio of 1:150. For the blank, 1500 µL of reagent (A) and 10 µL of water were added. For the sample, 1500 µL of reagent (A) and 10 µL of the sample were added. For the standard, 1500 µL of reagent (A) and 10 µL of the standard solution were added. The contents were mixed

thoroughly, and the mixtures were incubated for 2 minutes at room temperature (15–25°C).The absorbances of the sample (Ax) and the standad (As) were then measured against the blank (Doumas et al., 1971).

3.11.5 Results calculation:

Albumin g/dL = Ax/As x 3 (standard value), Conversion Factor: g/dL x 144.9 = µmol/l

3.12 Alanine aminoransferase (ALT) test:

3.12.1 Principle of the assay:

Alanine aminotransferase in the sample converts alanine into pyruvate and glutamate when α-ketoglutarate is present. Pyruvate is converted to lactate and NAD when NADH and lactate dehydrogenase are present. The ALT concentration in the sample is proportional to the amount of NADH consumed per time unit, as measured at 340 nm.

3.12.2 Kit components:

The contents of the ALT Giesse Diagnostics (Italy) kit were presented in Table 3-12.

Table 3-12: Contents of the ALT Kit

No.	Content
1-	**Reagent (A) ALT (Volume = 40/80 ml)** - Tris pH 7.8 (100 mmol/L), L-alanine (500 mmol/L), and LDH (1000 U/L).
2-	**Reagent (B) ALT** - Volume = 10/40/80 ml, NADH (0.18 mmol/L), and α-ketoglutarate mmol/L).

3.12.3 Reagent preparation:

The material was brought to room temperature (15–25 °C) prior to use. For the monoreagent assay, one part of reagent B was mixed with four parts of reagent A. The working solution (A + B) was found to remain stable for two weeks when stored at 2–8 °C.

3.12.4 Procedure:

The assay was performed at a wavelength of 340 nm with a light path of 1 cm and a temperature of 37 °C. Readings were taken against distilled water using the decreasing kinetic method. For the monoreagent assay, 1000 µL of the working solution (A + B) was mixed with 100 µL of the sample. For the bireagent assay, 800 µL of reagent A was mixed with 100 µL of the sample and 100 µL of reagent B. The mixtures were incubated, the initial absorbance was recorded, and three subsequent readings were taken at 60-second intervals. The change in absorbance per minute (ΔA/min) was calculated (Young, 2001).

3.12.5 Results calculation:

Activity (U/L) was calculated as ΔA/min × 1750. The calibrator (REF. 6002/8 - 8x3 ml) was used to verify this factor.

3.13 Aspartate aminotransferase (AST) test:

3.13.1 Principle of the assay:

Aspartate aminotransferase in the sample converts aspartate to oxalacetate and glutamate when α-ketoglutarate is present. When malate dehydrogenase and NADH are present, oxaloacetate is transformed into malate and NAD. The amount of NADH used per unit of time, as determined by a measurement at 340 nm, is proportional to the sample's AST concentration (Young, 2001).

3.13.2 Kit components:

The contents of the AST Giesse Diagnostics (Italy) kit were presented in Table 3-13.

Table 3-13: Contents of the AST kit

No.	Content
1-	**Reagent (A) AST (Volume = 40/80 mL)** - Tris Buffer pH 7.8 (80mmol/L), L-aspartate (200 mmol/L), LDH (600 U/L), and MDH (400 U/L).
2-	**Reagent (B) AST (Volume = 20/40/80 ml)** - NADH (0.18 mmol/L), and α-ketoglutarate (12 mmol/L).

3.13.3 Reagent preparation:

The material was brought to room temp. (15–25°C) before it was used. For monoreagent use, 1 part of reagent B was mixed with 4 parts of reagent A. The working solution (A+B) was found to be stable for 3 weeks at 2–8°C.

3.13.4 Procedure:

The assay was conducted at 340 nm with a 1cm light path and 37°C, using distilled water as a blank and the decreasing kinetic method. For the monoreagent assay, 1000 µL of working solution (A+B) was mixed with 100 µL of sample, while the bireagent assay used 800 µL of reagent A, 200 µL of reagent B, and 100 µL of sample. After incubation, initial absorbance was recorded, followed by three readings at 60-second intervals. The absorbance change per minute (ΔA/min) was calculated according to Young (2001).

3.13.5 Results calculation:

Activity (U/L) was calculated as ΔA/min × 1750. The calibrator (REF. 6002/8 - 8x3 ml) was used to verify this factor

3.14 Urea test:

3.14.1 Principle of the assay:

Urease hydrolyzed urea in the sample to produce carbon dioxide and ammonium ions in the presence of glutamate dehydrogenase. The generated ammonium ions reacted with α-ketoglutarate and NADH to produce

glutamate and NAD^+. The urea concentration in the sample was proportional to the amount of NADH oxidized per unit time, as measured at 340 nm.

3.14.2 Kit components:

The contents of the urea Giesse Diagnostics (Italy) kit were presented in Table 3-14.

Table 3-14: Contents of urea kit

No.	Content
1-	**Reagent (A) (Volume 40/80 ml)** - Good Buffer (100 mmol/L), ADP (1 mmol/L), α-ketoglutarate (9 mmol/L), Urease (8100 U/L), and GLDH (1350 U/L).
2-	**Reagent (B) (Volume 10/40/80 ml)** - NADH (1.5 mmol/L).
3-	**Standard (Volume 10 ml)** - Urea 50 mg/dL (8.32mmol/L)

3.14.3 Reagent preparation:

The material was brought to room temperature (15–25 °C) prior to use. For the monoreagent assay, one part of reagent B was mixed with four parts of reagent A. The working solution (A + B) was found to remain stable for one week when stored at 2–8 °C.

3.14.4 Procedure:

The assay was performed at a wavelength of 340 nm (range: 334–365 nm) with a light path of 1 cm and a temperature of 37°C. Readings were taken against distilled water using the decreasing kinetic method. For the monoreagent assay, 1000 µL of reagents A and B were combined, followed by the addition of 100 µL of the sample. For the bireagent assay, 1000 µL of reagent A was combined with 250 µL of reagent B and allowed to react for 30 seconds, after which 10 µL of the sample was added. The mixture was thoroughly mixed and incubated for 30 seconds at 37°C. The initial

absorbance was measured against distilled water, and a second reading was taken exactly 60 seconds later. The change in absorbance for the sample was then calculated (Kaplan & Pesce, 1989).

3.14.5 Results Calculation:

Urea mg/dL = ΔAX/ΔAs x 50 (standard value).

3.15 Creatinine test:

3.15.1 Principle of the assay:

A yellow-orange salt forms when creatinine reacts with picric acid in an alkaline environment. The intensity of the resulting color is directly related to the amount of creatinine in the sample, observed over a specified time period.

3.15.2 Kit components:

The contents of the creatinine Giesse Diagnostics (Italy) kit were presented in Table 3-15.

Table 3-15: Contents of the creatinine kit

No.	Content
1-	**Reagent (A) CREA (Volume 50/100/250 ml)** - Picric Acid (29 mmol/L).
2-	**Reagent (B) CREA (Volume 50/100/250 ml)** - Buffer (100 mmol/L), and Sodium hydroxide (500 mmol/L).
3-	**Standard (Volume 5 ml)** - Creatinine derivative (Value In label).

3.15.3 Reagent preparation:

The reagents (A) and (B) were mixed in equal parts. The working solution was stabilized for 15 minutes prior to use. The working solution rem -ained stable at room temperature for a duration of 7 days.

3.15.4 Procedure:

The assay was performed at a wavelength of 492 nm (range: 490–510 nm) with a light path of 1 cm and a temperature of 37 °C. Readings were taken against distilled water using the increasing kinetic method, with a sample-to-reagent ratio of 1:10. A total of 1000 µL of reagents A and B were combined with 100 µL of the sample. The mixture was incubated at 37 °C for 30 seconds. The absorbances of the sample (Ax1) and the standard (As1) were measured. Exactly one minute after the first reading, the absorbances of the sample (Ax2) and the standard (As2) were measured (Kaplan & Pesce, 1989).

3.15.5 Results calculation:

Creatinine mg/dL = (Ax2 - Ax1) / (As2 - As1) x Standard Value.

3.16 Pereferal Blood Lymphcyte Preparation for Karyotype:

Peripheral blood samples were collected from 15 women who had experienced abortion and 5 healthy pregnant women and were stored in lithium heparin tubes. Lymphocytes were examined to detect chromosomal abnormalities in actively dividing cells during the infection period. Karyotype analysis was performed to assess both the number and structure of chromosomes. Following culture and staining, chromosomes were observed under a microscope and arranged according to their shape and size, facilitating the detection of numerical or structural alterations. The preparation of lymphocyte karyotypes involved several key steps, including the stimulation of cell division, arresting cells at metaphase, hypotonic treatment, fixation, and staining. This method enabled the visualization and examination of chromosomes, allowing the identification of chromosomal abnormalities.

3.16.1 Assay procedure:

3.16.1.1 Lymphocyte culture:

To promote cell proliferation, peripheral blood lymphocytes were cultivated in a medium that contains a mitogen, such as phytohemagglutinin (PHA). Incubation of the culture usually lasts for a certain amount of time (e.g., 72 hours) at 37°C in an environment with 5% CO_2.

3.16.1.2 Metaphase arrest:

To stop cell division at the metaphase stage, when chromosomes were most condensed, a mitotic inhibitor like colchicine is added to the culture.

3.16.1.3 Hypotonic treatment:

Cells were treated with a hypotonic solution (e.g., 0.075M KCl) to induce swelling in order to facilitate the chromosomes' spread. For the greatest possible chromosomal observation, this step is crucial.

3.16.1.4 Fixation:

To maintain their structure and get them ready for staining, the cells were fixed, usually using a methanol-acetic acid solution.

3.16.1.5 Slide Preparation and Staining:

The fixed cells were placed onto slides and left to air dry. After that, the slides were stained, usually with Giemsa stain, which shows the chromsomes' banding patterns.

3.16.1.6 Karyotype Analysis:

Under a microscope, the stained chromosomes were examined for any structural or numerical anomalies. Chromosomes can be paired according to size and banding patterns to form kyrotypes.

Chapter Four:

Results and Discussion

4. Results and Discussion:

The study's findings were derived from statistical analysis of the data gathered throughout the time. The samples were collected between December 2024 and March 2025. As previously mentioned, there were two study groups: 130 aborted women and 50 healthy pregnant women with negative IgM and IgG for CMV as a control group.

4.1. Demographic characteristics of study groups:

4.1.1 Age:

This study involved 180 participants, comprising 130 women who experienced abortion and 50 healthy controls. The mean age of the patient group was (30.76 ± 0.61) years, while the mean age of the control group was (30.22 ± 1.00) years. The difference in mean age between the two groups was statistically insignificant (P = 0.642) (Table 4-1).

Table 4-1: Mean age of the study groups

Groups		N	Mean ± SE	*P*-value < 0.05
Age	**Patients**	130	30.76 ± 0.61	0.642
	Controls	50	30.22 ± 1.00	
***** Values are expressed as mean **±** standard error (SE)				* Independent-samples T test

The current study found that the average age of all participants in the study was within the appropriate age for fertility and childbearing. The current study was consistent with a previous study by Kalaf and Jameel (2023). It surely relates to the ideal sample technique and the most accurate community representation.

4.1.2 Seroprevalence of anti-CMV Ab among study groups:

The statistical results of the current study showed that the percentage of positive anti-CMV IgM antibodies was 25.4% in the aborted women

group compared to the control group (0.0%), and this difference was highly statistically significant (*P* = 0.001). Similarly, the results indicate that the percentage of positive anti-CMV IgG antibodies was 100% in the aborted women group compared to the control group (0.0%), and this difference was also highly statistically significant (*P* = 0.001) (Table 4-2).

Table 4-2: Seroprevalence of anti-CMV IgM and IgG Ab among study groups

ELISA test	Group	N	% of total	*P*-value
IgM^+	Patients	33	25.4%	0.001
	Controls	0	0.0%	
IgG^+	Patients	130	100%	0.001
	Controls	0	0.0%	
* Values are expressed as mean ± standard error (SE)				* Independent-samples T test

The results of IgM antibodies in the current study were comparable to another study conducted in Baqubah City, Iraq, by Hussein et al. (2017), which showed that 36% of HCMV IgM positivity was indicated in pregnant women with spontaneous abortion. The results of the current study were also consistent with a study conducted in Europe by Antona et al. (2017), which indicated that the seroprevalence of anti-CMV IgG antibodies ranged from 45.6% to 95.7%. In Basra City, southern Iraq, Raisan and Al-Amara (2020) found a seroprevalence rate of anti-CMV IgM at 26.7% and a seroprevalence rate of anti-CMV IgG at 100%. These results were consistent with those of the current study. The current study was inconsistent with another study conducted in Romania by Radoi et al. (2024), which indicated that the seroprevalence rate of anti-CMV IgM antibodies was 2.26. The findings of the present investigation were fully aligned with a study by Ali (2020) in Erbil, northern Iraq, which showed a 100% seroprevalence rate of anti-CMV IgG. The results of this study were consistent with a study in Tanzania City

by Awadh et al. (2021) that reported a 100% seroprevalence of IgG in the serum of women who had aborted. The current results were comparable to another study conducted in Diyala Governorate in Iraq by Kalaf and Jameel (2023), which showed that the seropositive anti-CMV IgG in aborted women was 96.3%.

Since the anti-CMV IgM may occur prior to the anti-CMV IgG antibody after the initial infection, IgM was known to be the body's first Ab to form in response to the first exposure to the infection. According to Capolunghi et al. (2013), it was widely believed that the presence of circulating IgM antibody signified an acute phase infection or recent infection. According to Vidarsson et al. (2014), the circulating IgG antibody typically increases after the IgM antibody declines and signifies prior exposure to or infection with a pathogen. The HCMV IgG avidity test depends on the sensitivity of the HCMV IgM testing, verifying the location and evaluation of the IgG avidity of all HCMV IgM-positive specimens (Al-Mousawi and Al- Hajjar, 2021). An increase in the levels of anti-CMV-IgM antibodies in the serum of abortive women indicates virus reactivation or reinfection again due to the decrease in the immunity of pregnant women. As for the control group, this decrease indicates that their blood was free of anti-CMV-IgM antibodies and not infected with CMV until the test was conducted. Regarding the high level of anti-CMV-IgG in the serum of aborted women, this indicates a previous exposure to CMV at some point in their lives and the formation of antibodies that stay in the blood for a long time. Conversely, the decrease in the level of these antibodies in the healthy women indicates that their serum was free of these antibodies and that there was no previous infection with the virus.

4.1.3 Cytomegalovirus infection and age categories:

The statistical analysis revealed that the highest prevalence of anti-CMV IgM^+ antibodies was observed in the 19–25 and 26–35 year age groups, with equal proportions of 12.3%. In contrast, the lowest prevalence was recorded in the 36–44-year-old age group (0.8%), and this variation was statistically significant ($P = 0.002$). With respect to IgM^- antibodies, the highest proportions were detected among the 19–25 (31.5%) and 26–35 (42.3%) year age groups, whereas the 36–44 year group demonstrated the lowest prevalence (26.2%). Nevertheless, the differences across age groups were not statistically significant ($P = 0.387$), as summarized in Table 4-3.

Table 4-3: Seroprevalence of anti-CMV Ab among age categories

Age category		Anti-CMV antibodies	N	% of total positive women	*P*-value
IgM^+	19–25 years (Young Adults)	Positive	16	12.3%	0.002
		Negative	25		
	26–35 years (Adults)	Positive	16	12.3%	
		Negative	39		
	36–44 years (Mid-age Adults)	Positive	1	0.8%	
		Negative	33		
IgM^-	19–25 years (Young Adults)	Positive	41	31.5%	0.387
		Negative	0		
	26–35 years (Adults)	Positive	55	42.3%	
		Negative	0		
	36–44 years (Mid-age Adults)	Positive	34	26.2%	
		Negative	0		

***P* value < 0.05**

***Values were expressed as mean ± standard error (SE).**

*** One-way ANOVA**

The statistics showed that middle-aged women had a lower percentage of anti-CMV Ab than adults and young adults. The findings of the current study were in line with a study by Kalaf and Jameel (2023) in Baqubah, Diyala Governorate, which revealed that the age group of 21 to 30 had the highest rate of abortions and pregnant women. The statistical results were consistent with a study by Waje et al. (2025) in Bauchi metropolis, Nigeria, which detected that the prevalence of CMV was greater among subjects aged 21–30 years. The current result in the 36–44 category was consistent with the study of Waje et al. (2025), which detected that the prevalence of positive HCMV-IgM in women between the ages of 41 and 50 years was 3 (1%) out of 300 participants. The current results were not consistent with a study conducted in France by Antona et al. (2017), which showed that the seroprevalence for women born in non-Western countries, according to age groups (15-24), (25-34), and (35-49), was 98%, 100%, and 99.1%, respectively. The results of the current study were not consistent with a study conducted in Germany by Lachmann et al. (2018), which showed that the seroprevalence of CMV increases with age in women. The results of the age categories indicated that the women in the study were representative of society, particularly since most women marry and have children between the ages of 20 and 25. Other women become pregnant again after a period of time spent caring for young children. Pregnancy after the age of 40 or older is infrequently observed because of cultural, economic, and medical factors.

4.1.4 Cytomegalovirus infection and residence:

The findings of the present study demonstrated that the distribution of abortion cases varied significantly across different socioeconomic and residential groups. Women residing in urban areas with high socioeconomic status accounted for 15.4% of cases, whereas those with low socioeconomic status represented the majority at 67.7%. In comparison, 16.9% of cases were recorded among women from rural areas. When compared to the control

group, this variation was found to be statistically significant ($P < 0.005$), as illustrated in Table 4-4.

Table 4-4: Comparison of study groups based on place of residence

Group	N	%of Urban**	% of Urban*	% of Rural	*P*-value
Patients	**130**	**20 (15.4%)**	**88 (67.7%)**	**22 (16.9%)**	**PC^S**
Control	**50**	**43 (86%)**	**0 (0.0%)**	**7 (14%)**	

PC : Statistical difference between patients and control.

S : P < 0.005 (Significant).

N : P > 0.005 (Non – significant).

(Urban) High socioeconomic levels.**

(Urban*) Low socioeconomic levels.

The results indicated a significant difference in socioeconomic levels among individuals in urban areas. The percentage of patients was notably higher in urban areas with low socioeconomic levels compared to the control group. This difference was statistically significant ($P < 0.005$). The statistical results were consistent with another study conducted by Ghailan and Mohammed (2020), in which the majority of the study sample lived in urban areas and had barely sufficient economic status. The current study does not agree with Porobic-Jahic etal. (2019), which showed rural environments have been shown to be risk factors for CMV infection. The current study was inconsistent with the findings of Mahmoud et al. (2023), which indicated that the seropositivity prevalence of CMV infection was 22% in rural areas and 3.8% in urban areas. The current study does not agree with a German study conducted by Greye etal. (2023) that showed the prevalence of CMV in rural areas was 54.8%. Regarding aborted women in the current study, 108 were urban residents, while 22 were rural residents. There are several factors

that support the spread of pathogens in urban areas faster than in rural areas. the spread of day care centers in the city is greater than in the countryside, which contributes to the transmission of infection among children and then it is transmitted to parents, the huge numbers of people are in small areas, the population's lack of commitment to public health procedures, the poor services in the city, the pollution of food, water, air and soil, the accumulation of waste within residential areas, the spread of informal housing and its overcrowding are considered incubators for various epidemics and a suitable focus for the spread of diseases and their transmission to a greater and faster extent than in rural area.

4.1.5 Cytomegalovirus infection and occupation:

The results revealed that 68.5% of the women with a history of abortion were housewives, while 31.5% were employed. In contrast, within the control group, only 16% were housewives, and the majority, 84%, were employed. This difference between the two groups was statistically significant ($P < 0.005$), as shown in Table 4-5.

Table 4-5: Comparison of study groups based on occupation

Group	N	Occupation		% of total	*P-value*
Patients	**130**	**Housewife**	**89**	**68.5%**	**HPC^S**
		Employer	**41**	**31.5%**	
Control	**50**	**Housewife**	**8**	**16%**	**EPC^S**
		Employer	**42**	**84%**	

PC : Statistical difference between housewives patients and control.

EPC: Statistical difference between employer patients and control.

***S* : P < 0.005 (Significant).**

***N* : P > 0.005 (Non – significant).**

The findings indicated that the proportion of housewives was considerably higher than that of employed women within the patient group.

In contrast, the control group demonstrated an opposite trend, where the proportion of employed women exceeded that of housewives. The results, which were in line with those of another study, demonstrate the potential for pregnant women to have CMV infections brought into the home by their young children and spouses (Stagno et al. 1984). The findings were consistent with another study by Habeeb et al. (2020), which showed there is a relationship between CMV infection and the presence of children in the home. The statistical results were consistent with another study conducted by Ghailan and Mohammed (2020), in which the majority of the study sample were housewives. Previous studies have shown that there is a positive relationship between the contact with children and an individual's infection with CMV, as confirmed by another study Balegamire et al., (2022), which confirmed that childcare workers, not health care workers, are at an increased risk of infection with CMV. It is likely that the mother, a housewife, is in close contact with children who bring the infection to the family, as mentioned in the study by Stango et al., (1984), and thus shed the virus through their saliva and urine, which infects the mother also, the mother at home is exposed to great stress due to taking care of the children, cleaning them, and meeting their needs, which makes her vulnerable to infection or reactivation of the virus. According to Rector et al. (2014), stress may encourage non-clinical CMV reactivation. The findings did not align with those of another study that found no connection between occupation and CMV infection (Winter et al., 2020).

4.1.6 Cytomegalovirus infection and education:

The statistical results of the current study indicated that among the IgM-positive women, 27 attended primary school and 6 attended secondary school, while none pursued a bachelor's degree; the difference was statistically significant compared to the control group ($P < 0.005$). Similarly, among the IgM-negative women, 68 attended primary school and 22

attended secondary school, while only 7 obtained a bachelor's degree; the difference was statistically significant compared to the control group ($P < 0.005$). Conversely, in the control group, there were 46 women who obtained a bachelor's degree and 4 who attended secondary school, while none of them were in primary school, as illustrated in Table 4-6.

Table 4-6: Comparison of study groups based on education

Group	N	Education		% of total women			*P*-value
				Primary	Secondary	Bachelor's	
IgM^+	33	Primary	27	73.1%	21.5%	5.4%	MC*S*
		Secondary	6				
		Bachelor's	0				
IgM^-	97	Primary	68				MC*S*
		Secondary	22				
		Bachelor's	7				
Control	50	Primary	0	0.0%	8%	92%	
		Secondary	4				
		Bachelor's	46				

MC : Statistical difference between IgM^+ and control.

GC : Statistical difference between IgM- and control.

***S* : P < 0.005 (Significant).**

***N* : P > 0.005 (Non – significant).**

The results of the present study demonstrated that the majority of women in the patient group had a low educational level, accounting for 73.1%, whereas only 21.5% had secondary education and 5.4% had attained higher education. In contrast, women in the control group exhibited a markedly different distribution, with 92% having higher education, while 8% had secondary education, and none were recorded with primary education. The current results were consistent with those of another study, which demonstrated that high incidence of infectious diseases is linked to poor

educational attainment (Ross & Wu, 1995). The findings were consistent with a study conducted by Dowd et al. (2009), which showed that low social class was associated with lower secretory immunoglobulin A (sIgA), cited as a first line of defense against infection. The findings were in line with another study that showed that lower education and job status (SES) were positively associated with CMV infection (Rector et al., 2014). The results were consistent with another study conducted by Korndewal et al. (2015), which showed that persons with lower education were independently associated with CMV seropositivity. The results were consistent with anothor study conducted by Lachmann et al. (2018), wich showed that higher education was inversely associated with CMV seropositivity. The findings were in line with Porobic-Jahic et al. (2019), which showed that one of the recognized risk factors for CMV infection is lower educational attainment. The findings were in line with a research by Barrichello et al. (2022), which noted that there is strong evidence linking a person's educational attainment to the majority of health-related activities.

People's awareness is directly proportional to the increase in education. The better the individual's educational level, the greater the health awareness and use of scientific methods to avoid diseases and pathogens. Education is not limited only to obtaining grades and passing a certain class but rather includes acquiring information, skills, and ways of thinking. Therefore, the educational level is important for living a healthy life for a longer period. Education also helps to promote healthy lifestyles and positive choices, sustain them, and enhance personal, family, and community well-being. Education can reduce the severity of the disease and its symptoms. The clinical and immunological effects of HIV infection are influenced by the patient's educational attainment (Collazos et al., 2009).

4.1.7 Cytomegalovirus infection and endogamy:

The findings of the current study revealed that among women with positive IgM antibodies, 21 were in consanguineous relationships, whereas 12 were not. Similarly, within the IgM-negative group, 50 women reported consanguinity compared to 47 without such a relationship. In the control group, 17 women were in consanguineous marriages, while 33 were not, as presented in Table 4-7.

Table 4-7: Comparison of study groups based on endogamy

Group	N	Endogamy		% of total women		*P-value*
		Yes	No	Yes	No	
IgM^+	33	21	12	54.6%	45.4%	MC*s*
IgM^-	97	50	47			
Control	50	17	33	34%	66%	GC*s*

MC : Statistical difference between IgM^+ and the control.

GC : Statistical difference between $IgG^+$and the control.

***S* : P < 0.005 (Significant).**

***N* : P > 0.005 (Non – significant).**

The results indicated that the patient group had the highest percentage of endogamy (54.6%), and their percentage of non-endogamy was 45.4%. Conversely, the women in the control group had the lowest percentage of endogamy (34%), and their percentage of non-endogamy was 66%. The statistical results of the present study were consistent with the findings of Ghailan and Mohammed (2020), who also reported that the majority of their study sample were in consanguineous relationships. The findings of the current study in line with another study showed that inherited monogenic

variations lead to inborn errors in immunity (IEI) (Guilz et al., 2023). Certain genetic disorders are more likely to occur when related people marry. Inherited single-gene variations that impact the human immune system's operation and result in immunological disorders are known as IEI (Tangye et al., 2022). A tiny portion of IEI is caused by natural killer cell deficiency (NKD), in which NK cells are the main immune lineage impacted in addition to a severe recurring viral infection, NKD manifests as a loss of NK cells or a lack of NK cell cytotoxic capability (Mace & Orange, 2019). NK cell-mediated immunity is especially effective against viruses of the Herpesviridae family, such as Epstein-Barr virus (EBV), varicella zoster virus (VZV), and HCMV (Della Chiesa et al., 2019). Herpes viruses are believed to predominantly avoid cytotoxic T lymphocyte (Tc) responses by suppressing the expression of HLA-I in infected host cells, making them vulnerable to NK cell death (Orange, 2013; Della Chiesa et al., 2019).

Awareness among families has become more than before, regarding the marriage of relatives, especially with those families who have a history of genetic reasons, to avoid the persistence of the disease in their children. On the other hand, there are many social, environmental, economic and cultural factors that contribute to the continuation of marriage between close relatives, despite the consequences it causes for future generations.

4.1.8 Cytomegalovirus infection and animal contact:

The results showed that only one woman in the IgM-positive group reported contact with animals, whereas 32 did not, with no statistically significant difference compared to the control group. Among the IgM-negative group, five women had contact with animals while 92 did not, and again no significant difference was observed relative to the control. Similarly, within the control group, three women reported animal contact and 47 did not, as summarized in Table 4-8.

Table 4-8: Comparison of study groups based on animals contact

Group	N	Animal contact		% of total women Yes	% of total women No	*P*-value
IgM^+	33	Yes	1	4.6%	95.4%	MC^N
		No	32			
IgM^-	97	Yes	5			
		No	92			GC^N
Control	50	Yes	3	6%	94%	
		No	47			

MC: Statistical difference between IgM^+ and control.

GC: Statistical difference between IgM^- and control.

***S* : *P* < 0.005 (Significant).**

***N* : *P* > 0.005 (Non – significant).**

The current study showed a significant decrease in the percentage of animal contact in both groups. The current study was consistent with Powers & Früh's (2008) study, which showed that each CMV species is highly adapted to its respective host species but is unable to infect other, even closely related, hosts. The current study's findings were explained that most families do not agree to raise animals, particularly since they need specialized care and appropriate locations. In addition to the financial expenses and the concern about human-animal disease, the virus can easily spread in environments with a high concentration of animals, such as poultry or livestock farms. It can be transmitted through bodily fluids or direct contact, similar to how COVID-19 spreads (Warren & Sawyer, 2023).

4.2 The blood parameters and study groups:

4.2.1 Complete blood count (CBC):

The results indicate that Complete Blood Count (CBC) tests revealed significant differences between women who were CMV-IgM-positive aborted patients and healthy controls.

Hemoglobin (Hb) levels were significantly lower in the IgM-positive group (9.43 ± 0.18 g/dL) compared to the controls (12.93 ± 0.20 g/dL) (P = 0.001). Similarly, the red blood cells (RBCs) count was lower in the IgM-positive patients (3.28 ± 0.02 M cells/μL) than in the controls (4.35 ± 0.05 M cells/μL) (P = 0.001).

Platelet (PLT) count was also significantly lower in the IgM-positive group (103.93 ± 4.09 $\times 10^3$ cells/μL) compared to the controls (256.04 ± 9.86 $\times 10^3$ cells/μL) (P = 0.001).

Conversely,the white blood cells (WBCs) count was markedly higher in the IgM-positive patients (13.08 ± 0.53 $\times 10^3$ cells/μL) than in the controls (6.05 ± 0.24$\times 10^3$ cells/μL) (P = 0.001).

Hb levels were lower in the IgM-negative group (10.11 ± 0.07) than in the control group (12.93 ± 0.20); this difference was statistically significant (P = 0.001).

The IgM-negative group's RBC levels were lower (4.13 ± 0.10) than those of the control group (4.35 ± 0.05), and the difference was not statistically significant (P = 0.082).

The IgM-negative group's PLT count was 254.54 ± 11.99, while the control group's was 256.04 ± 9.86, and the difference was not statistically significant (P = 0.928).

The IgG-positive group's WBC levels (6.2808 ± 0.15614) and the control group's (6.0508 ± 0.24641) were comparable, and the difference was not statistically significant (P = 0.502) , as summarized in Table 4-9.

Table 4-9: CBC profile among study groups

Parameter (Normal range)	Group	N	Mean ± SE	*P*-value
Hb (11.5-16 g/dL)	IgM^+	33	9.43 ± 0.18	MC^S
	IgM^-	97	10.11 ± 0.07	
	Control	50	12.93 ± 0.20	GC^S
RBCs (3.9-5.3 M cells/µL)	IgM^+	33	3.28 ± 0.02	MC^S
	IgM^-	97	4.13 ± 0.10	
	Control	50	4.35 ± 0.05	GC^N
PLT (150 - 450 cells/µL)	IgM^+	33	103.93 ± 4.09	MC^S
	IgM^-	97	254.54 ± 11.99	
	Control	50	256.04 ± 9.86	GC^N
WBC (4000 -11000 cells/µL)	IgM^+	33	13.08 ± 0.53	MC^S
	IgM^-	97	6.28 ± 0.15	
	Control	50	6.05 ± 0.24	GC^N

MC : Statistical difference between IgM^+ and the control.

GC : Statistical difference between IgM^- and the control.

***S* : *P* < 0.005 (Significant).**

***N* : *P* > 0.005 (Non – significant).**

The results indicated that the hemoglobin blood (Hb) rate, RBCs rate, and PLT rate of IgM-positive aborted women were lower than those of their counterparts in the control group, while the WBC count was higher than that of the control group. The statistical findings of the current study align with those from a previous study by Sing and Ruscetti (1995). This earlier research demonstrated that HCMV can infect both stromal components and hematopoietic progenitor cells, indicating that the entire hematopoietic system is susceptible to HCMV latency and dissemination. Lympho-and

myelosuppression may arise from the direct reduction of progenitor cell growth and the impaired self-renewal of stem cells due to stromal cell dysfunction. The current study's statistical findings were consistent with the study by Meyer-König et al. (1997), which demonstrated that granulocytes, monocytes, and $CD34^+$ progenitor cells responsible for producing blood components—all contained HCMV DNA. The statistical findings of the present investigation are in agreement with those of another study by Nishio et al. (2018), which demonstrated that CMV is one of the primary infectious causes of thrombocytopenia. The current study's statistical findings are in line with a study by Shragai et al. (2020), which found a link between CMV and thrombocytopenia. The current investigation's results are incongruent with those of another study, Altunal et al. (2023), which found that patients with CMV had a greater platelet-to-lymphocyte ratio (PLT). The findings about Hb, RBCs, and PLT were consistent with a study by de Melo Silva et al. (2020), which suggested that CMV may be a significant factor in the development of chronic hematological disorders like hemoglobinopathies. The levels of WBCs were higher in IgM-positive women than in the control group. The findings indicated leukocytosis was caused by CMV infection, which was consistent with another study by Min et al. (2017). The statistical findings were consistent with the findings of Mahmoud et al. (2023), which indicated that CMV infection causes leukocytosis. The current findings incompatible with a study by AL-Koufi and AL-Khilkhali (2022), which found that the CMV-IgM positive aborted women had significantly fewer WBCs than the control group. Leukopenia is caused by CMV infection, according to a different study by Schoeberl et al. (2023), which contradicts the statistical findings of the current study.

The low Hb levels of the women in the study could be caused by CMV infection in addition to other variables, such as malnutrition and the significant bleeding during the abortion. Regarding the CBC of IgM-

negative women, the decline in Hb levels was evident and statistically significant, but the values of the other parameters were within the normal range. WBC, PLT, and RBC counts did not exhibit any statistical significance. The heavy menstrual flow is a common symptom among women of reproductive age and a significant risk factor for iron deficiency and iron deficiency anemia, the most severe form of the condition (Munro et al., 2023). According to another study, women with low Hb levels had a sixfold higher risk of spontaneously ending their pregnancy than women with normal hemoglobin levels; the study findings align with those of that investigation (Larasati et al., 2023). The low Hb level may be attributed to several factors, including the patient's severe bleeding from the miscarriage, which led to anemia; heavy menstrual flow; malnutrition; or anemia that existed prior to conception and contributed to the miscarriage. At the time of the test, the WBC counts were normal, indicating the absence of any inflammatory issues.

4.2.2 Cytomegalovirus infection and blood groups:

The association between CMV infection and blood group types is not statistically significant ($P = 0.870$), as determined by the Pearson Chi-Square test. Among women with a positive IgM Ab, 39.4% had blood group $\mathbf{O^+}$, 0.0% had $\mathbf{O^-}$, 33.3% had $\mathbf{A^+}$, 21.2% had $\mathbf{B^+}$, and 6.1% had $\mathbf{AB^+}$. In contrast, among those with a negative IgM Ab, 57.8% had blood group $\mathbf{O^+}$, 1.0% had $\mathbf{O^-}$, 19.6% had $\mathbf{A^+}$, 20.6% had $\mathbf{B^+}$, and 1.0% had $\mathbf{AB^+}$. The $\mathbf{O^+}$ group had the highest percentage at 53.1%, and the $\mathbf{O^-}$ group had the lowest percentage at 0.8% ($P = 0.870$) (Table 4-10)**.**

Table 4-10: Correlation between anti-CMV IgM and blood groups

Group		Blood Group					*P* -value
		O^+	O^-	A^+	B^+	AB^+	
IgM	Positive	13 (39.4%)	0 (0.0%)	11 (33.3%)	7 (21.2%)	2 (6.1%)	0.870
	Negative	56 (57.8%)	1 (1.0%)	19 (19.6%)	20 (20.6%)	1 (1.0%)	
% of total Women		69 (53.1%)	1 (0.8%)	30 (23%)	27 (20%)	3 (2.3%)	

The results of the current study indicated that blood group **O^+** had the highest percentage at 53.1% among the assessed blood groups, whereas blood group **O^-** had the lowest percentage at 0.8% within the category of aborted women. The current results were consistent with the study conducted by ALSaikl and Tolaifeh (2023) in Babylon, Iraq, which found the highest incidence of CMV infection in individuals with blood type **O^+**. The results were consistent with another study conducted by Khaleefah et al. (2025), which indicated that the blood group **O^+** was the most prevalent among pregnant women who had experienced abortion and CMV IgG latent infection. The results were not consistent with another study conducted by Vega et al. (2021), which showed that blood group **A** is more susceptible to viral infection.

4.2.3 Inflammatory markers and study groups:

The study compares the inflammatory markers between the aborted women and the control group:IgM-positive women had significantly higher levels of C-reactive protein (CRP) (10.00 ± 0.30 mg/L) than control (2.21 ±

0.18 mg/L) (P = 0.001). Likewise, the erythrocyte sedimentation rate (ESR) of the sick group was significantly higher (61.39 ± 2.39 mm/hr) than that of the control (29.68 ± 3.39 mm/hr), indicating statistical significance (P = 0.001). Comparing the inflammatory markers of the IgM-negative women with the control group, the study found that the CRP levels rose marginally (2.53 ± 0.11 mg/L) compared to the control group's levels (2.21 ± 0.18 mg/L); there was no statistically significant difference (P = 0.173). The patient and control group's ESR levels were higher than the normal range (32.06 ± 3.13 mm/hr and 29.68 ± 3.39 mm/hr , respectively). However, there was no statistical significance (P = 0.608) (Table 4-11).

Table 4-11: Comparison of inflammatory markers among study groups

Parameter (Normal range)	Group	N	Mean ± SE	*P*-value
CRP (0-6 mg/L)	IgM^+	33	10.00 ± 0.30	MC^S
	IgM^-	97	2.53 ± 0.11	
	Control	50	2.21± 0.18	GC^N
ESR (0-20 mm/hr)	IgM^+	33	61.39 ± 2.39	MC^S
	IgM^-	97	32.06 ± 3.13	
	Control	50	29.68 ± 3.39	GC^N

MC : Statistical difference between IgM^+ and the control.

GC : Statistical difference between IgM^- and thecontrol.

***S : P* < 0.005 (Significant).**

***N : P* > 0.005 (Non – significant).**

The levels of CRP and ESR showed a statistically significant increase in IgM-positive women compared to those in the control group. Additionally, the levels of these markers in IgM-negative women were also different from those in the control group. CRP levels did not show a significant increase and remained within normal range for both the IgM-negative and control

groups. In contrast, ESR levels were elevated beyond the normal range in both the patient and control groups.

The results were aligned with those of another study by Zhu et al. (1999), which demonstrated that CMV causes an inflammatory response and raises CRP levels. The statistical findings of the present investigation were aligned with a different study by Simanek et al. (2011), which demonstrated that the liver's IL-6 production raises CRP levels when the virus reactivates or leaks from host cells. The current study was consistent with that of another study by Qader (2018), which found that the group with HCMV-IgM seropositive status had the highest rates of CRP positivity. The current study was aligned with that of another study by Barlık et al. (2022) that demonstrated a favorable connection between CRP levels and CMV-IgM positivity. The findings aligned with those of another study that found higher CRP levels in patients infected with CMV (Kalogeropoulos et al., 2023). The ESR test is performed to detect or monitor inflammation in the body. When inflammation occurs, the immune system secretes special inflammatory proteins to fight infection. When inflammation occurs, RBCs clump together, making them heavier and fall more quickly. There were many reasons that led to an increase in ESR, and these reasons may have appeared in the women included in the current study, including an increase in WBCs and anemia. Additionally, it often rises in pregnant women. These were the most important reasons that were particularly relevant to the patients in the current study and that explain the reason for the high ESR rate (Van den Broek & Letsky, 2001; Agrawal et al., 2025).

4.2.4 Liver function tests and study groups:

The present study demonstrated that IgM-positive women exhibited significantly lower albumin levels (2.50 ± 0.07 g/dL) compared to the control group (4.24 ± 0.07 g/dL; P = 0.001). In contrast, liver enzymes were markedly elevated in this group, with ALT levels of 74.08 ± 1.84 U/L versus

30.19 ± 0.72 U/L and AST levels of 60.33 ± 2.69 U/L versus 27.47 ± 0.84 U/L in controls (both $P = 0.001$). These findings suggest hepatic involvement associated with CMV infection in IgM-positive women. Conversely, IgM-negative women showed albumin, ALT, and AST values within normal ranges, indicating no significant hepatic alteration compared to the control group (Table 4-12).

Table 4-12: Comparison of liver function tests among study groups

Parameter (Normal range)	Group	N	Mean ± SE	*P* - value
Albumin (3.4-5.4 g/dL)	IgM^+	33	2.50 ± 0.07	MC^S
	IgM^-	97	4.61 ± 0.44	
	Control	50	4.24 ± 0.07	GC^N
ALT (0-40 U/L)	IgM^+	33	74.08 ± 1.84	MC^S
	IgM^-	97	28.27 ± 0.69	
	Control	50	30.19 ± 0.72	GC^N
AST (0-37 U/L)	IgM^+	33	60.33 ± 2.69	MC^S
	IgM^-	97	27.55 ± 0.64	
	Control	50	27.47 ± 0.84	GC^N

MC : Statistical difference between IgM^+ and the control.
GC : Statistical difference between IgM^- and the control.
***S* : *P* < 0.005 (Significant).**
***N* : *P* > 0.005 (Non – significant).**

Albumin levels were much lower in IgM-positive women than those of the control group, but ALT and AST levels were noticeably greater than those of the healthy women. The current findings were in line with the study by Borthakur et al. (2007), which demonstrated a significant correlation between symptomatic CMV reactivation and low serum albumin. The current findings were in line with those of another study by Ye and Zhao

(2017), which demonstrated that an HCMV infection can cause hepatitis and increase the liver enzymes. The current investigations were consistent with those of another study by Ye et al. (2022), which indicated that the infection group's ALT and AST levels were considerably higher than the non-infected group's. The findings align with another study by Jha et al. (2023) that found increased liver enzymes in women infected with CMV. The present study's statistical findings were in line with those of another study by Altunal et al. (2023), which demonstrated that patients with CMV had lower albumin levels. The study findings were inconsistent with the study by Al-Halani et al. (2024) that demonstrated that CMV infection had no effect on liver enzymes.

Liver functions are directly impacted by the active virus. IgG antibodies indicate a previous viral infection rather than the virus's current activity. This explains why IgM-negative women do not have liver problems. The tumor necrosis factor (TNF) protein alerts the immune system to activate and attract macrophages, NKc, Tc, and antigen-presenting cells (APCs) when the body is infected with a virus. In addition to its antiviral properties, this cytokine is implicated in liver illnesses and may be a secondary mechanism by which the virus causes abnormalities of the liver enzymes (Orange et al., 1997).

4.2.5 Renal function tests and study groups:

The IgM-positive women had considerably higher urea levels (62.56 ± 1.84 mg/dL) than the controls (28.65 ± 1.25 mg/dL) (P = 0.001). Furthermore, the creatinine levels (1.40 ± 0.02 mg/dL) were significantly higher than the control group (0.91 ± 0.01 mg/dL) (P = 0.001). The urea levels of IgM-negative women were somewhat lower (27.92 ± 0.94) than those of the control group (28.65 ± 1.25), but there was no statistical significance (P = 0.897). Additionally, there was no statistical difference (P

= 0.997) in creatine levels, which were slightly higher (0.91 ± 0.01) than those of the control group (0.90 ± 0.01) (Table 4-13).

Table 4-13: Comparison of renal function tests among study groups

Parameter (Normal range)	Group	N	Mean ± SE	*P* - value
Urea (10-50 mg/dL)	IgM^+	33	62.56 ± 1.84	MC^S
	IgM^-	97	27.92 ± 0.94	
	Control	50	28.65 ± 1.25	GC^N
Creatinine (0.7-1.2 mg/dL)	IgM^+	33	1.40 ± 0.02	MC^S
	IgM^-	97	0.91 ± 0.01	
	Control	50	0.90 ± 0.01	GC^N

MC : Statistical difference between IgM^+ and the control.

GC : Statistical difference between IgM^- and the control.

***S* : *P* < 0.005 (Significant).**

***N* : *P* > 0.005 (Non – significant).**

The statistical findings demonstrated that IgM-positive aborted women had higher levels of both urea and creatinine than the control group, and there was statistical significance. On the other hand, patients who tested negative for IgM antibodies did not have greater levels of the same parameters than the control group. The concentrations were within the optimal range; there was no statistical significance. The statistical results of the current study were consistent with another study conducted by Singh and Nickeleit (2004), which showed the ability of some viruses, including CMV, to replicate and cause kidney disorders in immunocompetent and immunocompromised individuals. The results were consistent with another study conducted by Rajabinejad et al. (2021), which showed a positive correlation between viral load and kidney function. The statistical results of the current study were consistent with another study conducted by Ossami et

al. (2024), which showed CMV infection had a clinically significant negative effect on renal function.

Many earlier investigations have revealed that the kidney is one of the virus's target organs, as it multiplies in the renal tubules and excretes huge amounts of virus in the urine. This demonstrates that when the virus infects the kidneys following initial infection or activation from the latent condition, it disrupts their functions. This is evident from the results, but no interruption of these functions occurred in patients who had no complaints of recently active infection. Cryoglobulins and immune complexes are examples of indirect routes that might result in damage. Through indirect mechanisms such as circulating immune complexes or cryoglobulins, glomerular or tubulo-interstitial damage is commonly induced. (Singh & Nickeleit, 2004).

4.3 Vital signs and study groups:

The current study findings indicated that systolic blood pressure was significantly lower in IgM-positive women (105.75 ± 0.75 mm/Hg) compared to the control group (120.10 ± 0.41 mm/Hg), with statistical significance (P = 0.001). Diastolic blood pressure was also lower in IgM-positive women (63.18 ± 0.94 mm/Hg) compared to the control group (77.60 ± 0.49 mm/Hg), with statistical significance (P = 0.001). Women who tested IgM-negative were also compared to the control group. These patients exhibited a significantly lower systolic blood pressure (102.52 ± 0.55 mm/Hg) compared to the control group (120.10 ± 0.41 mm/Hg), with statistical significance (P = 0.001). Additionally, the diastolic blood pressure was significantly lower in patients (61.59 ± 0.55 mm/Hg) than in the control group (77.60 ± 0.49 mm/Hg), with a P-value of 0.001 (Table 4-14).

Table 4-14: Comparison of blood pressure among study groups

Parameter (Normal range)	Group	N	Mean ± SE	*P*-value
Systolic 120 mm/Hg	IgM^+	33	105.75 ± 0.75	MC^S
	IgM^-	97	102.52 ± 0.55	
	Control	50	120.10 ± 0.41	MC^S
Diastolic 80 mm/Hg	IgM^+	33	63.18 ± 0.94	MC^S
	IgM^-	97	61.59 ± 0.55	
	Control	50	77.60 ± 0.49	MC^S

MC : Statistical difference between IgM^+ and the control.

GC : Statistical difference between IgM^- and the control.

***S* : *P* < 0.005 (Significant).**

***N* : *P* > 0.005 (Non – significant).**

The statistical results showed that there was a decrease in the systolic and diastolic blood pressure rates of women who had aborted compared to their counterparts in the control group, and the difference was statistically significant for both parameters. The results contradict those of a different study by Hui et al. (2016), which found that patients with CMV infection had a noticeably higher incidence of essential hypertension (EH). The statistical findings were not consistent with another study conducted by Bonavita and Cardin (2021), which showed many cardiovascular diseases, including hypertension, are known to be caused by an HCMV infection. Numerous cardiovascular diseases, including hypertension, have been linked to CMV infection, according to a different study by Bomfim et al. (2023), which does not align with the statistical data of the current study. The most acceptable explanation is the recognized fact that the pregnant lady loses a

significant amount of blood during the miscarriage, causing severe hypotension. Bleeding is among the top three causes of maternal death (Zakira & Hardianto, 2021).

4.4 Cytomegalovirus infection and urinary tract infection:

The results indicated that the percentage of the UTI-positive women was 42.4% in the IgM-positive group compared to the control group's 0.0%, with statistical significance (P = 0.001), whereas the percentage was 1% in the IgM-negative group compared to the control group's 0.0%, without statistical significance (P = 0.845) (Table 4-15).

Table 4-15: Comparison of UTI infection among study groups

Group	N	UTI		% of Positive	*P*-value
		Positive	Negative		
IgM^+	33	14 (42.4%)	19 (57.6%)	42.4%	MC^S
IgM^-	97	1 (1%)	96 (99%)	1%	GC^N
Control	50	0 (0.0%)	50 (100%)	0.0%	/

MC : Statistical difference between IgM^+ and control.

GC : Statistical difference between IgM^- and control.

***S* : *P* < 0.005 (Significant).**

***N* : *P* > 0.005 (Non – significant).**

The results indicated a significant difference regarding UTI between the IgM-positive group (10.8%) compared with the control group (0.0%). The current study's statistical findings were in line with those of Paduch (2007), which discovered a link between lower urinary tract infection and certain viruses, including CMV. The current results were consistent with those of Pittet et al. (2010) and Vareille et al. (2011), which showed that during a viral infection, mammalian cells are vulnerable to bacterial adhesion. The results were consistent with those of another study, which

showed CMV is associated with a significantly increased risk of co-infection with opportunistic infections (OI) (Jorgenson et al., 2019). IgG antibodies do not indicate an active infection. Conversely, the appearance of IgM antibodies is known to be a sign of infection, so the number of UTI-positive cases was higher in IgM-positive women than in IgG-positive women. This indicates the possibility that the virus may encourage secondary bacterial infections due to the high viral load, which causes the immune system to become compromised, making the body vulnerable to existing opportunistic pathogens. Because viruses can weaken the mucociliary clearance structure, bacteria are more likely to bind to mucins and colonize (Paduch, 2007).

4.5 Cytomegalovirus infection and chronic diseases (CD):

The results of the current study indicated that the percentage of the CD-positive women was 27.3% in the IgM-positive group compared to the control group's 0.0%, with statistical significance (P = 0.001), whereas the percentage was 1% in the IgM-negative group compared to the control group's 0.0%, without statistical significance (P = 0.958) (Table 4-16).

Table 4-16: Comparison of chronic diseases among study groups

Group	N	Chronic disease		% of Positive	*P*-value
		Positive	Negative		
IgM^+	33	9	24	27.3 %	MC^s
IgM^-	97	1	96	1%	GC^N
Control	50	0	50	0.0%	/

MC : Statistical difference between IgM^+ and the control.

GC : Statistical difference between IgM^- and the control.

***S* : *P* < 0.005 (Significant).**

***N* : *P* > 0.005 (Non – significant).**

The current study indicated that the percentage of CD in the IgM-positive aborted women group was 27.3%, in the IgM-negative aborted women group was 1%, and in the control group was 0%. The findings were consistent with another study conducted by Azevedo et al. (2015), which mentioned that CMV is among the primary causes of infection problems following transplantation. The findings were consistent with another study conducted by Styczynski (2018). Several studies have shown a close association between recurrent CMV infection and chronic diseases, including autoimmune diseases, as well as organ transplantation, such as kidney, pancreas, liver, and lung transplantation. In such cases, patients receive immunosuppressive therapies to prevent rejection of the transplanted organ (Al Mana et al., 2019). The chronic diseases ranged from diabetes, thyroid gland diseases, aczema and asthma. All 130 women participating in the current study were positive for anti-CMV-IgG antibodies, while 33 out of 130 were positive for anti-CMV-IgM antibodies. This means that all women who were positive for IgM were also positive for IgG antibodies at the same time. Therefore, the appearance of IgM antibodies in the aborted women included in the current study was not the result of first exposure or primary infection with the virus, but rather reappeared after a new infection with the viral particles or reactivation of the virus from a latent state due to weakened immunity during pregnancy, either for nutritional reasons or chronic diseases, the presence of which contributes to reactivation of the virus and the occurrence of repeated CMV infections.

4.6 Chromosomal aberration and HCMV:

The current results indicate that the karyotyping study does not reveal any chromosomal aberrations in the women who were suffering from abortion. The current results were not consistent with a study conducted by Siew et al., which indicated that the CMV-associated protein *UL76* induces DNA damage and the accumulation of chromosome aberrations. The current

results were not consistent with the study that showed HCMV infection induces specific DNA damage. DNA damage can lead to cell mutation, death, apoptosis, and immune system activation (Smolarz et al., 2015).

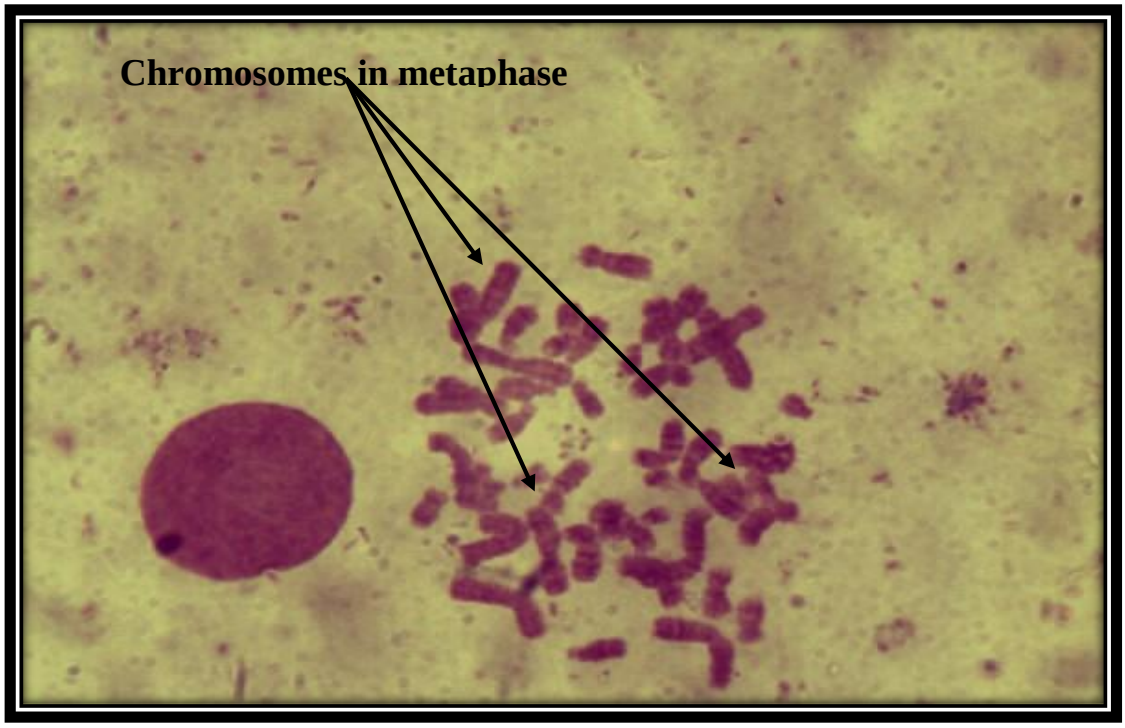

Figure 4-1: Microscopic slide of CMV-infected lymphocytes (Sample 1) showing normal chromosomes without detectable aberrations

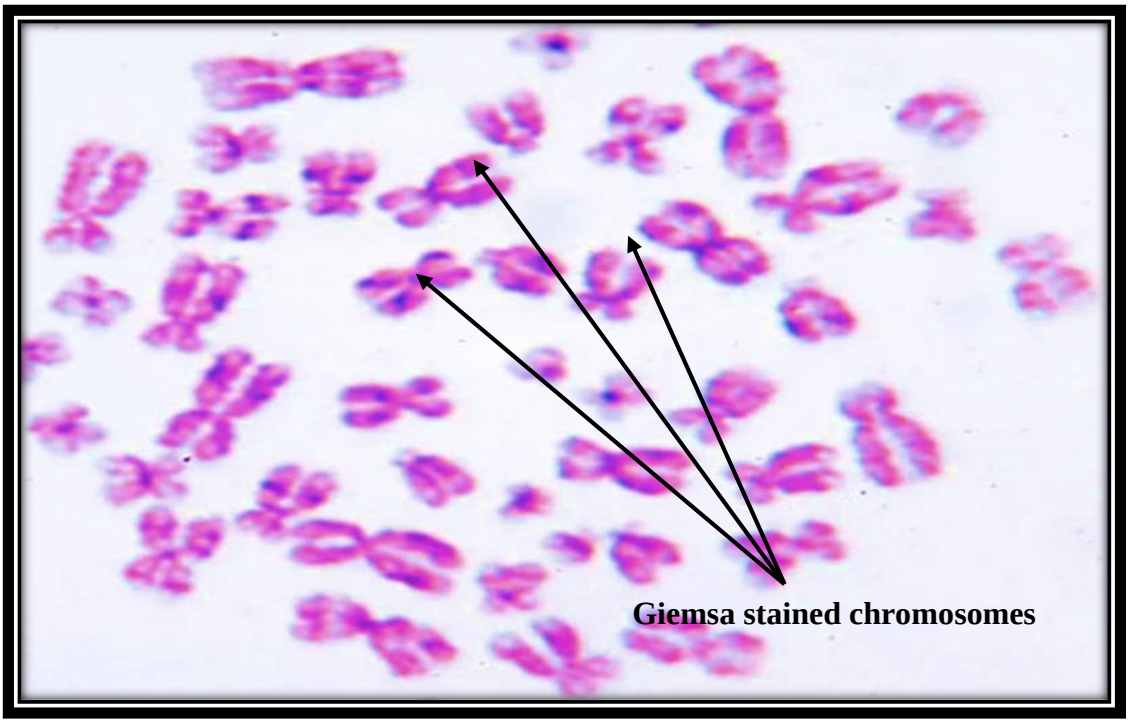

Figure 4-2: Microscopic slide of CMV-infected lymphocytes (Sample 2) showing normal stained chromosomes without detectable aberrations

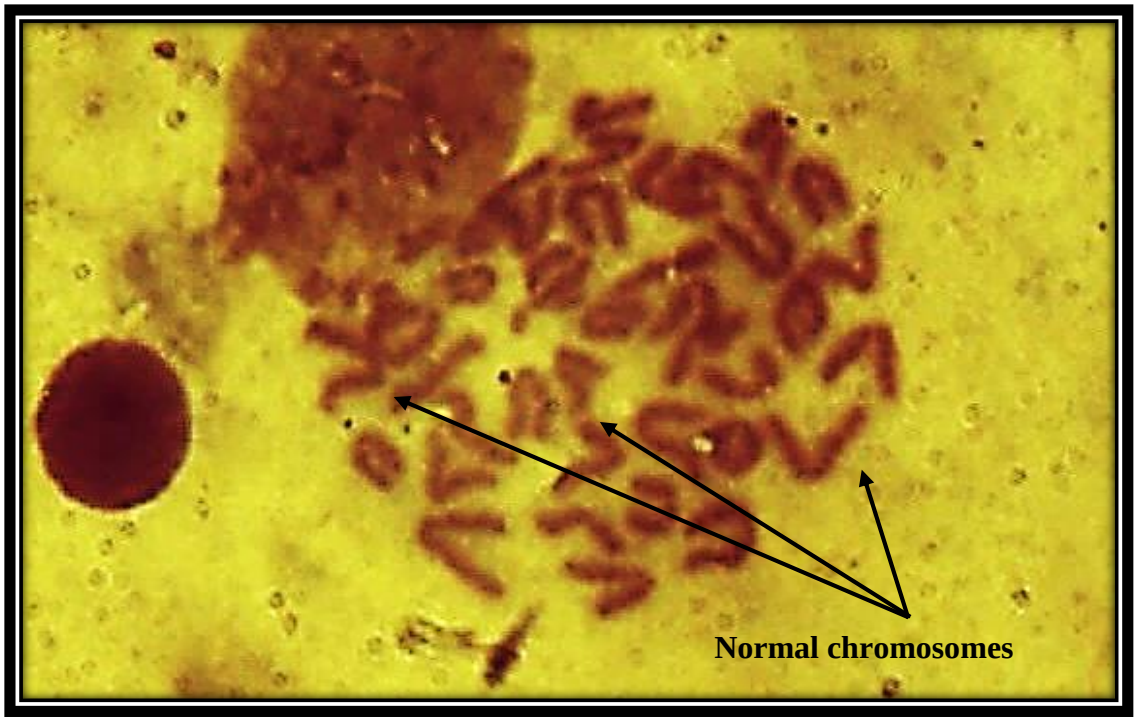

Figure 4-3: Microscopic slide (control) normal chromosomes in lymphocyte cell revealed no chromosomal aberrations

Chapter Five:

Conclusions and Recommendations

5-1 Conclusions:

1- In women who had miscarried, the seroprevalence of HCMV was much greater; anti-CMV IgM Ab was 25.4%, and anti-CMV IgG Ab was 100%. Additionally, every female who tested positive for IgM also tested positive for IgG. Accordingly, it is likely that the IgM-positive women who had previously been exposed had viral reactivation from a latent condition.

2- The women between the ages of 18 and 35 had a markedly higher prevalence of miscarriages and human cytomegalovirus infection. Additionally, the first trimester of pregnancy was when the majority of miscarriages happened.

3- The seroprevalence of human cytomegalovirus was highest among women living in urban areas with low socioeconomic status. It was also higher among housewives compared to employed women. Additionally, women who attended primary school had a higher seroprevalence than those who attended secondary school or obtained a bachelor's degree. The percentage of consanguineous marriages among women who had abortions was 54.6%.

4- Despite having a high degree of host species adaptation, CMV species cannot infect other hosts, even those that are closely related.

5- Because the virus can infect hematopoietic progenitor cells, it reduces hemoglobin, red blood cells, and platelets while simultaneously increasing white blood cells.

6- Blood group O^+ was the most prevalent among all other blood groups in women who had miscarried and had positive anti-CMV antibodies.

7- The virus causes a significant increase in C-reactive protein and erythrocyte sedimentation rate. The virus also causes disturbances in liver functions and enzymes, as well as renal functions.

8- Women who had abortions and had an active HCMV infection were more likely to have a secondary infection with opportunistic bacteria that cause UTIs than aborted women without an active HCMV infection.

9- Aborted women with chronic illnesses had a greater rate of HCMV reactivation from latent status than aborted women without chronic illnesses.

5-2 Recommendations:

1- Pregnant women should undergo frequent HCMV screening at governorate laboratories using IgG and IgM as well as real time PCR to assess the viral load.

2- Newborns of mothers infected with the virus during pregnancy should undergo medical examinations to assess the extent of its impact on their health.

3- Additional research is needed to enhance understanding of the role of specific genes and how they influence the risk of abortion. This includes investigating the *UL97* gene to identify mutations linked to resistance to HCMV medications.

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Appendices:

1- The questionnaire:

A- The patient's name…….

B- Age……

C- Residence…….

D- Education …….

E- Occupation ……

F- Endogamy…….

G- Animal contact……

H- Chronic diseases……

I- Smoking……

J- Birth defect……..

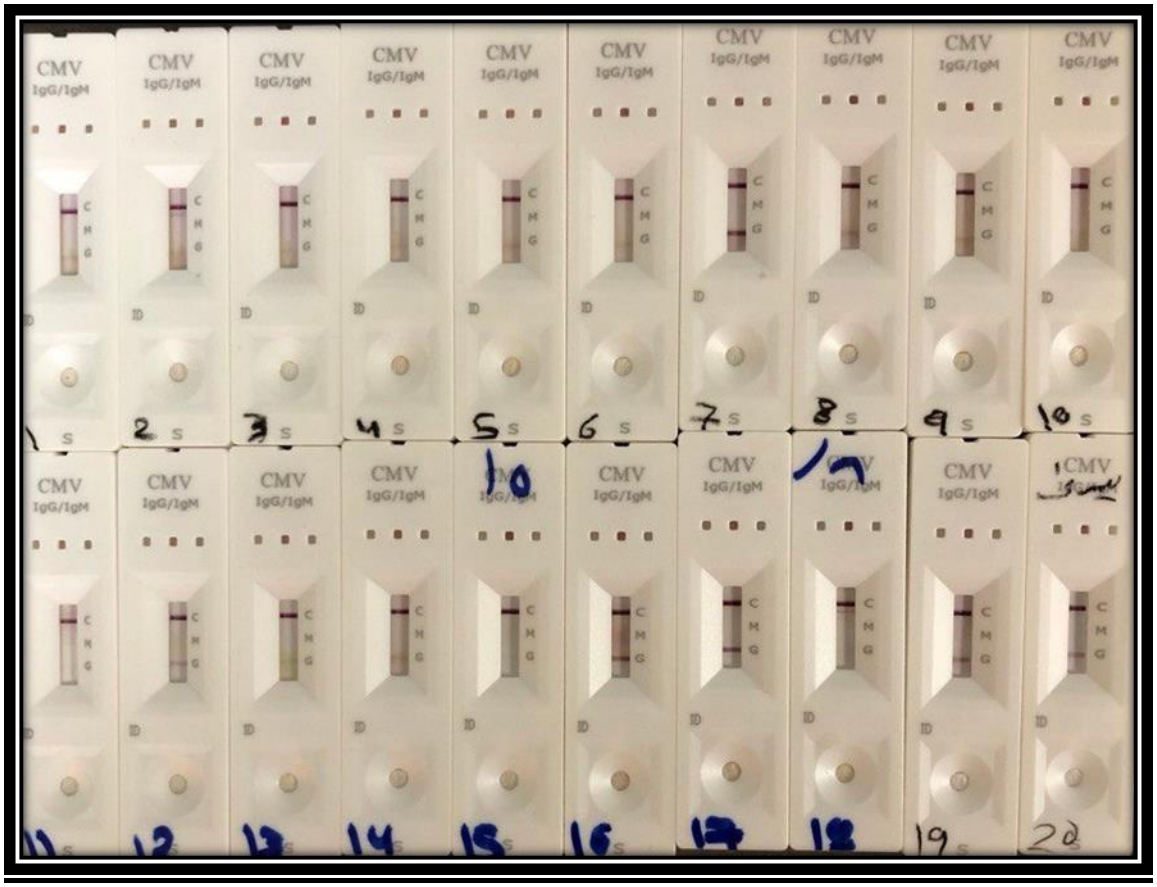
K- Number of abortion...…….

L- Vaginal infection.....……..

M- Previous abortion

N- Gestational duration……..

2- Anti-CMV IgM & IgG rapid test (cassette)



الخلاصة

الفيروس المضخم الخلايا البشري (HCMV) لا يُظهر أعراضًا لدى الأصحاء ومع ذلك، يزداد معدل الاعتلال والوفيات لدى المرضى الذين يعانون من نقص المناعة. كما يُسبب العديد من المشاكل الصحية للأم الحامل والجنين، مما قد يؤدي إلى الإجهاض. هدفت الدراسة الحالية إلى مقارنة النساء المُجهضات المصابات بالفيروس المضخم الخلايا في محافظة بغداد مع النساء الحوامل السليمات، ودراسة تأثير الفيروس على العديد من معايير الدم المهمة، بالإضافة إلى إرتباطه بعدد من الخصائص الاجتماعية والديموغرافية المختارة. أُجري اختبار الممتز المناعي المرتبط بالإنزيم (ELISA) لتحديد معدل الانتشار المصلي للغلوبيولين المناعي M (IgM) والغلوبيولين المناعي G (IgG) . شملت الدراسة 180 مشاركة، منهن 130 امرأة مُجهضة و50 امرأة سليمة كمجموعة سيطرة، في الفترة من كانون الأول 2024 إلى اذار 2025. أظهرت النتائج أن متوسط عمر مجموعة المريضات كان 30.76 ± 0.61 سنة، بينما كان متوسط عمر مجموعة السيطرة 30.22 ± 1.005 سنة ($P = 0.642$). كانت نسبة اختبارات الغلوبيولينات المناعية الإيجابية للفيروس في النساء اللواتي تعرضن للإجهاض (25.4 % و 100 % للغلوبيولين المناعي M والغلوبين المناعي G، على التوالي)، مع وجود فرق كبير عند مقارنتها بمجموعة السيطرة (P = 0.001). كانت نسبة الغلوبيولينات المناعية M وG المضادة للفيروس المضخم للخلايا أعلى بين المرضى الذين تتراوح أعمارهم بين 19-35 سنة، بمعدلات بلغت (96.9 % و73.8 %، على التوالي)، مع وجود فرق كبيرعند مقارنتها بمجموعة السيطرة ($P = 0.001$). فيما يتعلق بمنطقة السكن، كان 64.9 % من النساء المجهضات يعشن في مناطق حضرية ذات مستوى اقتصادي منخفض. كانت نسبة 68.5% من النساء المجهضات ربات منزل. حضرن 73.1% من النساء المجهضات المدرسة الابتدائية. كانت نسبة 54.6 % من النساء اللواتي تعرضن للإجهاض في علاقات زواج أقارب. 4.6 % من النساء المجهضات قد تواصلوا مع الحيوانات. كانت مستويات خضاب الدم (Hb) وكريات الدم الحمر(RBCs) والصفيحات الدموية (PLT) أقل في مجموعة النساء المجهضات (9.43 غرام/ديسلتر، 3.28 مليون خلية/مايكرولتر، و103.93خلية/ مايكرولتر، على التوالي)، منها في مجموعة السيطرة (12.93 غرام/ديسلتر، 4.35 مليون خلية/ مايكرولتر، و256.04 خلية/مايكرولتر، على التوالي)، مع وجود فرق معنوي ($P = 0.001$) بينما كانت مستويات كريات الدم البيضاء(WBC) أعلى بشكل ملحوظ لدى النساء المجهضات (13.08خلية/مايكرولتر) مقارنة مع نساء مجموعة السيطرة (6.05 خلية/مايكرولتر). بالإضافة إلى ذلك، كانت نسبة 53.1% من النساء المجهضات من فصيلة الدم O^+. كانت مستويات البروتين التفاعلي سي (CRP) مرتفعة في مجموعة المريضات (10.00ملغرام/لتر) مقارنة بمجموعة

السـيطرة (2.21 ملغرام/لتر) مع وجود فرق معنوي ($P = 0.001$). ارتفع معدل ترسـيب كريات الدم الحمر(ESR) في مجموعة المريضـات (61.39 ملم/سـاعة) عن مجموعة السيطرة (29.68 ملم/سـاعة). كانت مسـتويات الألبومين أقل بشـكل ملحوظ في في مجموعة المريضـات (2.5غرام/ ديسـليتر) مقارنة بمجموعة السيطرة (4.24غرام/ديسليتر) مع وجود فرق معنوي ($P = 0.001$) علاوة على ذلك، كانت قيم انزيم ناقل الامين (ALT) وانزيم ناقل الأسـبارتات (AST) واليوريا والكرياتينين أعلى بشكل ملحوظ في مجموعة المريضـات (74.08 وحدة دولية/لتر، 60.33 وحدة دولية/لتر، 62.56 ملغرام/ديسـلتر، و1.40 ملغرام/ ديسـلتر، على التوالي)، منها في مجموعة السـيطرة (30.19 وحدة دولية/لتر، 27.47 وحدة دولية/لتر، 28.65 ملغرام/ديسـلتر، و0.91 ملغرام/ديسـلتر، على التوالي)، مع وجود فروقات معنوية ($P = 0.001$). كان ضـغط الدم الانقباضي والانبساطي أقل في مجموعة المريضات (105.75ملم زئبق، و63.18 ملم زئبق، على التوالي)، منها في مجموعة السـيطرة (120.10ملم زئبق، و77.60ملم زئبق،على التوالي)، مع وجود فروقات معنوية ($P = 0.001$). كانت نسـبة إيجابية عدوى المسـالك البولية في مجموعة المريضـات 11.5% مقارنة بمجموعة السـيطرة 0.0 % وبفارق معنوي ($P = 0.001$). كانت الأمراض المزمنة في مجموعة المريضـات 8.5% مقارنة مع مجموعة السـيطرة 0.0 % وبفارق معنوي ($P = 0.001$). أشارت نتيجة فحص الكروموسومات إلى عدم وجود أي انحراف فيها.

في الختام، خلصت الدراسة الحالية إلى أن الانتشارالمصلي للغلوبيولينات المناعية M وG المضـادة لـ CMV واسـعة الانتشـار بين النسـاء اللواتي تعرضـن للإجهاض. علاوة على ذلك، ارتبطت الإصـابة بالفيروس بالحالة الاجتماعية للمريضـات، بما في ذلك مسـتوى التعليم ومكان الإقامة. كما اسـتنتجت الدراسـة أن العديد من معايير الدم والإنزيمات والوظائف الحيوية للأعضـاء تتأثر بشكل مباشر بالإصابة ب CMV.

الخلاصة

جمهورية الـــعراق
وزارة التعليم العالي والبحث العلمي
جامعة ديالـــــــــى
كلية العلـــــــــوم
قسم علوم الحياة

ألانتشار المناعي للفيروس المضخم للخلايا وتأثيره على المعايير الدموية، البايوكيميائية والجينية لدى النساء المجهضات في بغداد

رسالة
مقدمة إلى مجلس كلية العلوم/ جامعة ديالى
وهي جزء من متطلبات نيل درجة الماجستير في علوم الحياة

من قبل
أحمد شهاب أحمد
إشراف
أ.د إبراهيم هادي محمد

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