REV SEN
rev-sen.ec
OPEN ACCESS

Primary care for kidney disease in pregnant women: Narrative review.

Niuvis Ávila Aldana [ID] [1], Gregorio Hernández Castellanos [ID] [1].

1. Policlínico Universitario de la Familia "Alex Urquiola Marrero", Facultad de Ciencias Médicas "Mariana Grajales Coello", Universidad de Ciencias Médicas de Holguín, Cuba.

Received: November 4, 2024.
Accepted: February 17, 2025.
Published: February 21, 2025.
Editor: Dr. Franklin Mora Bravo.

Cite:
Avila N, Hernandez G. Primary care for kidney disease in pregnant women: Narrative review. REV SEN 2025;13(1):20-29.

DOI: http://doi.org/10.56867/98
Sociedad Ecuatoriana de Nefrología, Diálisis y Trasplantes.

ISSN-L: 2953-6448

Abstract

Introduction: Healthy women may show various renal disorders during pregnancy, from mild acute forms without consequences to severe forms, which compromise the completion of pregnancy and cause severe consequences for the pregnant woman and fetus.

Objective of the review: To provide an update from the point of view of primary care, on managing pregnant patients with renal diseases.

Essential points of the review:

Pregnancy induces adaptive physiological changes in the renal system, essential for ensuring maternal-fetal health. The increase in renal size and glomerular filtration leads to increased urate excretion.

Pregnancy activates the renin-angiotensin-aldosterone system and decreases plasma osmolarity due to water retention and reduced sodium concentration. Consequently, the increase in compensatory sodium reabsorption increases.

In women with chronic kidney disease (CKD), these adaptations may be compromised, increasing the risk of complications such as preeclampsia, preterm birth, and low birth weight. The risk depends on the degree of kidney function loss before pregnancy.

Pregnancy-related acute kidney disease is less common in developed countries but remains a significant cause of maternal mortality and morbidity.

Conclusions: Adequate prenatal care is essential for women with chronic kidney disease or acute kidney disease during pregnancy. This includes close monitoring of blood pressure, kidney function, and fetal well-being.

Keywords:

Pregnancy, Acute kidney failure, Chronic kidney disease, Risk factor.

* Corresponding author

Email: Niuvis Ávila Aldana <niuvisaviaaldana85@gmail.com>/Address: "Alex Urquiola Marrero" Family University Polyclinic, "Mariana Grajales Coello" Faculty of Medical Sciences, Avenida Lenin No. 4, Holguín, Cuba. Tel [53] 5 2135576.

Pregnancy is a physiological event that affects multiple organs and systems, including the kidneys. Renal physiology adapts to the demands of 40 weeks of gestation. These include hematological, metabolic, endocrine, digestive, pulmonary, renal and cardiovascular changes, reversible during puerperium [1].

Hemodynamic changes are significant, with an increase in cardiac output of up to 50% by week 24. This occurs due to a rise in preload from greater stroke volume, a decrease in postload from reduced peripheral resistance, and an increase in maternal heart rate [2]. Blood pressure drops to 10 mmHg by the end of the first trimester, but in the second and third trimesters, it returns to prepregnancy values; this is due to increased nitric oxide production and reduced aortic resistance. Blood volume increases by 50% from the first trimester, initially by 10- 15% between weeks 6 and 12, and continues to rise until week 34 [3,4]. After that point, the increase becomes less pronounced until delivery. The benefits include decreased blood viscosity, protection against postpartum hemorrhages, and enhanced renal and placental flow, contributing to improved fetal nutrition.

At the same time, modifications to the coagulation system produce a state of hypercoagulability that reduces postpartum hemorrhages, but this is dangerous because it increases the risk of thromboembolic processes [5].

The referred hemodynamic changes affect the kidneys of pregnant women, with the most notable change being an increase in kidney size by one centimeter in length during pregnancy due to the rise in renal vascular volume. During pregnancy, the dilation of the collecting system, or physiological ectasia, is thought to result from increased prostaglandin secretion, contributing to a higher incidence of vesicoureteral reflux, which can persist up to 12 weeks postpartum. Additionally, glomerular filtration increases by 40–60%, resulting in physiological hyperfiltration with decreased plasma levels of urea and creatinine [6,7].

Renin can increase up to eightfold, and angiotensinogen can rise three- to fourfold, allowing plasma renin activity to increase up to 15-fold due to heightened production by the ovary and maternal decidua[8].

Hyperfiltration decreases uric acid levels from the beginning of pregnancy and reaches their lowest value at 24 weeks. From this point, they progressively rise and get a nonpregnant state at the end of the pregnancy. This is because the reabsorption of uric acid increases in tubules, but the reasons for this increase are still unknown [9].

Plasma osmolarity decreases in the second week after conception, primarily due to a reduction in plasma sodium concentration and its associated electrolytes. Factors that promote sodium loss during pregnancy include increased glomerular filtration and the natriuretic action of progesterone.[10].

To counteract these effects, the renal tubules must increase sodium reabsorption by the renal tubules, representing the most critical physiological change in the renal system during pregnancy [11].

Aldosterone, estrogens, and deoxycorticosterone, whose concentrations are elevated during pregnancy, favor sodium reabsorption. A significant increase in aldosterone is the most decisive factor in preventing massive natriuresis due to elevated glomerular filtration [12].

It is evident that in the normal development of pregnancy, specific renal adaptations must occur for the fruit of pregnancy to reach term; however, in the case of a woman with chronic kidney disease, problems arise from infertility to achieve pregnancy, such as failures in adaptations that put the life of the fetus and the mother at risk [13].

Acute kidney disease in the context of pregnancy constitutes a significant clinical challenge because two patients need to be considered: the mother and the fetus. While pregnancy-related acute kidney disease has become a rare disease in the developed world, it is highly associated with significant long-term mortality and morbidity [14].

The evolution and course of pregnancy in the context of kidney disease depend on the degree of loss of kidney function before the onset of pregnancy, which is close to normal when the glomerular filtration rate is above 60 ml/min. In contrast, in advanced stages (glomerular filtration rate below 30 ml/min), a more significant decrease in glomerular function and an increase in maternal and fetal morbidity occur [15].

Women with chronic kidney disease have less capacity to adapt to the aforementioned physiological changes to carry a pregnancy to term. In most cases, there are complications associated with organ dysfunction, such as marked anemia, the accumulation of uremic toxins, alterations in electrolyte concentrations (such as calcium and phosphorus) that are associated with bone remodeling and, above all, the rapid progression of kidney disease to a terminal stage [16].

In women with chronic kidney disease, the physiological changes typical of pregnancy are compromised, thus increasing the risk for both the mother and the fetus. The evolution of pregnancy depends on the degree of loss of kidney function before pregnancy, which implies more significant risks and complications.

Pregnancy involves various physiological changes that affect the renal system. However, for women with chronic kidney disease, these adjustments are compromised, leading to a significant increase in risks and complications for both the mother and the fetus. Therefore, managing kidney disease during pregnancy presents an important clinical challenge that requires a multidisciplinary approach and careful follow-up [17].

Gestational nephropathies

Healthy women can present various kidney problems during pregnancy, ranging from mild acute forms without consequences (the most frequent is urinary tract infection) or acute kidney disease, with a risk for the fetus and mother, to chronic kidney disease or other noncommunicable chronic diseases, which compromise arrival at the end of gestation and establish severe long-term consequences for the pregnant woman and fetus [18].

The incidence of gestational nephropathy is approximately 1 in every 1,000 patients. Most authors consider that 30% of preeclamptic cases are nephropathies of this type [19 -21].

The current incidence of the disease in developed countries is estimated to be approximately 1 in 20,000 pregnancies. Although the incidence tends to decrease, it remains an essential factor that contributes to fetal mortality and maternal morbidity, with the development of terminal kidney diseases in the third trimester and the postpartum period being associated with an incidence of up to 39% neonatal mortality [21-23].

The incidence of acute kidney disease in pregnant women requiring dialysis is estimated to be less than 1 in 10,000 to 15,000 pregnancies, and accurate recognition of the incidence of mild degrees of kidney failure is complex. The disease is observed more frequently during the postpartum period, resulting in diabetes and high blood pressure, the two most common causes [22,23].

The estimated global prevalence of chronic kidney disease is 9.1%. However, this number varies according to the different stages of kidney disease. For stages one and two, the prevalence is 5%; for stage three, it is 3.9%; for stage four, it is 0.16%; and for stage five, it is 0.07%. The prevalence for dialysis cases is 0.041%, and for kidney transplantation, it is 0.011% [22,23].

The prevalence of chronic kidney disease is more significant in women than in men. However, some studies show the opposite pattern and indicate that in pregnant women, it is estimated that it affects 0.1%-4% of women of reproductive age [24,25].

Overall, kidney disease affects 3.3% of pregnancies, with a prevalence of 2.4% in stage one, 0.8% in stage two, and 0.1% in stage three. In more advanced stages, it affects one in every 150 women of reproductive age and one in every 750 pregnancies. Early pregnancy losses are more common in this population of women with the disease and comorbid conditions, which may have gone unnoticed in other studies [26,27].

In developing countries, the incidence of acute kidney disease in the obstetric population is estimated to be 5%, which represents one case in every 2,000--5,000 pregnancies and 25% of admissions to dialysis centers. In the United States, acute renal failure in the obstetric population occurs in only 1 case per 15,000 pregnant women. Notably, in pregnant women with acute kidney disease, the death rate is approximately 38%, and one-third of births are preterm [28].

The prevalence of chronic kidney disease has shown a sustained increase in the last decade and may affect 3% of women of childbearing age. Few studies have explored the prevalence of this disease in pregnant women, so it is difficult to define the disease in the early stages because there is a lack of solid data on its prevalence [27,28].

It is estimated that advanced chronic kidney disease (stages 3 to 5) affects 1 in 150 women of reproductive age and 1 in 750 pregnancies. The population incidence rates for dialysis and transplant pregnancies vary between countries. They are derived chiefly from historical registry data, which may have reporting biases, especially with poor capture of early pregnancy losses. The reported pregnancy rate in chronic dialysis patients is 3.1 per 1,000 patients per year [29].

Preexisting kidney disease at any stage affects maternal and perinatal outcomes. The challenging nature of these pregnancies underscores the need for careful pre-pregnancy planning in patients with known kidney disease, early identification of kidney disease and shared decision-making management of the pregnancy, as well as a patient-centered approach, in a specialized integrated service of obstetrics and nephrology.

It is estimated that 1 in 10 adults suffer from kidney failure worldwide due to the high prevalence of diabetes mellitus and high blood pressure [30]. In Latin America, there is a trend toward a progressive increase in renal replacement therapy. In Cuba, figures grow annually by 10%, and in Holguín, an average of 37 new cases in treatment therapy have been registered in the last 5 years [20].

According to James [21], acute kidney disease occurs in one in every 10,000 to 20,000 pregnancies in industrialized countries and underdeveloped countries in one in every 2,000 to 5,000 pregnancies.

Pregnancy occurs as a complication of severe preeclampsia or hypovolemic shock secondary to placenta previa or placental abruption, generally at the end of the third trimester, whereas in the first week of pregnancy, it is related mainly to abortion syndrome and its complications and the use of toxic substances; in 5% of cases, the cause is severe nephrotic syndrome, malignant hypertension or hemolytic uremic syndrome [31,32].

Over the years, numerous studies have been conducted to understand better gestational nephropathies' pathophysiology, risk factors, and management strategies. Endothelial dysfunction, renin–angiotensin–aldosterone system activation, and inflammation have been shown to play essential roles in developing these complications.

In addition, the usefulness of specific biomarkers, such as proteinuria and blood pressure, in the early detection and prognosis of gestational nephropathies has been established. Although significant progress has been made in this regard, there are still challenges in identifying the best strategies for each patient. These challenges relate to key issues such as the timeliness of diagnosis and treatment from an individualized perspective in each case.

Management of gestational nephropathy

In this context and the interest of research, it is possible to group gestational nephropathies into the following groups:

1- Woman of childbearing age with chronic kidney disease in the event of a potential pregnancy.

Its management is complex and challenging for nephrologists and obstetricians because there are no well-designed clinical studies that answer the risk due to the various pathologies that cause it and the stage of the disease [20]. According to Zhang [22] and Nevis [23], it is necessary to evaluate some criteria that indicate the best moment

for conception, which is conditioned by the presence of stable glomerular disease, for a period greater than six months or one year and a glomerular filtration rate greater than 45 liters per minute, without progression and proteinuria. The obstetric consequences of active kidney disease of any cause are preeclampsia, prematurity, abortion and fetal and/or maternal death [20 -24].

2-Pregnant without chronic disease with acute kidney injury or acute kidney failure during pregnancy.

It is linked to obstetric events that endanger both the mother and the fetus, making its presence an emergency and largely avoidable challenge. The primary causes include severe bleeding, sepsis, gestational hypertension (preeclampsia and eclampsia), and other complications during childbirth. Between 0.2% and 1% of pregnant women require admission to intensive care.[33-34].

The diagnosis of this entity in pregnant women should follow two directions: the physiopathogenesis according to the triggering cause before obstetric complications or not, and the early detection of renal dysfunction by the two criteria indicated for any of the classifications [34]. The determination of creatinine is essential in its diagnosis. Still, it is limited in healthy women, as it increases from very low typical values due to the presence of standard physiological elements during pregnancy.

3-Pregnant woman with chronic kidney disease

3.1. Pregnant woman with active glomerulopathies or with an estimated glomerular filtration rate of less than 60 ml/min or who is in progression.

Its actual incidence is not established; however, it is infrequent for various reasons: pregnancies occur mainly in healthy women, mild renal dysfunction may go unnoticed if glomerular filtration is not calculated, and infertility accompanies kidney disease, which may be underreported. Bili [27] and Javaballa [35] reported that the presence of micro- or macroproteinuria, which increases fetal mortality, is a risk factor for worse outcomes. In asymptomatic women, the presence of proteinuria greater than 500 mg/day causes a prepartum mortality of 7%, and 50% are born prematurely with growth disorders. A decrease in the glomerular filtration rate to less than 60 liters per minute is associated with 73% premature deliveries and 57% low birth weight.

3.2. Pregnant woman in dialysis replacement renal therapy methods: hemodialysis or peritoneal dialysis.

The diagnosis of pregnancy in these patients, owing to its infrequency and due to the menstrual irregularities present in these patients, is generally delayed since it is not considered [25]. Owing to fertility disorders, which are typical of kidney disease, the frequency of pregnancies in dialysis replacement therapies is exceptional. Still, recombinant human erythropoietin and other agents that stimulate erythropoiesis, which eliminate hypoxia and improve hormonal disorders, as well as advances and improvements in dialysis techniques, explain their relative increase in recent years [25]. However, complications such as spontaneous abortion, placental abruption, infection, premature rupture of membranes and polyhydramnios occur in 70% of pregnant women. In preterm delivery, uncontrolled arterial hypertension and preeclampsia-eclampsia occur in 80% of cases, including hemorrhage, the need for cesarean section and maternal death [26].

3.3. Transplanted pregnant

Suppose some conditions are not considered, such as the time between transplantation and conception. In that case, it is suggested that at least one year should pass for a living related donor and two years for an unrelated living donor. Additionally, there should be no arterial hypertension or only a minimal antihypertensive regimen, and a lack of or minimal proteinuria of less than 0.5 grams per day is required, along with a routine renal ultrasound showing no pyelocaliceal dilation. Pregnancy can result in a worsening of the disease and the emergence of the complications described in the preceding cases (3.1 and 3.2) [36]. Notably, the interpretation and comparison of results between studies are limited by the small sample size, restricted clinical data, historical cohorts from different eras of medical care, heterogeneous cohorts with primary diseases, and variable clinical characteristics and definitions [36]. However, any gestational nephropathy increases the probability of adverse maternal–fetal outcomes, with risks aggravated by the advancement of the disease stage, hypertension, proteinuria, and comorbidities [37].

Pregnant women with gestotic nephropathies, compared with healthy or low-risk controls, have an excessive maternal risk of preeclampsia and cesarean section and a fetal risk of preterm delivery, poor growth, low birth weight and the need for admission to neonatal intensive care. The rates of pregnancy and perinatal complications, which are driven mainly by preeclampsia, increase with increasing severity of kidney disease [37].

The current evidence concerning the risk of renal impairment during pregnancy remains contradictory. Some studies, such as Zhang's study [22], do not reveal an association between pregnancy and impaired kidney function, regardless of the etiology. However, for Piccoli [26], some associations indicate that 7.6% of pregnant women with some nephropathy have a significant deterioration of kidney function.

Gopalakrishnan [38] reported a mean age of 25.4 ± 4.73 years among pregnant women with gestational nephropathies and a higher frequency of disease among pregnant women between 20 and 30 years of age. As factors associated with gestational nephropathy, sepsis and preeclampsia have been reported.

On the other hand, Jarrick 17 provides evidence of a greater risk of preterm birth in pregnant women with gestational nephropathy. It establishes a fourfold more significant risk of preeclampsia in these pregnant women than in those who do not suffer from kidney disease during pregnancy.

Prakash [39] reported an incidence of 8.35% of gestational nephropathies in India, in which sepsis and preeclampsia are present in 9.4% and 3.5%, respectively; however, there are no cases of hyperemesis gravidarum associated with gestational nephropathies.

In this context, the absence of an international work guide or protocol on improving the results safely for future mothers and fetuses is evident. The bibliography analyzed reveals the need for a comprehensive, methodological approach yet to be carried out.

Conclusions

A comprehensive approach that considers the previous elements to optimize disease management and improve maternal perinatal outcomes is needed. In the context of primary health care, enabling timely identification, comprehensive management, preventing or minimizing complications, and allowing timely referral, all of which translate into better quality and effectiveness of care provided to patients, becomes vitally critical for pregnant women with kidney disease.

Abbreviations

AKI: Acute renal failure.
CKD: chronic kidney disease.

Supplementary information

The supplementary materials have not been declared.

Acknowledgments

Does not apply.

Authors' contributions

Niuvis Ávila Aldana: Conceptualization, methodology, research, Writing - Original draft.
Gregorio Hernández Castellanos: Conceptualization, Project management, Supervision, validation, visualization, Writing - review and edition.
All the authors read and approved the final version of the manuscript.

Financing

The study was self-financed by the authors.

Availability of data or materials

Does not apply.

Declarations

Ethics committee approval and consent to participate

It does not apply to narrative revisions.

Consent for publication

It does not apply when specific images, radiographs or photographs of patients are not published.

Conflicts of interest

The authors declare that they have no conflicts of interest.

Author information

Not declared.

References

1. Koren G, Pariente G. Pregnancy- Associated Changes in Pharmacokinetics and their Clinical Implications. Pharm Res. 2018 Feb 12;35(3):61. doi: 10.1007/s11095-018-2352-2. PMID: 29435666.

2. Jee SB, Sawal A. Physiological Changes in Pregnant Women Due to Hormonal Changes. Cureus. 2024 Mar 5;16(3):e55544. doi: 10.7759/cureus.55544. PMID: 38576690; PMCID: PMC10993087.

3. Dai JC, Nicholson TM, Chang HC, Desai AC, Sweet RM, Harper JD, Sorensen MD. Nephrolithiasis in Pregnancy: Treating for Two. Urology. 2021 May;151:44-53. doi: 10.1016/j.urology.2020.06.097. Epub 2020 Aug 28. PMID: 32866511.

4. Yarlagadda RD, Johnson J, Vårtun Å, Flo K, Acharya G. Maternal plasma pro-atrial and C-type natriuretic peptide levels and their associations with cardiovascular and renal function in the second half of normal pregnancy: a longitudinal study. BMC Pregnancy Childbirth. 2021 May 5;21(1):358. doi: 10.1186/s12884-021-03824-3. PMID: 33952207; PMCID: PMC8097896.

5. Moronge D, Sullivan JC, Faulkner JL. Physiology of Pregnancy-Related Acute Kidney Injury. Compr Physiol. 2023 Jun 26;13(3):4869-4878. doi: 10.1002/cphy.c220026. PMID: 37358509; PMCID: PMC11694322.

6. Ngene NC, Moodley J. Physiology of blood pressure relevant to managing hypertension in pregnancy. J Matern Fetal Neonatal Med. 2019 Apr;32(8):1368-1377. doi: 10.1080/14767058.2017.1404569. Epub 2017 Nov 27. PMID: 29172798.

7. Kreepala C, Srila-On A, Kitporntheranunt M, Anakkamatee W, Lawtongkum P, Wattanavaekin K. The Association Between GFR Evaluated by Serum Cystatin C and Proteinuria During Pregnancy. Kidney Int Rep. 2019 Apr 8;4(6):854-863. doi: 10.1016/j.ekir.2019.04.004. PMID: 31194092; PMCID: PMC6551540.

8. Soma-Pillay P, Nelson-Piercy C, Tolppanen H, Mebazaa A. Physiological changes in pregnancy. Cardiovasc J Afr. 2016 Mar-Apr;27(2):89-94. doi: 10.5830/CVJA-2016-021. PMID: 27213856; PMCID: PMC4928162.

9. Garovic VD, Dechend R, Easterling T, Karumanchi SA, McMurtry Baird S, Magee LA, Rana S, Vermunt JV, August P; American Heart Association Council on Hypertension; Council on the Kidney in Cardiovascular Disease, Kidney in Heart Disease Science Committee; Council on Arteriosclerosis, Thrombosis and Vascular Biology; Council on Lifestyle and Cardiometabolic Health; Council on Peripheral Vascular Disease; and Stroke Council. Hypertension in Pregnancy: Diagnosis, Blood Pressure Goals, and Pharmacotherapy: A Scientific Statement From the American Heart Association. Hypertension. 2022 Feb;79(2):e21-e41. doi: 10.1161/HYP.0000000000000208. Epub 2021 Dec 15. Erratum in: Hypertension. 2022 Mar;79(3):e70. doi: 10.1161/HYP.0000000000000212. PMID: 34905954; PMCID: PMC9031058.

10. Gonzalez Suarez ML, Kattah A, Grande JP, Garovic V. Renal Disorders in Pregnancy: Core Curriculum 2019. Am J Kidney Dis. 2019 Jan;73(1):119-130. doi: 10.1053/j.ajkd.2018.06.006. Epub 2018 Aug 16. Erratum in: Am J Kidney Dis. 2019 Jun;73(6):897. doi: 10.1053/j.ajkd.2019.02.005. PMID: 30122546; PMCID: PMC6309641.

11. Koratala A, Bhattacharya D, Kazory A. Chronic Kidney Disease in Pregnancy. South Med J. 2017 Sep;110(9):578-585. doi: 10.14423/SMJ.0000000000000693. PMID: 28863222.

12. Al-Sulttan S, Achary C, Odor PM, Bampoe S. Obstetric anesthesia 1: physiological changes in pregnancy. Br J Hosp Med (Lond). 2019 Jul 2;80(7):C107-C111. doi: 10.12968/hmed.2019.80.7.C107. PMID: 31283386.

13. Kulkarni M, Norouzi S, Hassanein M, Shah S. Glomerulonephritis in Pregnancy. 2024 Oct 29. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan–. PMID: 39536139.

14. Vinturache A, Popoola J, Watt-Coote I. The Changing Landscape of Acute Kidney Injury in Pregnancy from an Obstetrics Perspective. J Clin Med. 2019 Sep 6;8(9):1396. doi: 10.3390/jcm8091396. PMID: 31500091; PMCID: PMC6780924.

15. Calimag-Loyola APP, Lerma EV. Renal complications during pregnancy: In the hypertension spectrum. Dis Mon. 2019 Feb;65(2):25-44. doi: 10.1016/j.disamonth.2018.03.001. Epub 2018 Jun 8. PMID: 29891230.

16. Jarrick S, Lundberg S, Stephansson O, Symreng A, Bottai M, Höijer J, Ludvigsson JF. Pregnancy outcomes in women with immunoglobulin A nephropathy: a nationwide population-based cohort study. J Nephrol. 2021 Oct;34(5):1591-1598. doi: 10.1007/s40620-021-00979-2. Epub 2021 Mar 8. PMID: 33683676; PMCID: PMC8494659.

17. Prakash J, Pant P, Prakash S, Sivasankar M, Vohra R, Doley PK, Pandey LK, Singh U. Changing picture of acute kidney injury in pregnancy: Study of 259 cases over a period of 33 years. Indian J Nephrol. 2016 Jul-Aug;26(4):262-7. doi: 10.4103/0971-4065.161018. PMID: 27512298; PMCID: PMC4964686.

18. Blom K, Odutayo A, Bramham K, Hladunewich MA. Pregnancy and Glomerular Disease: A Systematic Review of the Literature with Management Guidelines. Clin J Am Soc Nephrol. 2017 Nov 7;12(11):1862-1872. doi: 10.2215/CJN.00130117. Epub 2017 May 18. PMID: 28522651; PMCID: PMC5672957.

19. Fitzpatrick A, Mohammadi F, Jesudason S. Managing pregnancy in chronic kidney disease: improving outcomes for mother and baby. Int J Womens Health. 2016 Jul 14;8:273-85. doi: 10.2147/IJWH.S76819. PMID: 27471410; PMCID: PMC4948734.

20. Hill NR, Fatoba ST, Oke JL, Hirst JA, O'Callaghan CA, Lasserson DS, Hobbs FD. Global Prevalence of Chronic Kidney Disease - A Systematic Review and Meta-Analysis. PLoS One. 2016 Jul 6;11(7):e0158765. doi: 10.1371/journal.pone.0158765. PMID: 27383068; PMCID: PMC4934905.

21. James PR, Nelson-Piercy C. Management of hypertension before, during, and after pregnancy. Heart. 2004 Dec;90(12):1499-504. doi: 10.1136/hrt.2004.035444. PMID: 15547046; PMCID: PMC1768605.

22. . Zhang JJ, Ma XX, Hao L, Liu LJ, Lv JC, Zhang H. A Systematic Review and Meta-Analysis of Outcomes of Pregnancy in CKD and CKD Outcomes in Pregnancy. Clin J Am Soc Nephrol. 2015 Nov 6;10(11):1964-78. doi: 10.2215/CJN.09250914. Epub 2015 Oct 20. PMID: 26487769; PMCID: PMC4633792.

23. Nevis IF, Reitsma A, Dominic A, McDonald S, Thabane L, Akl EA, Hladunewich M, Akbari A, Joseph G, Sia W, Iansavichus AV, Garg AX. Pregnancy outcomes in women with chronic kidney disease: a systematic review. Clin J Am Soc Nephrol. 2011 Nov;6(11):2587-98. doi: 10.2215/CJN.10841210. Epub 2011 Sep 22. PMID: 21940842; PMCID: PMC3359575.

24. Bili E, Tsolakidis D, Stangou S, Tarlatzis B. Pregnancy management and outcome in women with chronic kidney disease. Hippokratia. 2013 Apr;17(2):163-8. PMID:

24376324; PMCID: PMC3743623.

25. Chang JY, Jang H, Chung BH, Youn YA, Sung IK, Kim YS, Yang CW. The successful clinical outcomes of pregnant women with advanced chronic kidney disease. Kidney Res Clin Pract. 2016 Jun;35(2):84-9. doi: 10.1016/j.krcp.2015.12.005. Epub 2016 Feb 17. PMID: 27366662; PMCID: PMC4919570.

26. Piccoli GB, Cabiddu G, Attini R, Vigotti FN, Maxia S, Lepori N, Tuveri M, Massidda M, Marchi C, Mura S, Coscia A, Biolcati M, Gaglioti P, Nichelatti M, Pibiri L, Chessa G, Pani A, Todros T. Risk of Adverse Pregnancy Outcomes in Women with CKD. J Am Soc Nephrol. 2015 Aug;26(8):2011-22. doi: 10.1681/ASN.2014050459. Epub 2015 Mar 12. PMID: 25766536; PMCID: PMC4520166.

27. Bili E, Tsolakidis D, Stangou S, Tarlatzis B. Pregnancy management and outcome in women with chronic kidney disease. Hippokratia. 2013 Apr;17(2):163-8. PMID: 24376324; PMCID: PMC3743623.

28. Durnin JV, Fidanza F. Evaluation of nutritional status. Bibl Nutr Dieta. 1985;(35):20-30. PMID: 3924018.

29. Shetty PS, James WP. Body mass index. A measure of chronic energy deficiency in adults. FAO Food Nutr Pap. 1994;56:1-57. PMID: 7925867.

30. Bartsch E, Medcalf KE, Park AL, Ray JG; High Risk of Preeclampsia Identification Group. Clinical risk factors for preeclampsia determined in early pregnancy: systematic review and meta-analysis of large cohort studies. BMJ. 2016 Apr 19;353:i1753. doi: 10.1136/bmj.i1753. PMID: 27094586; PMCID: PMC4837230.

31. Crump C, Sundquist J, Sundquist K. Adverse pregnancy outcomes and long-term risk of chronic kidney disease in women: national cohort and cosibling study. Am J Obstet Gynecol. 2024 May;230(5):563.e1-563.e20. doi: 10.1016/j.ajog.2023.10.008. Epub 2023 Oct 11. PMID: 37827269; PMCID: PMC11006822.

32. Nevis IF, Reitsma A, Dominic A, McDonald S, Thabane L, Akl EA, Hladunewich M, Akbari A, Joseph G, Sia W, Iansavichus AV, Garg AX. Pregnancy outcomes in women with chronic kidney disease: a systematic review. Clin J Am Soc Nephrol. 2011 Nov;6(11):2587-98. doi: 10.2215/CJN.10841210. Epub 2011 Sep 22. PMID: 21940842; PMCID: PMC3359575.

33. Cheung KL, Lafayette RA. Renal physiology of pregnancy. Adv Chronic Kidney Dis. 2013 May;20(3):209-14. doi: 10.1053/j.ackd.2013.01.012. PMID: 23928384; PMCID: PMC4089195.

34. Kendrick J, Sharma S, Holmen J, Palit S, Nuccio E, Chonchol M. Kidney disease and maternal and fetal outcomes in pregnancy. Am J Kidney Dis. 2015 Jul;66(1):55-9. doi: 10.1053/j.ajkd.2014.11.019. Epub 2015 Jan 16. PMID: 25600490; PMCID: PMC4485539.

35. Jayaballa M, Sood S, Alahakoon I, Padmanabhan S, Cheung NW, Lee V. Microalbuminuria is a predictor of adverse pregnancy outcomes including preeclampsia. Pregnancy Hypertens. 2015 Oct;5(4):303-7. doi: 10.1016/j.preghy.2015.08.001. Epub 2015 Aug 13. PMID: 26597745.

36. Sousa MV, Guida JPS, Surita FGC, Parpinelli MA, Nascimento MLCD, Mazzali M. Twin pregnancy after kidney transplantation: case report and systematic review. J Bras Nefrol. 2021 Jan-Mar;43(1):121-126. doi: 10.1590/2175-8239-JBN-2020-0016. PMID: 32672328; PMCID: PMC8061955.

37. Bramham K, Briley AL, Seed PT, Poston L, Shennan AH, Chappell LC. Pregnancy outcome in women with chronic kidney disease: a prospective cohort study. Reprod Sci. 2011 Jul;18(7):623-30. doi: 10.1177/1933719110395403. Epub 2011 Feb 1. PMID: 21285450.

38. Gopalakrishnan N, Dhanapriya J, Muthukumar P, Sakthirajan R, Dineshkumar T, Thirumurugan S, Balasubramaniyan T. Acute kidney injury in pregnancy--a single center experience. Ren Fail. 2015;37(9):1476-80. doi: 10.3109/0886022X.2015.1074493. Epub 2015 Sep 3. PMID: 26338215.

39. Jarrick S, Lundberg S, Stephansson O, Symreng A, Bottai M, Höijer J, Ludvigsson JF. Pregnancy outcomes in women with immunoglobulin A nephropathy: a nationwide population-based cohort study. J Nephrol. 2021 Oct;34(5):1591-1598. doi: 10.1007/s40620-021-00979-2. Epub 2021 Mar 8. PMID: 33683676; PMCID: PMC8494659.

DOI: Digital Object Identifier. **PMID**: PubMed Identifier.

Editor's Note

REV SENs remain neutral concerning jurisdictional claims on published maps and institutional affiliations.