Movement Disorders
CLINICAL PRACTICE
REVIEW

The Management of Parkinson's Disease Before, during and after Pregnancy—an MDS Scientific Issues Committee Review

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Abstract: Background: Pregnancy after a Parkinson's diagnosis presents complex challenges. Due to the paucity of literature, there is no evidence-based guidelines and protocols for preconception care, management of pregnancy, childbirth and the postpartum period in women with early-onset Parkinson's disease (PD). Decision-making can be fraught with uncertainty for both patients and healthcare providers.

Objectives: This review is aimed to provide pragmatic advice to help guide women with PD before, during and after pregnancy, and to address key gaps in the existing literature.

Methods: An interdisciplinary working group of movement disorder specialists, obstetricians, perinatal neuropsychiatrists, physiotherapist, pharmacist and individuals with lived experiences collaborated to assess published evidence. In areas lacking robust data, recommendations were derived from case studies, registries, clinical and personal expertise.

Results: Key recommendations include:

1. **Motor Symptom Management:** Levodopa remains the safest treatment during the perinatal period. Monotherapy is preferred over polypharmacy.
2. **Non-Motor Symptom Management:** Some non-motor symptoms are particularly common in this patient group and warrant individualized care.

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3. **Preconception Considerations:** Proactive planning about medical management should be done before conception. Genetic counseling and screening should be provided if desired.
4. **Peripartum and Postpartum Considerations:** The decision regarding mode of delivery should be based upon women's birth plans and obstetric indications. Breastfeeding should be cautiously considered depending on the need for pharmacological treatment.

Conclusions: This article provides a framework for managing PD before, during and after pregnancy. Collaborative efforts and ongoing registries like PregSpark* will be important to develop robust, evidence-based guidelines in this unique population.

Parkinson's disease (PD) is common and its prevalence is increasing worldwide.[1] The incidence of PD increases with age, but about 5–10% of patients are diagnosed before the age of 40.[2] Therefore, there will be many women with early onset Parkinson's disease (EOPD) who are considering pregnancy after their diagnosis, whether or not they are first-time mothers. Guidance on managing PD in women of childbearing age and particularly during pregnancy and the postpartum period is currently limited. Most information about pregnancy outcomes and medication safety is anecdotal or based on case series. The current lack of knowledge about the impact of pregnancy on PD (eg, effect on motor and non-motor symptoms and disease progression), the impact of PD on pregnancy (eg, safety of anti-Parkinson's drugs, challenges with common pregnancy problems such as nausea, constipation and low blood pressure) and the lack of evidence-based guidelines make effective pregnancy care and decisions about future pregnancies difficult for both clinicians and women with PD.[3,4] Pre-conception counseling and subsequent pregnancy and postpartum care for women with EOPD requires a multidisciplinary team including specialists in movement disorders, genetic counseling, obstetrics, neurosurgery, perinatal psychiatry, sleep disorders, pharmacology, obstetric anesthetics, neonatology, pain management, as well as specialist midwives, physiotherapists and social workers (Box 1 and 2).

Methods

The aim for this article was to provide pragmatic advice for common management issues (Fig. 1). This is a narrative review based on available literature and expert opinion. The recommendations were developed through a series of structured, iterative online meetings over several months. A initial targeted literature search was conducted by five authors (AL, JYL, GS, SP and DB) using PubMed, employing the search terms "pregnancy" AND "Parkinson's disease," with inclusion limited to studies published from 2019 onwards. References from these articles were also reviewed for additional relevant literature which was then included. The author group consists of a specifically composed subgroup of the Scientific Issue Committee and a subgroup of the EOPD study group of the MDS, the Women in Movement Disorders Special Interest Group and the team of PregSpark (www.PregSpark.com is a globally accessible online registry to collect data on pregnancy, delivery and birth outcomes in women with Parkinson's disease. Pregnant PD women all over the world can enroll at the website. Collected data are self-reported using web-based surveys and cover health history, health of the mother and the child during pregnancy, delivery and in the postpartum period with a 2 year follow up. The collected data will allow the development of evidence based guidelines concerning the periconceptional

TABLE 1 *Box*

Case 1
One of our patients is a 47-year-old woman. She had been diagnosed with PD at the age of 28 and genetic testing at the time was negative. In her late 30s she raised a desire to have children and started in vitro fertilization (IVF). At this point her medications (levodopa/carbidopa/entacapone and amantadine) were changed to levodopa/benserazide monotherapy due to drug safety considerations during pregnancy (which led to some worsening of her motor fluctuations). The woman did not have any detrimental effects of the IVF drugs on her PD motor or non-motor symptoms. The pregnancy was uneventful but due to the baby's size and the fact it was in breech position the decision was made for an elective caesarean section (CS). Birth was uneventful and the patient was able to care for her baby and able to breastfeed without any significant issues. Postnatally the patient had increasing issues with motor fluctuations and early wearing off and so she stopped breastfeeding after 4 months and restarted her preconception medication regime of levodopa/carbidopa/entacapone and amantadine. The patient underwent DBS surgery 17 months after having given birth. Since then, she rejoined the workforce as a teacher aide and raised her child independently. Her son is now 10 years old and healthy. He had normal early developmental milestones and developed normally.

TABLE 2 *Box*

Case 2

Another patient is a 28-year-old woman who presented 17 weeks into her third pregnancy with a several-year-history of upper limb tremors. At the time of review, she was not treated with any medication. The patient reported having difficulty with eating with knife and fork and with fine motor skills. She also reported worsening balance, without any falls. Brain imaging and screening blood tests were normal. Several typical parkinsonian features were noted on examination and the preliminary diagnosis of EOPD was made. In view of her current pregnancy the decision was made not to commence any new medication at the time. The patient gave birth to a healthy daughter via vaginal delivery at 39 weeks. After delivery she started breastfeeding her baby but although she reported a mild improvement to her motor symptoms post-partum she struggled to care for her baby due to her tremors and difficulty with fine motor skills. A 18F-Fluorodopa (FDOPA)-PET scan was performed 3 months after delivery confirming the diagnosis of PD. The patient received genetic counseling and is considering genetic testing. Six months after having given birth she was commenced on levodopa/benserazide monotherapy 100/25 mg three times a day and she continues to breastfeed. Her symptoms have improved markedly on treatment with her tremors, stiffness and bradykinesia being largely resolved. Now, 10 months after delivery her daughter is healthy and developing well with normal developmental milestones.

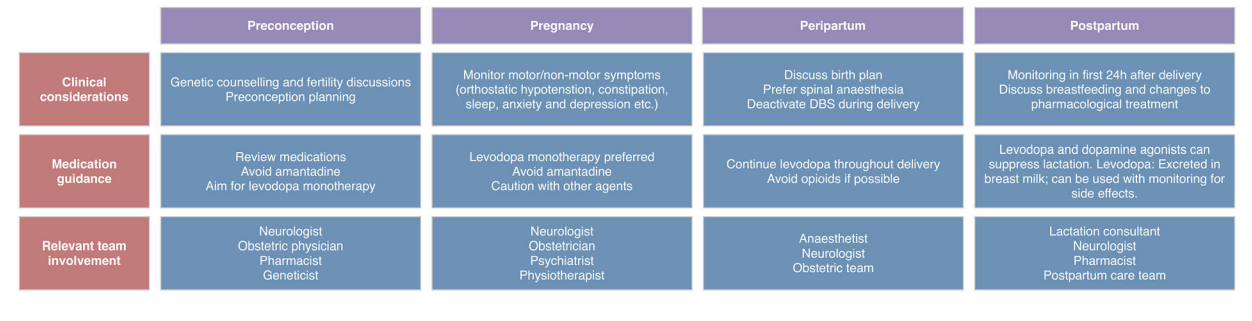

Figure 1. Management of Parkinson's disease in the perinatal period.

period, pregnancy, delivery, and breastfeeding in women with PD and provide these women with the information they need to be able to make an informed decision regarding (future) pregnancies), a recently established registry for Pregnancy in Parkinson's disease, persons with lived experience of EOPD, as well as specialists in obstetric medicine and perinatal neuropsychiatry. Two of the authors are also women with lived experience of early-onset Parkinson's disease. One was working in obstetric training at the time of diagnosis and now practices forensic medicine and works as a medical adviser; the other is a practicing obstetrician. Both provided unique insights that informed the framing of clinical recommendations and review of practical considerations during pregnancy, delivery, and postpartum care. Their participation ensured that lived experience informed not only the review content but also the tone and priorities of the guidance offered.

Results

Pre-Conceptional Care

Every consultation with a woman of reproductive age with PD represents an opportunity for discussion of preconception care, where desired. Pre-conception care for women with PD will vary from patient to patient but should follow some general recommendations. PD does not appear to impact fertility and is not associated with adverse pregnancy-specific outcomes.[5] No alteration to recommendations for preconception vitamins is required. A significant proportion of individuals with EOPD have detectable genetic variations.[6] Genetic counseling and screening should be made available to women concerned they may have a heritable form of PD to assist in making informed decisions regarding pregnancy. Where desired pre-implantation genetic screening with assisted fertility or post-conception fetal testing in utero may be considered.

Considerations Regarding Anti-Parkinsonian Medications Pre-Pregnancy

For planned pregnancies, proactive decisions should be made regarding which medications to continue and which to discontinue before conception.

TABLE 1 *Recommendations for anti-parkinsonian medication use in pregnancy and breast feeding (adapted from Seier et al,[10] García-Ramos et al[5] and Young et al[11] and updated with data from more recent case series and reports[12–14])*

Class of medications	Birth outcomes[a]	Breastfeeding[b]
Levodopa/carbidopa, Levodopa/benserazide	(>150 cases, >80% live birth excluding data without outcomes) easy adjustability and most effective drug during pregnancy. No significant increases in the rates of miscarriages, birth complications or teratogenesis, but reported neonatal seizure, placental abruption, ventricular septal defect (VSD), minor anomalies	• Excreted in milk • Can use, but may have to monitor potential side effects in infants
Dopamine agonists	(> 160 cases, >80% live birth excluding data without outcomes) Number of cases: pramipexole > carbergoline > bromicriptine > ropinirole > rotigotine > piribedil > pergolide > apomorphine placental abruption, neonatal seizure, VSD, premature infant	• Data too limited to make recommendation. Need to decide on case-by-case basis
Anticholinergics	Limited data (<10) reported no increasing rate of miscarriage, birth complications or teratogenesis	• Trihexyphenidyl excreted in milk • Data too limited to make recommendation Need to decide on case-by-case basis
Amantadine	Teratogenesis (cardiovascular malformation) = > contraindicated	• Excreted in milk • Not recommended
COMT inhibitors	Limited data (<10) Among the five live birth, one neonatal seizure, PPROM for twin (one VSD) No data for opicapone	• May be excreted in breast milk (opicapone)Data too limited to make recommendation Need to decide on case-by-case basis
MAOB inhibitors	Limited data (<10) PPROM and VSD in one twin (selegiline), one neonatal death due to liver enzyme deficiency (rasagiline) No report for safinamide	• Data too limited to make recommendation Need to decide on case-by-case basis

[a]For most anti-parkinsonian drugs even including levodopa, animal reproduction studies showed some adverse effects on fetus, but there are no adequate human studies on pregnant women.
[b]All anti-parkinsonian medications can suppress lactation.

No systematic studies have been conducted on the use of anti-PD medications during and after pregnancy in patients with PD. Evidence regarding the safety of anti-PD medications during pregnancy and breastfeeding is limited, as the literature primarily consists of case reports and case series. Food and Drug Administration classifications may be misleading with respect to medication safety in pregnancy and with breastfeeding. The TERIS database (and for Francophones the CRAT database) may be a useful guide regarding risk of teratogenesis.[7,8] A reference that is currently available in its 12th edition is *Brigg's Drugs in Pregnancy and Lactation: A Reference Guide to Fetal and Neonatal Risk*.[9] Advice from specialists in obstetric pharmacology, and literature searches of Medline and Google Scholar, may be valuable in enabling women to make informed decisions regarding the safety of medications.

Levodopa is the most widely used drug during pregnancy. Levodopa/carbidopa or levodopa/benserazide have both good safety data during pregnancy and generally should be the first line treatment.[5] The available data is more limited around the use of dopamine agonists, MAO-B inhibitors, or anticholinergics during pregnancy, but no significant risk increase was observed with these drugs (see Table 1).

So far no data are available regarding the safety of opicapone during pregnancy and only case-reports are available regarding the use of entacapone.[15,16] Amantadine has shown teratogenicity with maternal exposure during the first trimester of pregnancy, so should be avoided.[17] No published data are available regarding the use of continuous subcutaneous infusions with apomorphine or foslevodopa-foscarbidopa, and only one case report was published regarding a patient having received a continuous intestinal infusion of levodopa-carbidopa intestinal gel during pregnancy.[18]

We recommend individualized and tailored approaches in prescribing anti-PD medication in this patient group. For patients with very early-stage disease who are on no pharmacological treatment or treated with only a MAO-B-inhibitor or anticholinergic medication, further pharmacological treatment might be able to be delayed until the end of the pregnancy. In patients who are well managed with levodopa monotherapy or combined dopaminergic medications, we suggest keeping the anti-PD medications stable and adjust dosing/frequency depending on clinical need. Amantadine is contraindicated. Considering the principles in the management of chronic neurological conditions during pregnancy, monotherapy is generally preferred to

polypharmacy. Fertility treatments, if needed, and the cessation of contraception may require additional adjustments due to the impact of hormone levels on PD symptoms.[19,20]

Exercise Prescription in PD and Pregnancy

Aerobic, resistance and mind–body exercises improve gait stability, postural control, balance, sleep and cognitive function in individuals with PD.[21,22] Moderate-intensity physical activity is safe in pregnancy and provides improvements in maternal and fetal health, and reductions in pregnancy-related complications including hypertensive disorders of pregnancy, risk of developing gestational diabetes mellitus, risk of fetal macrosomia, avoidance of excessive weight gain, and reduction in musculoskeletal pain and discomfort.[23] Society guidelines recommend prescription of at least 30 minutes of moderate-intensity aerobic or strength conditioning exercise for at least five to seven days per week.[24] Before starting exercise, consulting specialists in neurological physiotherapy is recommended to assist women in making informed and personalized decisions about the safety of different exercise modalities, doses, and intensities during pregnancy and postpartum. Compared to land-based therapy, aquatic therapy showed specific benefits in quality of life, mental health, pain, flexibility and sleep quality in individuals with PD, and has been shown to have positive effects in the general population in pregnancy in preventing maternal weight gain, improving back pain, preventing maternal depression and improving glucose tolerance.[25,26] Functional training and pilates are effective in improving cognition, depressive symptoms, anxiety, and happiness in individuals with PD.[27] Pilates is effective in improving sleep quality, pain, depression and physical mobility in pregnancy in the general population.[28,29] Delivery of exercise and cognitive behavior sessions via telemedicine significantly improved total motor symptoms, cognitive function, depressive symptoms, anxiety symptoms and may be an useful adjunct in managing women with PD in pregnancy.[30]

Specific Issues in the Management of Non-motor Symptoms

Pre-conception counseling provides an opportunity for discussion of the potential influence of pregnancy on the non-motor clinical manifestations of EOPD, including cardiac, gastrointestinal and genitourinary dysautonomia, pain, sleep and neuropsychiatric disorders. Physiological changes in pregnancy may result in worsening of upper and lower gastroparesis, predisposing to nausea, vomiting, gastrooesophageal reflux and constipation. Peripheral vasodilation may cause increased severity of orthostatic hypotension, particularly in the second trimester.[31] Women should be reassured that orthostatic hypotension has not been shown to result in adverse fetal or neonatal outcomes.[32] Genitourinary symptoms suggestive of neurogenic bladder or urine retention due to anti-PD medications are important given the adverse fetal and maternal outcomes associated with urinary tract infection in pregnancy.[33] Pregnancy may be associated with exacerbation of hyperhidrosis (especially in third trimester), seborrheic dermatitis, and ptyalism/sialorrhoea.[34] Pregnancy is associated with increased prevalence of, and increased severity of existing obstructive sleep apnoea (OSA). OSA is associated with significantly increased risk of adverse pregnancy outcomes including hypertensive disorders of pregnancy, eclampsia, fetal growth restriction and stillbirth.[35] Screening tests for OSA should be considered in pre-conception counseling, and polysomnography performed where suggestive of sleep-disordered breathing. Maintenance of a healthy weight is important to reduce the risk of hypertensive disorders of pregnancy, OSA, gestational diabetes mellitus and teratogenesis.

Health professionals should also specifically enquire regarding the possible use of complementary therapies given that it is estimated that 40% of PD individuals use such therapies without disclosure, and the potential for adulteration with teratogenic or fetotoxic substances.[36]

Deep Brain Stimulation and Pregnancy Management

Deep Brain Stimulation (DBS) is a well-established treatment option for advanced PD, improving motor symptoms, reducing daily fluctuations and allowing for reductions in dopaminergic medication.[37] Recent studies like the EARLY STIM trial showed the efficacy of DBS not only in advanced PD but also at earlier stages of the disease.[38] Therefore, DBS therapy is being offered to an increasing number of PD women in their reproductive period, with the aim to reduce or discontinue anti-PD medication, and to reduce fetal exposure to medication.[39] Unfortunately, scarce data are available regarding the safety of DBS during pregnancy.[40–43] Moreover, there are no studies regarding DBS's effects on lactation and future fertility. Previous studies, which evaluated effects and safety of DBS for movement disorders (MDs), excluded pregnant and breastfeeding women, as well as females of childbearing age not using adequate contraception.[41] Reviews on the topic included several different MDs, without a specific focus on the PD population, revealing the lack of detailed clinical information on DBS parkinsonian patients before, during and after pregnancy.[40–43] There are no studies related to the fact that during pregnancy there is a specific hormone production which stimulates GABA-like activity with a possible, direct influence on dopaminergic networks.[41] Therefore, pregnant patients might require a specific setting of the stimulation to achieve a satisfactory therapeutic effect.

A review of the available data, which summarize clinical evidence for pregnancy management during DBS, can be found in Table 2 and Table S1.

Until now, only three PD patients, affected by PRKN variants with bilateral subthalamic nucleus (STN) DBS before pregnancy, who then were followed during their pregnancies have been described.[40,43] During pregnancy, two patients discontinued pharmacological treatment without any significant clinical worsening or

TABLE 2 *Demographic and clinical characteristics of patients affected by Movement Disorders (and Parkinson's disease, in brackets), who experienced pregnancy after Deep Brain Stimulation implantation*

Authors	*n.* patients (n. PD)	Disease	Age at onset	Age at DBS	Age at delivery
Scelzo E et al 2015[40] *Smilowska K* et al 2024[43]	11 (3)	PRKN variant Parkin mutation PD	19	35	37
		PRKN variant Parkin mutation PD	14	30	33
		PRKN variant Parkin mutation PD	18	39	43
King C et al 2022[41]	27 (3)	3 PD (Scelzo et al 2015 series)			
Baláž M et al 2023[42]	26 (3)	3 PD (Scelzo et al 2015 series)			

	Scale scores (UPDRS-ME)						Medical treatment			STN-DBS parameter changes
	Before DBS		After DBS (bilateral STN)							
Authors	Med off	Med on	Med off, Stim off	Med off, Stim on	Med on, Stim off	Med on, Stim on	Before pregnancy	During pregnancy	After pregnancy	During pregnancy
Scelzo E et al 2015[40] Smilowska K et al 2024[43]	42/108	19/108	43/108	28/108	15/108	9/108	Pramipexole CR 1.05 mg Rasagiline 1 mg	No	Pramipexole CR 1.05 mg Rasagiline 1 mg	No
	29/108	5/108	39/108	24/108	27/108	11/108	Ropinirole 14 mg	Levodopa 200 mg	Ropinirole 10 mg	No
	30/108	4/108	35/108	19/108	8/108	4/108	Rasagiline 1 mg Ropinirole 2 mg Trihexyphenidyl 150 mg	On medication from the 6 months of pregnancy: Rasagiline 1 mg Ropinirole 2 mg Trihexyphenidyl 150 mg	Rasagiline 1 mg Ropinirole 2 mg Trihexyphenidyl 150 mg	No
King C et al 2022[41]	Previous reported data									
Baláž M et al 2023[42]	Previous reported data									

Abbreviations: BS, deep brain stimulation; Med, medication; PD, Parkinson's disease; Stim, stimulation; STN, subthalamic nucleus; UPDRS-ME, Unified Parkinson's Disease Rating Scale Motor Exam.

TABLE 3 *Practical advice for the management of patients with Parkinson's disease who are managed with Deep Brain Stimulation before, during and after pregnancy from a multidisciplinary point of view*

	Before pregnancy	During pregnancy/Delivery	After pregnancy
Movement disorders specialists	Consider DBS at early stages of PD for women at childbearing age Offer genetic counseling to establish DBS effectiveness Plan generator battery checks to avoid sudden depletion of battery or replacement during pregnancy Adequate pregnancy planning	Reducing or discontinuing antiparkinsonian medication Re-programming can be performed if the clinical conditions require it Switching off the stimulator during delivery (because of possible interferences in cardiac monitoring of both mother and baby) Neurological review within 24 hours of delivery	Reintroducing antiparkinsonian medication or increasing dosage No contraindications for breastfeeding in DBS PD patients
Neurosurgeons	Choice of infraclavicular generator placement Choice of rechargeable devices Weight control for preventing generator placement discomfort		
Obstetricians	Adequate pregnancy planned	Vaginal delivery encouraged Vaginal delivery or C-section switching off the stimulator (because of possible interferences in cardiac monitoring of both mother and baby) In case of C-section, bipolar hemostasis is preferable C-section should be performed at least 15 cm away from the implanted generator, connecting cables and intracerebral electrodes for preventing injuries and current spreading Ultrasound diathermy is contraindicated Obstetric high-dependency monitoring	Breastfeeding can be encouraged
Anesthetists	Adequate pregnancy planned	Spinal anesthesia rather than general anesthesia during delivery is advisable	

Abbreviations: C-section, caesarean section; DBS, deep brain stimulation; PD, Parkinson's disease.

impact on baby's health. In all these cases no adverse effects were observed during pregnancy, and in only one case caesarean section was performed at term for obstetric indications. Motor function remained stable postpartum. The available data encourages a multidisciplinary team approach to provide clinical advice for the management of DBS PD patients during the fertility period. Therefore, practical advice from a multidisciplinary point of view is proposed here to help clinicians in the management of this crucial period in a PD patients' life (Table 3).

MD specialists and neurosurgeons should encourage the choice of rechargeable devices before DBS implantation in young women with potential pregnancies to avoid battery replacement during the pregnancy period. In the case of planned pregnancy, the anticipation of early battery replacement could be helpful for preventing surgical complications.

Pregnancy Care

Managing Motor Symptoms during Pregnancy

Motor symptoms of PD can vary during pregnancy, with many women having either improvement or worsening of motor symptoms and/or motor complications during and after pregnancy.[44] Estrogen appears to have a neuroprotective and dopaminergic effect in PD: thus hormonal changes during pregnancy may have beneficial motor effect for PD. [10] There are several other factors (fluid/volume changes, changes in sleep pattern etc.) that influence motor control of PD during pregnancy, but sub-optimal medication management is likely the biggest factor.[10,45,46] Pregnancy complications such as hyperemesis and constipation, as well as fear of increasing/changing medication regimen due to safety concerns, both contribute to difficulty in achieving the optimal pharmacotherapy to control motor symptoms during pregnancy.

For patients with motor complications, the addition of a COMT inhibitor or an advanced therapy might have to be considered. Due to their limited safety data (as outlined above) these decisions have to be made on a case-by-case basis.

Rehabilitation and exercise are crucial for managing PD and this is also the case during pregnancy for both physical and emotional well-being. Regular physiotherapy effectively addresses symptoms such as stiffness and balance issues, enhancing mobility and daily functioning.[47,48] While data is limited, women with PD can exercise during pregnancy if there are no complications, although some modifications to the exercise routine may be necessary. Effective communication among neurologists, obstetricians, and gynecologists is essential for coordinated rehabilitation care.

Management of Non-motor Symptoms during Pregnancy

Safety of medications for non-motor manifestations in pregnancy and breastfeeding can be found in Table 4.

Management of Anemia

Anemia is common during pregnancy. Approximately half of women in the general community treated with oral iron supplementation have adverse gastrointestinal side-effects. These symptoms may be more common/severe in PD due to gastroparesis or anti-PD medications. It is also important to know that iron, particularly when orally absorbed, may interfere with levodopa efficacy.[61] There should be a low threshold for iron infusions for anemia and restless legs syndrome in the setting of iron deficiency. Ferric carboxymaltose infusions have a more rapid response than oral iron, with a low risk of anaphylactic reactions (~ 1:200000 infusions). In women intolerant of oral iron, and not wishing to have iron infusion, lactoferrin treatment may be an alternative.

Management of Constipation

Managing constipation during pregnancy for women with PD can be complicated by overlapping challenges posed by gastroparesis, effects of anti-PD medications and iron supplements. Increasing dietary fiber, fiber supplements such as psyllium, adequate intake of fluids (>1.5 l/day), and maintenance of physical activity may be helpful. Where lifestyle interventions are inadequate, treatment with bisacodyl, lactulose and docusate are all safe and effective during pregnancy.[50] As a first step, osmotic agents like Macrogol (PEG 3350) are commonly used. Bulking agents and stimulant laxatives like bisacodyl can also be used to enhance bowel movements.

Management of Nausea and Vomiting

Nausea and vomiting are common symptoms during pregnancy, particularly in the first and second trimesters. Where persistent and severe this may result in weight loss, intravascular volume depletion, electrolyte imbalances, acid–base disturbances, and nutrient deficiencies including thiamine. Nausea and vomiting may be aggravated or precipitated by dopaminergic medications, gastroparesis and iron supplements. Managing these symptoms effectively in pregnant patients with PD is crucial to ensure effective absorption of dopaminergic medications, and avoid parkinsonism-hyperpyrexia syndrome due to sudden withdrawal of therapy.

Women with nausea and vomiting should be advised to take smaller, more frequent meals, and take medications with food, juice or jelly, and address and treat constipation.

Metoclopramide and prochlorperazine should be avoided in patients with PD as they can exacerbate motor symptoms. Domperidone (not available in the United States) orally is suggested as first line treatment in this patient group (caution: QT prolongation risk), and ondansetron sublingually or intravenously for severe cases. The concomitant use of ondansetron with apomorphine should be avoided due to an increase in the risk of severe hypotension. Proton-pump inhibitors may be used safely in managing gastro-esophageal reflux.[53] Further investigation of nausea and vomiting is not indicated in the absence of marked weight loss, dysphagia, severe anemia or haematemesis. For guidance on investigations in severe nausea and vomiting cases, refer to the guidelines by the Royal College of Obstetricians and Gynecologists.[62]

Management of Orthostatic Hypotension

Orthostatic hypotension (OH) is common in PD due to autonomic dysfunction and can be exacerbated by dopaminergic medications. During pregnancy, the physiological changes of peripheral vasodilation and fall in blood pressure can further challenge cardiovascular stability.[31] Non-pharmacological interventions should be used as the first line of management. These

TABLE 4 *Safety of medications for non-motor manifestations in pregnancy and breastfeeding*

Condition	Medication	Safety in pregnancy	Safety in Lactation
Anemia	Iron	Benefits outweigh risks[49]	Safe
Constipation	Bisacodyl	No increase adverse pregnancy outcomes[50]	Safe
	Lactulose	No increase adverse pregnancy outcomes[50]	Safe
	Docusate	No increase adverse pregnancy outcomes[50]	Safe
	Macrogol	No increase adverse pregnancy outcomes[50]	Safe
Nausea and Vomiting	Domperidone	No increase adverse pregnancy outcomes[51]	Safe
	Ondansetron	No increase adverse pregnancy outcomes[52]	Safe
	Prednisolone	No increase adverse pregnancy outcomes other than maternal glucose intolerance	Safe—usually cease postpartum
	Proton pump inhibitors	No increase adverse pregnancy outcomes[53]	Safe—usually cease postpartum
Orthostatic Hypotension	Fludrocortisone	No increase adverse pregnancy outcomes other than maternal oedema and hypokalaemia	Safe
	Midodrine	Two case reports only	Unknown
	Droxidopa	Unknown	Unknown
	Erythropoietin (with anemia)	No increase adverse pregnancy outcomes other than risk of maternal hypertension	Safe
	Pyridostigmine	No increase adverse pregnancy outcomes	Safe
Fatigue	Modafinil	Tendency toward lower birthweight and reduced neonatal head circumference[54]	Use with caution
Anxiety and depression	Tricyclic antidepressants	No increase adverse pregnancy outcomes; possible link to preterm delivery, small gestational age (confounded by anxiety/depression risks)	Safe—care with preterm infants; risk of postural hypotension, urine retention
	Mirtazapine	No increase adverse pregnancy outcomes other than neonatal adaptation syndrome[55]	Safe
	SSRIs	Avoid paroxetine—increased risk of major congenital malformations; otherwise no evidence of increased risk. Neonatal abstinence syndrome in 30%.[56]	Safe; possible link to preterm delivery, small gestational age (confounded by anxiety/depression risks)
Psychosis	Antipsychotic drugs	No increased risk of major congenital anomalies or other fetal issues.[57] Cave risk of agranulocytosis with Clozapine.[58]	Safe
Ptyalism/Sialorrhoea, Hyperhidrosis	Clonidine (oral)	No increase adverse pregnancy outcomes except potential for neonatal withdrawal; Extensive use in hypertension management	High levels in breast milk—avoid
	Onabotulinumtoxin A	No increase adverse pregnancy outcomes[59,60]	Safe
Hypertension	ACEi and ARBs	Likely not teratogenic, fetotoxic; contraindicated in 2nd and 3rd trimester; reasonable pre-conception with informed discussion	Captopril, enalapril, quinapril, candesartan safe; cease when pregnancy confirmed
	Alpha-methyldopa, nifedipine, labetalol	Safe	Safe
	Hydralazine, verapamil	Safe	Safe

(Continues)

TABLE 4 *Continued*

Condition	Medication	Safety in pregnancy	Safety in Lactation
Chronic Pain	Paracetamol	Safe	Safe
	NSAIDs	Not teratogenic; use sparingly in first trimester; contraindicated after 28 weeks' gestation—risk of premature closure of ductus arteriosus	Best choices: ibuprofen and diclofenac
	Pregabalin	Possible increased risk of major congenital malformations—avoid in first trimester; not associated with preterm birth, SGA, autism spectrum disorder, intellectual disability	Limited data; low levels in breast milk—not a reason to stop breastfeeding
	Lamotrigine	Safe	Safe—monitor infant for rash, drowsiness, withdrawal
	Lamotrigine	Safe	Safe—monitor infant for rash, drowsiness, withdrawal

Abbreviations: ACEi, angiotensin converting enzyme inhibitors; ARB, angiotensin II receptor blockers; SSRIs, selective serotonin reuptake inhibitors.

include advising patients to rise slowly from sitting or lying positions, elevating the head of their bed by 30–45 degrees (anti-Trendelenburg position), increasing fluid and salt intake, avoiding Valsalva-like maneuvers, and take care with exposure to heat (eg, showers, weather). The rapid ingestion of fluid (~ 500 ml of tap water in less than 5 min) has a rapid pressor effect and should be considered before getting out of bed and at intervals during the day.[63] Caffeine may be associated with adverse pregnancy outcomes, and the safe amount for intake in pregnancy has not been defined.[64,65] Regular, gentle physical activity can also help improve cardiovascular function and reduce symptoms of OH. Compression stockings are ineffective as most of the blood volume pools in the splanchnic circulation and abdominal binders are contraindicated in pregnancy.[66,67]

Fludrocortisone may be safely used in pregnancy; however, efficacy may be limited, and complicated by supine hypertension, peripheral oedema and hypokalaemia.[68,69] Only two case reports describe the safe use of midodrine in human pregnancy, and there is no published literature regarding the use of droxidopa in pregnancy.[70,71] Erythropoietin deficiency should be considered in women with orthostatic hypotension and anemia, and treatment may be associated with improvements in both postural hypotension and hemoglobin.[72,73] Pyridostigmine does not cross the placenta in significant amounts and may be safely used in pregnancy, though dosage adjustment may be required as a result of increased renal clearance and expanded maternal blood volume.[74] Dopaminergic medications should be reviewed and rationalized as they contribute to the development of orthostatic hypotension.

Management of Fatigue

Fatigue is a common and sometimes debilitating symptom in Parkinson's disease, often exacerbated by the physiological demands of pregnancy. Non-pharmacological strategies can be helpful, particularly in mild to moderate cases: This includes optimizing sleep hygiene, encouraging regular, moderate physical activity, implementing structured rest periods throughout the day and ensuring good nutrition. Previous studies regarding the safety of modafinil have revealed conflicting data regarding the risk of teratogenesis. A recent multicentre case series of the European Network of Teratology Information Services reported no increased risk of major congenital malformations with first trimester exposure in 173 prospectively ascertained cases, though there was a tendency toward lower birthweight and reduced neonatal head circumference.[54] The authors advised against the use of modafinil in pregnancy until further studies allowed for a definite conclusion.

Management of Anxiety and Depression

Anxiety and depression are the most common psychiatric disorders during pregnancy, and they have a major impact on quality of life and a range of child outcomes.[75] They are also the most common mood disorders that affect patients with PD thus appropriate diagnosis and management is paramount.[76]

Managing mood disorders during pregnancy with PD involves addressing both the neurological and psychiatric aspects of their condition. Early detection is important and can be facilitated through regular screenings and open, empathetic communication. Establishing a trusting relationship with your patient encourages honest discussions about mental health. Utilizing validated screening tools, such as the Edinburgh Postnatal Depression Scale can help identify symptoms early.[77] Once identified, a comprehensive care plan should be developed by the multidisciplinary team. This team-based approach ensures holistic care, addressing both physical and mental health needs specific to PD .

Interventions should be tailored to the individual, considering the severity of symptoms, the progression of PD, and the patient's preferences. Non-pharmacological treatments, such as cognitive-behavioral therapy and mindfulness-based stress reduction (MBSR), have shown efficacy in managing anxiety and depression during pregnancy and should be considered for women with PD.[78–80] These therapies can be complemented by

lifestyle modifications, including regular physical activity, balanced nutrition, and adequate sleep, tailored to the capabilities and needs of someone with PD .

In cases where medication is necessary, the benefits and risks need to be assessed carefully, considering the safety profiles of the various psychotropic medications during pregnancy. The use of tricyclic antidepressants (TCAs) and mirtazapine during pregnancy does not appear to result in significant adverse effects on the embryo or fetus. Most studies on the use of SSRIs during pregnancy, particularly the recent large-scale population-based research,[55,57] indicate that they are relatively safe.[81] The initiation of psychotropic medication, especially for this complex subgroup of patients, should be undertaken only in close collaboration with a team of health professionals experienced in managing mental health issues during pregnancy. Ongoing monitoring and follow-up are crucial, as both mental health and Parkinson's motor symptoms can change rapidly during pregnancy. Also, neonatal abstinence syndrome occurs in 30% of neonates exposed to SSRIs in utero.[56] Providing a supportive environment and ensuring the patient feels heard and understood can significantly mitigate anxiety and depression, promoting a healthier pregnancy outcome for women with PD. For helpful advice regarding the management of mental health in the perinatal period please see guidelines by the Centre of Perinatal Excellence (COPE) or the National Institute for Health and Care Excellence (NICE).[58,82]

Management of Psychosis

Managing psychosis in patients with PD during the perinatal period requires a nuanced and multidisciplinary approach to ensure the well-being of both the mother and the developing fetus. Psychosis in PD, often manifesting as hallucinations or delusions, can be exacerbated by dopaminergic medications or the disease itself. During the perinatal period, the balance between treating psychosis and maintaining optimal motor function becomes even more important. Untreated psychosis is associated with relapse and adverse effects on pregnancy (eg, stillbirth, poor antenatal attendance).[58] Prenatal exposure to antipsychotic drugs does not appear to elevate the risk of major congenital anomalies or other fetal issues.[57]

In the management of psychosis, non-pharmacological interventions should be prioritized initially, including behavioral strategies, environmental modifications to reduce stress, and ensuring adequate sleep hygiene. Regular monitoring of mental health status and open communication with the patient about symptom changes are important. When pharmacological treatment is necessary, the choice of antipsychotic medication must carefully consider both efficacy and safety profiles during pregnancy and postpartum. Second-generation antipsychotics, such as quetiapine, are generally preferred in patients with PD due to their safety profiles and lower risk of exacerbating symptoms.[57,83,84] Clozapine may be considered in treatment-resistant cases but requires close monitoring due to potential side effects like agranulocytosis.[58] Collaboration with a multidisciplinary team is crucial to ensure comprehensive care. Regular fetal monitoring and frequent follow-up visits are necessary to adjust treatment plans based on the patient's response and the progression of pregnancy.

Peripartum Care

The decision regarding mode of delivery should be based upon obstetric indications and in accordance with a birth plan, when possible.[11] Cooling of the room may be of benefit in women with orthostatic hypotension or hyperhidrosis.[67] Administration of oral levodopa should continue throughout the process of vaginal delivery, taking into consideration additional doses of levodopa that woman may routinely self-administer.[85] Spinal anesthesia is safe in patients with PD, and should be used whenever possible rather than general anesthesia for CS to minimize cerebral effects of anesthesia, reduce the risk of aspiration, improve pain control, avoid respiratory depression and minimize effects on pulmonary function.[86–88] This also allows continued administration of oral anti-PD medication peripartum, enables communication with the woman, avoids surgical site infection, reduces the risk of thromboembolism, and enables early mobilization postpartum.[87,89]

PD-related tremor may interfere with monitoring basic signs such as pulse oximetry.[87] Close monitoring is required to detect autonomic cardiovascular instability, particularly with neuraxial anesthesia. Care is required with opioids, especially fentanyl, as they may cause muscle rigidity and acute dystonic reactions in individuals with PD.[86] Inhalational anesthetics such as halothane may lead to arrythmias in women taking levodopa.[90] Ondansetron may be used to manage nausea and vomiting. If ileus occurs following caesarean delivery levodopa should be delivered via a duodenal feeding tube given absorption occurs in the small bowel, and gastric feeding tubes may be suboptimal due to delayed gastric emptying.

In women with DBS it is recommended that stimulation be switched off during both vaginal delivery and CS to avoid interference in monitoring for the mother and fetus. Where CS is required for obstetric indications, bipolar coagulation should be performed at least 15 cm away from the implanted generator to avoid potential damage to DBS systems.[42]

Postpartum Care

Obstetric high-dependency monitoring and neurological evaluation within 24 hours of delivery are recommended.[11] Non-steroidal anti-inflammatory medications may be used for analgesia postpartum to avoid opioid use, and are suitable for breastfeeding, though the mother needs to be monitored for precipitation of hypertension. Ibuprofen and diclofenac are the best choices for breastfeeding because of their short half-life.

Levodopa and dopamine agonists may suppress lactation through reduction of prolactin levels. In women desirous of breastfeeding involvement of a lactation consultant around

36 weeks' gestation may be useful. Domperidone may be used to increase milk supply.[91]

Breast-fed infants were estimated to receive approximately 0.3% and 0.5% of the maternal weight adjusted dosage of levodopa with sustained release and immediate release preparations, respectively.[92] No adverse effects were noted in breastfed infants whose mothers were receiving levodopa though data is very limited.[10]

A single case found no selegiline in blood from an exclusively breastfed infant whose mother was using a 6 mg selegiline patch daily.[93] Another single case described a woman who took selegiline 10 mg, levodopa 400 mg and benserazide 100 mg daily throughout pregnancy and continued them while breastfeeding her infant for 3 days. The child was followed for 10 years and no developmental abnormalities were found.[94] There is no published data regarding lactation with maternal therapy with apomorphine, other MAO B inhibitors, non-ergot dopamine agonists, amantadine or anticholinergics. Breastfeeding does not appear to be affected by DBS and may be practiced safely.

In view of the limited data available on the potential risks of anti-PD medication exposure to infants, women should be provided with the available information to make an informed decision regarding breastfeeding. If breastfeeding is desired in a patient requiring pharmacological treatment we would recommend levodopa/benzerazide or levodopa/carbidopa monotherapy. If other agents are required for the management of motor symptoms, then cessation of breastfeeding should be considered. For further information the LactMed database is a helpful resource.[95] It offers detailed information on drugs and chemicals that breastfeeding mothers may encounter and provides data on the concentrations of these substances in breast milk and the blood of infants, along with potential adverse effects on nursing infants.

Imaging during the Perinatal Period

In certain clinical scenarios, radiological imaging during the perinatal period may be considered for women with PD. Magnetic resonance imaging (MRI) without contrast utilizing a magnet strength of 3 Tesla or less is not associated with increased risk of harm to the fetus or in early childhood. Gadolinium should be avoided given in pregnancy as it is associated with an increased risk of stillbirth and neonatal death, as well as childhood rheumatological, inflammatory and infiltrative skin conditions.[96]

Imaging utilizing ionizing radiation should only be used if the potential information gained outweighs any risk to the fetus. The background environmental radiation exposure to the fetus during pregnancy is estimated to be 0.5–1 micro-Gray (mGy). Except for the potential increased risk of later childhood malignancy with fetal exposure to greater than 10 mGy, exposure to less than 50 mGy of ionizing radiation at any gestation is associated with negligible additional risk to the fetus. The thresholds for fetal radiation exposure resulting in increased risks of adverse outcomes, and estimated fetal exposures with maternal cerebral imaging in pregnancy are summarized in supplementary Table S2.

While there is no published data regarding the fetal exposure to radiation with dopamine transporter scans, no cases of mental retardation, childhood cancer or malformation were reported following maternal PET-CT examinations performed for cancer during pregnancy, for outcomes data from 46 children at 6 months of age, 29 at 12 months of age, and 15 at 24 months of age.[100]

Where imaging involving ionizing radiation is to be performed in breastfeeding women, an adequate amount of breastmilk should be expressed prior to the procedure to cover the period during which breastfeeding should be withheld (usually 6–24 h), the duration guided by advice from the radiologist performing the imaging.

Conclusion

With input from a diverse group of interdisciplinary experts and women living with Parkinson's disease, this review provides pragmatic guidance on managing PD before, during, and after pregnancy. While limited data currently exist, our findings suggest that with appropriate planning and multidisciplinary care, women with PD can safely navigate pregnancy, childbirth, and breastfeeding. The recommendations outlined here serve as a framework to support clinical decision-making, ensuring that patients receive individualized and evidence-informed care.

However, significant knowledge gaps remain, particularly regarding the safety of newer anti-PD medications, the impact of maternal PD on child development and the long-term effects of pregnancy on PD progression. Addressing these gaps requires global collaboration and systematic data collection. The recently established PregSpark registry provides an opportunity to generate robust, real-world evidence that will ultimately inform future guidelines and improve care for this unique patient population.

We strongly encourage movement disorder specialists, obstetricians, and all healthcare professionals involved in the care of women with PD to utilize this registry and actively guide their patients toward participation. Only through a collective international effort can we refine our understanding and provide women with the comprehensive, evidence-based guidance they need to make informed decisions about their reproductive health.

Author Roles

A. Conception, B. Literature review, C. Writing of the first draft, D. Review and Critique.

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Data sharing not applicable to this article as no datasets were generated or analysed during the current study. ■

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Supporting Information

Supporting information may be found in the online version of this article.

Table S1. Pregnancy features of patients affected by Parkinson's disease before and after Deep Brain Stimulation

Table S2. Estimated radiation thresholds for fetal injury, and fetal exposures with imaging procedures involving ionizing radiation in pregnancy[97–99]