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Clinical Outcomes of Pregnancy in Women with Advanced Chronic Kidney Disease and on Dialysis: A Shared Decision-Making and Multidisciplinary Precision Management Approach

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Abstract

Introduction: Pregnancy in women with chronic kidney disease (CKD) stage 4–5 or those receiving dialysis is associated with substantial maternal and fetal risks. Although guidelines recommend multidisciplinary team (MDT) management and shared decision-making (SDM), data on clinical implementation remain scarce, particularly in developing countries.

Methods: A retrospective analysis included 25 pregnant women with CKD stage 4–5 or on maintenance dialysis (September 2019–July 2025), categorized as CKD stage 4–5 without dialysis (n = 10) or pregnancy on dialysis (n = 15). A dynamic, cyclic SDM-based precision MDT model was implemented via a hybrid online/offline approach.

Results: Among 11 patients receiving comprehensive MDT management, the live birth rate was 100%, with no maternal or perinatal mortality. In the dialysis group (n = 5), the mean gestational age was 33.97 ± 1.16 weeks, and the mean birth weight was 1876 ± 356.27 g. Weekly dialysis duration increased from 11.1 ± 2.01 to 37.6 ± 2.19 hours, hemoglobin levels improved from 87.04 ± 8.84 to 101.3 ± 7.23 g/L, and blood urea nitrogen decreased from 15.86 ± 5.75 to 11.67 ± 2.98 mmol/L. In the CKD 4–5 group (n = 6), the mean gestational age was 33.76 ± 1.11 weeks, and the mean birth weight was 1758.33 ± 262.02 g. Half required dialysis initiation during pregnancy (mean 28.4 weeks), without severe adverse outcomes.

Conclusions: An SDM-based MDT precision model effectively improves pregnancy outcomes in women with advanced CKD or on dialysis. The hybrid approach facilitates broader implementation across regions.

Key Learning Points

What was known:

1) Pregnancy in women with chronic kidney disease (CKD) stage 4–5 or those receiving dialysis is associated with significantly increased risks of maternal complications and adverse perinatal outcomes, and was historically regarded as contraindicated.

2) Intensified hemodialysis (at least 36 hours per week) substantially improves live birth rates, with evidence from developed countries indicating rates above 85%.

3) International guidelines recommend MDT management and shared decision-making, yet clinical implementation data-especially from developing countries—remain scarce.

This study adds:

1) A dynamic, cyclic shared decision-making (SDM) model that integrates six iterative phases (assessment, decision-making, precision management, reassessment, revised decision, and adjusted management) achieves a 100% live birth rate among comprehensively managed patients.

2) Pregnancy outcomes, including gestational age at delivery and neonatal birth weight, in a non-metropolitan Chinese center are comparable to those reported in developed countries.

3) A hybrid online-offline MDT approach can overcome geographical barriers and extend high-quality pregnancy care to patients in resource-limited settings.

Potential impact:

1) CKD stage 4–5 and dialysis should not be regarded as absolute contraindications to pregnancy. SDM-based MDT care should be provided to all women seeking reproductive counseling.

2) Intensified dialysis with individualized initiation timing, guided by fetal growth trajectory rather than solely by biochemical thresholds, should be incorporated into routine obstetric and nephrology practice.

3) Telemedicine-supported MDT models can reduce regional disparities in high-risk pregnancy care and provide a replicable framework for healthcare systems in developing countries.

Introduction

Chronic kidney disease (CKD) has emerged as a major global public health concern, and pregnancy-related issues are becoming increasingly prominent as the prevalence of CKD rises among women of reproductive age [1]. For women with CKD stage 4–5 or dialysis dependence, pregnancy has historically been considered contraindicated owing to markedly elevated risks of maternal complications (including severe preeclampsia and irreversible deterioration of renal function) and adverse perinatal outcomes (such as preterm birth, fetal growth restriction, stillbirth, and neonatal death) [2, 3].

In recent years, with the widespread adoption of intensified hemodialysis strategies, studies from Canada and Italy have demonstrated that increasing dialysis frequency and duration can significantly improve live birth rates to over 85% [4, 5]. Hladunewich and colleagues established a dose-response relationship between dialysis intensity and live birth rate, with women receiving > 36 hours of dialysis per week achieving an 85% live birth rate compared to only 48% for those receiving ≤ 20 hours weekly [4].

Although guidelines from multiple countries recommend multidisciplinary team (MDT) management and respect for patients' reproductive autonomy [6–8], in clinical practice, particularly in low- and middle-income countries, physicians often tend to counsel termination of pregnancy due to uneven distribution of healthcare resources and limited experience in managing such high-risk pregnancies. This has resulted in a relative paucity of successful pregnancy data from developing countries for this population [9–11].

Shared decision-making (SDM) is essential for balancing maternal-fetal safety with patient autonomy in high-risk situations [12, 13]. Preconception counseling has been shown to help 92% of women with CKD make informed decisions aligned with their personal values [14]. However, reports on the specific implementation process of SDM and its impact on pregnancy outcomes in advanced CKD remain limited. This study retrospectively analyzed pregnancy outcomes in women with CKD stage 4–5. Those on dialysis were managed through a dynamic cyclic SDM model comprising six iterative phases: multidisciplinary initial assessment, decision-making, precision management, reassessment, revised decision-making, and adjusted management, at a tertiary hospital in China, aiming to explore the feasibility and effectiveness of this approach in non-metropolitan settings within a developing country.

Materials and methods

Study Population

This retrospective cohort study analyzed clinical data from 25 pregnant women with CKD stage 4–5 or on maintenance dialysis who received MDT consultation at our institution's CKD Pregnancy Multidisciplinary Clinic between September 2019 and July 2025. Patients were stratified into two groups based on renal function status at conception: CKD stage 4–5 pregnancy group (n = 10) and pregnancy on dialysis group (n = 15). The institutional ethics committee approved this study, and informed consent was waived due to its retrospective nature.

Implementation of Shared Decision-Making

Our SDM model encompassed three key phases. The first phase involved information exchange, during which the MDT objectively informed patients and their families of maternal risks (including permanent loss of renal function, emergent dialysis initiation, and preeclampsia/eclampsia) and fetal risks (extreme prematurity, growth restriction, and NICU admission)[12, 15]. The second phase focused on value clarification, utilizing psychological counseling and structured interviews to gain a comprehensive understanding of patients' desire to continue pregnancy, family support systems, and psychological capacity to cope with adverse outcomes [16]. In the third phase of decision formation, the clinical team and patient collaboratively determined whether to continue or terminate the pregnancy, based on the preceding medical assessment and patient preferences, with informed consent documented accordingly.

MDT Comprehensive Precision Management Protocol

MDT Comprehensive Precision Management Protocol
Our institution established a CKD pregnancy MDT management system in 2019. The team comprises fixed expert members from obstetrics, nephrology, pediatrics, pharmacy, clinical nutrition, ultrasonography, and music therapy, as well as international board-certified lactation consultants, with specialists from endocrinology, rheumatology, immunology, urology, and cardiovascular medicine invited to participate as clinically indicated. We implemented a dynamic cyclic SDM model of "multidisciplinary initial assessment → decision-making → precision management → reassessment → revised decision-making → adjusted management" (Fig. 1). Following the initial face-to-face multidisciplinary assessment, patients made their decision (to terminate or continue pregnancy), after which the MDT developed an individualized management plan based on the patient's choice.

Management components included: routine prenatal care, treatment of primary renal disease, monitoring and prenatal diagnosis for hereditary nephropathies, dialysis management (including timing of dialysis initiation and protocol adjustments), anemia management (iron supplementation, erythropoiesis-stimulating agents), nutritional management (regular body composition analysis, evidence-based dietary guidance, protein and energy intake assessment), medication management (antihypertensives, anemia medications, heparin, bone mineral metabolism agents, medications for comorbidities), psychological support (psychological assessment, music therapy), exercise guidance, close maternal-fetal surveillance (blood pressure monitoring, weight management, laboratory monitoring, ultrasound surveillance, fetal heart rate monitoring), and management of pregnancy complications [6–8].

Dialysis Management

For patients in the dialysis group, dialysis protocols were adjusted following pregnancy confirmation. Dialysis frequency was progressively increased from the standard 3 sessions per week to 5–6 sessions, and weekly dialysis duration was extended from the standard 11.1 hours to 24–40 hours. Ultrafiltration volume was maintained at 1–2 kg per session to prevent hemodynamic instability from excessive fluid removal. Pre-dialysis blood urea nitrogen levels were monitored regularly, with a target of maintaining levels below 10–12.5 mmol/L. High-biocompatibility dialysate was employed, and dialysate potassium concentration was adjusted according to serum potassium levels.

For patients with CKD stage 4–5 not yet on dialysis, an individualized, dynamic assessment approach was adopted to guide dialysis initiation, accounting for biochemical parameters, clinical symptoms, and fetal status. In our cohort, 50% (3/6) of patients in the CKD stage 4–5 group required dialysis initiation during the second or third trimester, with a mean gestational age at initiation of 28.4 ± 4.4 weeks (range: 23^{+3} – 31^{+6} weeks). At dialysis initiation, serum creatinine was 485.67 μmol/L (range: 345–584 μmol/L), and blood urea nitrogen was 22.36 mmol/L (range: 15.6–27.05 mmol/L). Blood pressure, weight, biochemical parameters, and fetal growth parameters were closely monitored for 1–2 weeks following dialysis initiation, with dialysis prescriptions dynamically optimized based on "reassessment" findings.

Statistical Analysis

Descriptive statistics were employed. Continuous variables are presented as mean ± standard deviation, and categorical variables as frequencies and percentages.

Results

Study Population Overview

A total of 25 patients were enrolled, comprising 10 in the CKD stage 4–5 pregnancy group and 15 in the pregnancy on dialysis group. Of these, only 2 (8%) were local Chongqing residents; the remaining 23 (92%) were referred from other provinces nationwide, either through referral from their initial treating hospitals following risk assessment or through self-referral. Nearly all of these patients had been advised by their initial physicians that pregnancy carried extremely high risks and that termination was recommended. In the CKD stage 4–5 group, 3 patients underwent induced termination during the second trimester due to family circumstances, 1 experienced a missed miscarriage in early pregnancy, and 6 achieved successful delivery. In the dialysis group, 4 experienced early pregnancy loss (3 missed miscarriages at 6–9 weeks gestation and 1 spontaneous miscarriage in the first trimester), 2 elected to terminate pregnancy at 11–13 weeks following comprehensive consideration of pregnancy risk assessment along with socioeconomic and family support factors, 1 underwent induced termination at 21 weeks due to intestinal infection, 1 elected termination at 19 weeks owing to concerns about fetal risks from irbesartan exposure until that gestational age, 1 was transferred from another hospital at 30^{+5} weeks and underwent emergency cesarean delivery on the day of admission due to regular contractions, cervical dilation, and abnormal fetal heart rate monitoring, 1 patient referred from another province received online MDT consultation starting at 18 weeks and obtained treatment recommendations while continuing dialysis locally—she underwent 2 online MDT consultations during pregnancy and ultimately delivered by cesarean section at 36 weeks at her local hospital, and the remaining 5 received comprehensive hybrid online-offline MDT management at our institution throughout their pregnancies.

Clinical Characteristics of Patients with Comprehensive MDT Management at Our Institution

General clinical information of 11 patients who delivered after comprehensive MDT management at our institution is presented in Table 1 (5 in the dialysis group and 6 in the CKD stage 4–5 group; 2 patients in the dialysis group who did not receive comprehensive MDT management at our institution were excluded from data analysis). Patients in the dialysis group had a mean age of 34.6 ± 2.97 years (range: 31–39 years), with a pre-pregnancy dialysis vintage of 6 ± 2.74 years (range: 2–9 years). Patients in the CKD stage 4–5 group had a mean age of 27.67 ± 4.41 years (range: 23–36 years). The predominant primary renal diseases identified were IgA nephropathy, sclerosing glomerulonephritis, and autosomal dominant polycystic kidney disease.

Table 1
General clinical characteristics of patients with comprehensive MDT management at our institution

Pt	Group	Age (y)	Primary kidney disease	Genetic testing	CKD stage	Dialysis duration (y)	Dialysis status during pregnancy	G	P	Initial GA (wk)
D1	Dialysis	31	IgAN	-	5	8	MHD	3	0	12^{+3}
D2	Dialysis	39	Unknown	-	5	6	MHD	4	1	6^{+6}
D3	Dialysis	33	Unknown	-	5	5	MHD	2	0	20^{+3}
D4	Dialysis	35	Unknown	-	5	9	MHD	2	0	15
D5	Dialysis	35	ADPKD	IFT140 missense variant	5	2	MHD	2	0	7^{+5}
Mean ± SD		34.60 ± 2.97				6 ± 2.74				12.5 ± 5.6
C1	CKD 4–5	27	IgAN	-	4	-	Stable renal function, no dialysis	2	0	4
C2	CKD 4–5	28	SGN	-	5	-	HD initiated at 23^{+5} wk	3	0	12
C3	CKD 4–5	26	IgAN	-	4	-	Stable renal function, no dialysis	1	0	12^{+3}
C4	CKD 4–5	23	SGN	-	4	-	HD initiated at 31^{+6} wk	3	1	14^{+5}
C5	CKD 4–5	26	Unknown	PAX2 missense variant	4	-	HD initiated at 30 wk	1	0	12^{+6}
C6	CKD 4–5	36	Unknown	COL4A1splice variant	5	-	HD recommended but declined	1	0	13
Mean ± SD		27.67 ± 4.41								11.5 ± 3.8

Note: Pt: patient; y: years; CKD: chronic kidney disease; G: gravidity; P: parity; GA: gestational age; wk: weeks; IgAN: IgA nephropathy; ADPKD: autosomal dominant polycystic kidney disease; SGN: sclerosing glomerulonephritis; MHD: maintenance hemodialysis; HD: hemodialysis; "-" indicates not applicable or missing data.

Dialysis Management and Laboratory Parameter Changes in the Dialysis Group

Dynamic changes in key clinical parameters throughout pregnancy for the 5 MDT-managed dialysis patients are summarized in Table 2. Through multiple MDT discussions and adjustments, weekly dialysis duration progressively increased from 11.1 ± 2.01 hours pre-pregnancy to 22.1 ± 2.01 hours after the first MDT, 31.8 ± 4.02 hours after the second MDT, 36.0 ± 0.0 hours after the third MDT, 34.4 ± 6.07 hours after the fourth MDT, and 37.6 ± 2.19 hours after the fifth MDT. Under MDT management, hemoglobin levels improved from 87.04 ± 8.84 g/L in early pregnancy (pre-MDT) to 101.3 ± 7.23 g/L before delivery. Pre-dialysis urea levels decreased from 15.86 in the 5 MDT-managed dialysis patients, as summarized in Table 2 (Fig. 2).

Table 2
Changes in parameters before and after MDT management during pregnancy in the dialysis group

Parameter	Pre-MDT	Post-MDT 1	Post-MDT 2	Post-MDT 3	Post-MDT 4	Post-MDT 5
Hb (g/L), Mean ± SD	**87.04 ± 8.84**	**100.2 ± 2.86**	**88.2 ± 12.46**	**93.4 ± 9.23**	**101.5 ± 15.50**	**101.3 ± 7.23**
D1	79.2	98	92	93	95	102
D2	86	100	67*	92	107	114
D3	78*	98	90	81	84	-
D4	98	105	100	94	-	-
D5	94	100	92	107	120	115
BUN (mmol/L), Mean ± SD	**15.86 ± 5.75**	**13.46 ± 5.89**	**20.91 ± 8.88**	**13.11 ± 3.75**	**10.51 ± 1.30**	**11.67 ± 2.98**
D1	17.2	7.4	11.9	8.5	9.78	16.07
D2	11.56	8.73	16.2	9.87	10.27	8.13
D3	10.99	13.18	23.34	14.25	8.86	10.81
D4	14.25	16	35	17.02	11.62	12.86
D5	25.3	22	18.1	15.9	12	10.48
HD time (h/wk), Mean ± SD	**11.1 ± 2.01**	**22.1 ± 2.01**	**31.8 ± 4.02**	**36.0 ± 0.0**	**34.4 ± 6.07**	**37.6 ± 2.19**
D1	12	20	27	36	36	36
D2	12	22.5	36	36	36	40
D3	12	20	30	36	24	36
D4	12	24	30	36	36	36
D5	7.5	24	36	36	40	40
AFI max (mm), Mean ± SD			**58.60 ± 20.35**	**57.20 ± 13.29**	**52.20 ± 13.05**	**41.25 ± 13.52**
D1	-	36	35	68	73	56
D2	-	-	49	51	48	49
D3	-	-	50	51	40	27
D4	-	-	74	42	44	-
D5	-	-	85	74	56	33
US-GA diff (d, individual values)						
D1	-	1	0	-4	-2	-6
D2	-	-	4	2	0	-1
D3	-	-	3	0	1	-5
D4	-	-	-5	2	-6	-
D5	-	-	-3	-2	-6	-8

*Note: MDT: multidisciplinary team; Hb: hemoglobin; BUN: blood urea nitrogen; HD: hemodialysis; h/wk: hours per week; AFI: amniotic fluid index; max: maximum; US: ultrasound; GA: gestational age; diff: difference; d: days; * indicates blood transfusion; "-" indicates not applicable or missing data*

Disease Progression and Dialysis Initiation Characteristics in CKD Stage 4–5 Patients During Pregnancy

The disease progression and dialysis initiation data for the CKD stage 4–5 group (n = 6) are summarized in Table 3 and illustrated in Fig. 3. All patients had significantly elevated baseline serum creatinine (range: 219–481 μmol/L). As pregnancy progressed, renal hyperfiltration and physiological burden increased, resulting in 50% (3/6) of patients (C2, C4, C5) experiencing disease deterioration requiring renal replacement therapy initiation. The mean gestational age at dialysis initiation was 28.4 weeks (range: 23^{+3} to 31^{+6} weeks). Indications for dialysis initiation varied among patients: patients C2 and C4 had developed overt azotemia at initiation (blood urea nitrogen of 27.05 mmol/L and 24.42 mmol/L, respectively) along with refractory hypertension or edema; patient C2 was the first case managed by our MDT, and dialysis initiation was relatively delayed; patient C4 had suboptimal compliance and agreed to initiate dialysis at 31^{+6} weeks only after extensive counseling; patient C5 had a blood urea nitrogen of only 15.6 mmol/L at dialysis initiation, with the primary indications being trends toward fetal growth restriction and severe protein intake restrictions. Patient C6 initially received 2 in-person MDT consultations at our institution before transitioning to online MDT follow-up management. The team repeatedly recommended establishing vascular access and initiating dialysis promptly, but the patient's compliance was poor, and these recommendations were not followed. At 32 weeks, the patient underwent emergency cesarean delivery at another hospital due to acute disease deterioration, with dialysis initiated immediately postpartum. The remaining 2 patients (C1, C3) maintained their

condition through strict conservative management (dietary control, medication adjustment) until delivery; however, during postpartum follow-up, C1 and C3 progressed to end-stage renal disease requiring dialysis initiation at 18.3 months and 5.5 months postpartum, respectively.

Table 3
Parameter changes during pregnancy in CKD stage 4–5 patier

Pt	Baseline Cr (μmol/L)	Baseline eGFR (mL/min/1.73m²)	Baseline BUN (mmol/L)	Baseline Hb (g/L)	Baseline Alb (g/L)	Baseline 24h proteinuria (g/d)	GA at HD initiation (wk)	Pre-HD BUN (mmol/L)	Pre-HD Cr (μmol/L)	Pre-delivery Cr (μmol/L)	Pre-delivery BUN (mmol/L)
C1	223	24.5	12.91	112	37.5	4.97	-	-	-	320	16.24
C2*	481	9.9	15.04	59	39.6	-	23^{+3}	27.05	584	357	6.76
C3	219	25.2	12.62	99	35.1	2.69	-	-	-	316	18.79
C4	340	15.6	10.25	85	35	2.66	31^{+6}	24.42	528	413	9.14
C5	319	20.15	7.91	107	34.4	5.38	30	15.6	345	289	13.4
C6	409	11.4	22.2	83	35.1	0.92	Declined			496.7	33.56
Mean ± SD	331.8 ± 103.0	17.79 ± 6.53	13.49 ± 4.92	90.83 ± 19.42	36.12 ± 2.02	3.32 ± 1.84	28.4 ± 4.4	22.36 ± 6.00	485.7 ± 125.00	365.3 ± 77.35	16.32 ± 9.54

Note: Pt: patient; Cr: creatinine; eGFR: estimated glomerular filtration rate; BUN: blood urea nitrogen; Hb: hemoglobin; Alb: albumin; 24h: 24-hour; HD: hemodialys team; "-" indicates not applicable or missing data

Pregnancy Outcomes

All 11 patients who achieved successful delivery underwent cesarean section, with a 100% live birth rate and 100% preterm delivery rate (Table 4). In the dialysis group, the 5 patients with comprehensive MDT management delivered at a mean gestational age of 33.97 ± 1.16 weeks (range: 32–35 weeks), with a mean neonatal birth weight of 1876 ± 356.27 g (range: 1360–2300 g). In the CKD stage 4–5 group, the 6 patients who achieved successful delivery had a mean gestational age at delivery of 33.76 ± 1.11 weeks (range: 32^{+1}–35^{+1} weeks) and a mean neonatal birth weight of 1758.33 ± 262.02 g (range: 1420–2060 g).

Table 4
Pregnancy outcomes of patients with MDT management at our institution

Pt	Indication for delivery	GA at delivery (wk)	Birth weight (g)	Birth length (cm)	Apgar score	Sex	NICU LOS (d)
D1	Fetal distress, threatened preterm labor	34^{+1}	1880	43.5	3-6-9	F	15
D2	Maternal request	34^{+4}	2300	47	9-10-10	M	6
D3	Oligohydramnios	34^{+1}	1750	42	10-10-10	F	10
D4	Fetal distress	35	2090	45	10-10-10	F	4
D5	Preeclampsia	32	1360	38	7-9-10	F	46
Mean ± SD		**33.97 ± 1.16**	**1876 ± 356.27**	**43.10 ± 3.40**			**16.2 ± 17.18**
C1	Severe ICP	35^{+1}	2060	46	8-9-9	M	19
C2	Preterm labor, cardiac dysfunction	33^{+2}	1860	43	9-10-10	F	9
C3	Preeclampsia	34^{+5}	2000	44	10-10-10	M	5
C4	Fetal distress, severe preeclampsia	33^{+1}	1420	42	8-9-9	F	21
C5	Subclinical chorioamnionitis	34^{+1}	1710	41	9-10-10	F	7
C6	Severe preeclampsia, acute exacerbation of CKD	32^{+1}	1500	42	8-9-9	M	38
Mean ± SD		**33.76 ± 1.11**	**1758.33 ± 262.02**	**43.00 ± 1.79**			**16.5 ± 12.39**

Note: Pt: patient; GA: gestational age; wk: weeks; F: female; M: male; NICU: neonatal intensive care unit; LOS: length of stay; d: days; ICP: intrahepatic cholestasis of pregnancy; CKD: chronic kidney disease.

Among all 11 successful deliveries, there were no cases of intrauterine fetal death or neonatal death, and no postpartum hemorrhage occurred. All 5 neonates in the dialysis group were appropriate for gestational age. Among the 6 neonates in the CKD stage 4–5 group, 4 were appropriate for gestational age, and 2 were small for gestational age (Fig. 4). Mean NICU length of stay was 16.2 ± 17.18 days in the dialysis group and 16.5 ± 12.39 days in the CKD stage 4–5 group. No serious complications occurred during NICU admission. Neonatal follow-up over 10–60 months revealed no significant abnormalities in growth curves, physical examinations, or neuropsychological development.

Among the 14 patients with pregnancy failure, 2 elected induced termination during the second trimester. One was a 39-year-old dialysis patient from northern China with crescentic IgA nephropathy confirmed by renal biopsy at another institution, complicated by hypertension and hypertensive heart disease, who first presented to our institution at 20 weeks of gestation. Following an MDT assessment indicating extremely high maternal risk and a recommendation for pregnancy termination, the patient expressed a strong desire to continue the pregnancy and had favorable family financial circumstances, insisting on continuing. Enhanced nutritional support and antihypertensive therapy were provided, along with antibiotic treatment for urea plasma-positive cervical culture. On day 9 of admission, the patient developed paroxysmal lower abdominal pain with leukocytosis (32.62×10^9/L). Intravenous and oral antibiotic therapy was intensified, and diarrhea developed the following day. Abdominal contrast-enhanced CT and hospital-wide multidisciplinary consultation ruled out surgical acute abdomen, confirming severe intestinal infection, and the patient ultimately elected induced termination. Another was a 33-year-old dialysis patient from China's northern border region with a dialysis vintage of 5 years, complicated by hypertension, who presented with an incidentally discovered pregnancy at 19 weeks upon evaluation for increasing abdominal girth. She was assessed at our institution at 20 weeks. Detailed medication history revealed the patient had been taking irbesartan through 18–19 weeks of gestation. The MDT comprehensively informed her of the potential severe consequences of angiotensin II receptor blocker exposure during the second trimester, including oligohydramnios, fetal renal developmental abnormalities, cranial hypoplasia, and even intrauterine fetal death or neonatal renal failure. Concerned about the possibility of long-term offspring renal failure, the patient ultimately elected for induced termination.

Patient D5, a 35-year-old woman diagnosed with autosomal dominant polycystic kidney disease (ADPKD) complicated by refractory hypertension, had been on dialysis for 2 years before pregnancy. The MDT recommended intensified dialysis early in pregnancy; however, considering financial factors, the patient wished to await amniocentesis results and detailed ultrasound examination to confirm the absence of fetal abnormalities before fully complying with the treatment regimen, resulting in delayed implementation of the intensified dialysis protocol. When cervical shortening appeared at 23 weeks of gestation with ultrasound showing increasing amniotic fluid volume (maximum amniotic fluid depth 85 mm, amniotic fluid index 199 mm), combined with refractory hypertension and inadequate dialysis, the risk of preterm delivery increased significantly. Only then did the MDT formally implement the intensified dialysis protocol. Ultrasound monitoring of amniotic fluid volume was performed every 3 days thereafter, with dynamic adjustment of the patient's diet and dialysis frequency and duration based on monitoring results. This patient underwent 6 MDT discussions, the most of any case in this study. Weekly dialysis duration was adjusted from 7.5 hours pre-pregnancy to 24 hours (after the first MDT), progressively increasing with advancing gestational age to 36 hours, ultimately reaching 40 hours per week. Through intensified dialysis, the patient's refractory hypertension, trend toward increasing amniotic fluid volume, and cervical shortening were effectively controlled; maximum amniotic fluid depth decreased to 33 mm, pre-dialysis urea level decreased from 25.3 mmol/L to 10.48 mmol/L, and hemoglobin increased from 94 g/L to 115 g/L. The patient ultimately delivered a female infant by cesarean section at 32 weeks of gestation,

with a birth weight of 1360 g. Although amniotic fluid volume was effectively controlled following intensified dialysis, due to the delayed implementation of intensified dialysis combined with concomitant refractory hypertension, this patient had the earliest gestational age at delivery among the dialysis group.

Case Report—Patient C5 (Special Decision-Making for Timing of Dialysis Initiation)

Patient C5, a 26-year-old woman with a pre-pregnancy diagnosis of CKD stage 4 (solitary kidney) and PAX2 gene variant, represents a unique case of being on dialysis for 2 years before pregnancy. The MDT recommended intensified dialysis blood pressure was well controlled during pregnancy, at 29 weeks of gestation—despite serum creatinine (289–329 μmol/L) and blood urea nitrogen (15.6 mmol/L) not reaching traditional dialysis thresholds—ultrasound monitoring demonstrated slowing fetal growth velocity (trend toward FGR), and the patient's nutritional status had declined due to excessive protein restriction aimed at preserving renal function. The MDT assessed that continuing conservative management at this point could exacerbate intrauterine fetal growth restriction. Following "revised decision-making," the team decided to initiate early hemodialysis (at 30 weeks), aiming to remove toxins and allow the patient to increase protein intake, thereby improving the fetal nutritional environment. The dialysis regimen was rapidly adjusted to an intensified protocol (6 sessions per week, 4 hours each). Following dialysis initiation, the patient's internal milieu improved, the fetal weight gain trajectory improved, and gestational age was successfully extended to 34 weeks. Due to signs of subclinical chorioamnionitis (elevated white blood cell count and procalcitonin), a cesarean delivery was performed, resulting in a live female infant with a birth weight of 1710 g (10th percentile for gestational age) and no serious complications.

Discussion

Unlike previous studies that focused solely on physiological parameters, this study emphasizes the SDM management model and psychological support interventions. Patients with CKD stage 4–5 and those on dialysis face tremendous psychological stress and decisional conflict. The literature indicates that a lack of adequate counseling is a major cause of patients either proceeding with unplanned pregnancies or undergoing unnecessary terminations [16, 17]. Proactive counseling and shared decision-making that attends to patient preferences can improve pregnancy management outcomes [16]. In this study, a total of 7 patients elected early artificial pregnancy termination following comprehensive assessment (3 in the CKD stage 4–5 group underwent induced termination during the second trimester due to family circumstances, 2 in the dialysis group elected termination at 11–13 weeks, 1 underwent induced termination at 21 weeks due to intestinal infection, and 1 elected termination due to concerns about offspring risks from mid-trimester irbesartan use). These patients made their decision to terminate pregnancy with full informed consent after comprehensively considering pregnancy risks, financial circumstances, family support, and offspring risks. The goal of shared decision-making is to assist patients in making informed choices consistent with their values, rather than simply pursuing live birth rates [12, 18]. This cyclical management model ensures that each patient receives an individualized treatment plan most suited to their specific circumstances, avoiding catastrophic outcomes from ill-advised pregnancies.

The most distinctive feature of this study is the adoption of a dynamic cyclic SDM model, ensuring that each patient receives a treatment plan tailored to their specific circumstances, rather than relying solely on conservative management. Notably, pregnant women who received comprehensive MDT management achieved a 100% live birth rate. In the dialysis group, mean gestational age at delivery was 33.97 weeks with a mean neonatal birth weight of 1876 g; in the CKD stage 4–5 group, mean gestational age at delivery was 33.76 weeks with a mean neonatal birth weight of 1758.33 g. These delivery outcomes are comparable to those reported in large cohort studies from developed countries [4, 19]. This indicates that the dynamic cyclic SDM model with multidisciplinary involvement plays a central coordinating role in pregnancy management for patients with CKD stage 4–5 and those on dialysis.

Through multiple MDT discussions and dynamic adjustments, this study implemented an "intensified dialysis" strategy, with weekly dialysis duration progressively increasing from a pre-pregnancy mean of 11.1 hours to a pre-delivery mean of 37.6 hours. Hladunewich and colleagues established a dose-response relationship between dialysis duration and live birth rate, recommending a weekly dialysis time of > 36 hours [4]. In this study, by dynamically monitoring amniotic fluid volume and blood urea nitrogen levels to adjust dialysis protocols, we maintained pre-dialysis blood urea nitrogen at a mean of 11.7 mmol/L. The 5 patients received a mean of 5.2 MDT consultations, with consultation frequency dynamically adjusted according to clinical status. An additional patient received dialysis at an outside hospital and underwent 2 online MDT consultations at our institution, delivering a 2 kg neonate at 36 weeks. As the specific dialysis details for this patient were unavailable, comparison with the 5 patients receiving comprehensive management at our institution revealed fetal growth restriction in her neonate, indirectly demonstrating the importance of comprehensive standardized MDT management for optimizing pregnancy outcomes in dialysis patients.

Beyond the management model, continuity of care is equally critical to pregnancy outcomes. This is well illustrated in patient D3. During this patient's pregnancy, the COVID-19 pandemic was prevalent, and following SARS-CoV-2 infection, she was isolated and transferred to another hospital, where adequate, intensified dialysis support and anemia management were not ensured. This patient's pre-delivery hemoglobin was only 84 g/L, representing the most severe anemia in the dialysis group. Patient C6's situation similarly illustrates this point. This patient initially received 2 in-person MDT consultations at our institution before transitioning to online MDT follow-up management due to circumstances, with specific treatment measures implemented at local hospitals. Lacking comprehensive standardized team management, this patient failed to initiate dialysis promptly and was ultimately delivered at 32^{+1} weeks due to severe preeclampsia and acute exacerbation of renal injury—the earliest gestational age at delivery among CKD stage 4–5 patients who were initially assessed as having no hypertensive complications. Bajpai et al. noted that dialysis resources may be limited during the COVID-19 pandemic, particularly in regions with relatively scarce healthcare resources, and that pregnant patients with renal disease—as a high-risk population—are more susceptible to these effects, emphasizing the need to fully utilize telemedicine to maintain continuity of prenatal management [20]. Patient C6's experience demonstrates that remote consultation alone cannot substitute for comprehensive standardized MDT management; how to ensure continuity of care for pregnant patients with renal disease under conditions of uneven healthcare resource distribution remains an urgent problem requiring solutions.

Patient C2 was the first CKD stage 5 pregnancy patient managed by our team. As an early exploratory case, a retrospective review of her management reveals two areas of deficiency. First, dialysis initiation was delayed; the patient-initiated dialysis at 23^{+3} weeks of gestation, when the blood urea nitrogen

had risen to 27.05 mmol/L, clearly exceeding the recommended threshold (17–20 mmol/L). Second, tocolytic selection was suboptimal. Third, dialysis initiation timing was related to threatened preterm labor after 32 weeks. As a beta-adrenergic agonist, ritodrine increases heart rate, causes vasodilation, and promotes sodium and water retention. Previous studies have shown that oral ritodrine can nearly double the risk of pulmonary edema and cardiac arrhythmias in pregnant women [21]. Dialysis patients often have volume overload and diminished cardiac reserve, making them more susceptible to the cardiovascular adverse effects of beta-adrenergic agonists. Three days after medication administration, this patient developed acute heart failure, necessitating emergency cesarean delivery. Based on these lessons learned, the team subsequently adopted a more proactive dialysis initiation strategy for pregnant women with CKD stage 4–5 and avoided beta-adrenergic agonist tocolytics when uterine contraction suppression was required.

For pregnant women with CKD stage 4–5, determining when to initiate dialysis represents a clinical decision-making challenge. Traditional perspectives often use blood urea nitrogen > 17–20 mmol/L or the presence of uremic symptoms as initiation criteria [7, 8]. A multicenter study including 169 advanced CKD pregnancies from Canada, Australia, Italy, and Mexico showed that 46.7% of pregnant women required dialysis initiation during pregnancy, with a median gestational age at initiation of 21.4 weeks; however, significant variations existed among countries regarding dialysis initiation indications and dialysis dosing, reflecting the lack of standardized consensus in this field [22]. Continued exposure to a high metabolic toxin environment due to delayed dialysis, as well as low-protein diets aimed at controlling toxins, can both lead to fetal growth restriction [23]. The experience with patient C5 in this study suggests that for pregnant women showing trends toward FGR or who cannot maintain nutritional balance, decisive dialysis initiation during the "reassessment" phase (even when blood urea nitrogen < 17 mmol/L), combined with an intensified dialysis regimen, can remove dietary protein restrictions, improve the intrauterine environment, and thereby extend gestational age and increase birth weight. The study also showed that even in pregnant women who did not initiate dialysis, mean postpartum eGFR declined by 8.4 mL/min/1.73m² within 1 year, suggesting that pregnancy itself may accelerate the progression of advanced CKD, further supporting the rationale for an aggressive dialysis strategy in high-risk pregnant women [22]. We suggest that when maternal strict protein restriction is required to control uremic toxins, or when ultrasound monitoring indicates signs of fetal growth restriction, dialysis initiation should be actively considered even if blood urea nitrogen has not reached traditional thresholds. Under the MDT model, dialysis initiation timing is individualized and dynamic rather than dependent on a single biochemical cutoff.

Genetic testing can provide an etiological diagnostic basis for young pregnant women with CKD of unknown etiology. In our study cohort, patients C5 (26 years old, solitary kidney) and D5 (polycystic kidney disease) were definitively diagnosed by genetic testing (PAX2 and IFT140 gene variants, respectively), and patient C6 had a COL4A1 gene variant. Previous studies have demonstrated that exome sequencing can identify monogenic etiologies in approximately 9.3% of patients with chronic kidney disease [24]. Particularly when the clinical diagnosis is unclear, the diagnostic yield of genetic testing improves significantly, with genetic diagnoses made in up to 17.1% of patients with unexplained nephropathy [24]. For pregnant women with concomitant reproductive tract anomalies (such as C5's uterine septum), polycystic ovary syndrome, or positive family history, routine whole exome sequencing is recommended. Establishing a genetic diagnosis has dual significance—it not only helps predict maternal perinatal risk but also guides prenatal diagnosis. In this study, after identifying maternal gene mutations, we ruled out fetal carriage of pathogenic genes through amniocentesis, substantially alleviating patient anxiety and strengthening their confidence to continue pregnancy. However, only 3 of 11 patients underwent genetic screening. This can be attributed to the relatively high cost of genetic testing, to patients presenting at advanced gestational ages, and—importantly—to the team's insufficient early recognition of the clinical value of genetic testing and failure to actively recommend testing to patients; this represents one of the limitations of this study. We recommend that preconception genetic counseling for women of reproductive age with CKD be strengthened, with genetic evaluation completed as early as possible to allow adequate time for pregnancy decision-making and prenatal diagnosis.

All 11 patients in this study underwent cesarean delivery, with a 100% preterm delivery rate. Cesarean delivery rates reported in Western literature are approximately 50–70% [2, 25, 26]. This may be related to our relatively small sample size. Patients with CKD stage 4–5 and those on dialysis are not incapable of vaginal delivery; however, given the precarious nature and high-risk status of such pregnancies, both clinicians and patients often tend to choose planned cesarean delivery to avoid unexpected complications that may arise during labor.

Our institution established the CKD Pregnancy Multidisciplinary Clinic in 2019, continuously learning from international guidelines and relevant literature on kidney disease in pregnancy, and gradually maturing through ongoing multidisciplinary communication and discussion, ultimately providing the most professional services for this special population. Analysis of pregnancy outcomes in this population managed at our institution over these years shows that gestational age at delivery and neonatal outcomes are comparable to those reported from developed countries [4, 19, 25, 27]. China is a developing country with an uneven distribution of healthcare resources across regions. Our institution is located in western China, and as a regional tertiary hospital, our experience demonstrates that even in non-national-level specialty centers or relatively resource-limited settings, through establishing standardized multidisciplinary management protocols, systematically learning international guidelines, and strengthening team training and communication, it is equally possible to provide high-quality pregnancy management services for patients with advanced CKD and those on dialysis, achieving clinical outcomes comparable to those in developed countries.

This study has certain limitations. First, as a retrospective observational study with a small sample size, causal relationships between renal disease and adverse maternal-fetal outcomes cannot be established. Second, clinical data were missing for some patients. Additionally, the team had limited experience with early case management. For example, insufficient emphasis on genetic screening recommendations led to low screening rates, and the first patient developed acute heart failure necessitating emergency cesarean delivery due to ritodrine hydrochloride use for tocolysis. Nevertheless, this study represents one of the largest case series on pregnancy management in patients with advanced CKD and those on dialysis reported domestically, and the accumulated experience and lessons learned hold important reference value for China—which has a large dialysis population—as well as for Asian populations with similar ethnic characteristics.

Conclusion

CKD stage 4–5 and dialysis are not absolute contraindications to pregnancy. An MDT management model grounded in shared decision-making can effectively improve pregnancy outcomes in women with advanced CKD and those on dialysis. The dynamic cyclic SDM model is a highlight of this study, ensuring that each patient can make the most appropriate choice for themselves, with full informed consent, and receive an individualized treatment plan. Intensified dialysis, close maternal-fetal surveillance, and individualized management are key to successful pregnancy in dialysis patients. Although our institution is located in western China, by systematically learning international guidelines and establishing standardized management protocols, patient pregnancy outcomes are comparable to those reported from developed countries, demonstrating the feasibility and effectiveness of this management model in developing countries. We hope that the experience from this study can serve as a reference and guide for other healthcare institutions managing similar high-risk pregnancies.

Declarations

Statement of Ethics

The Institutional Ethics Committee of the Third Affiliated Hospital of Chongqing Medical University approved this study. Informed consent was waived due to the retrospective nature of this study.

Conflict of Interest Statement

The authors have no conflicts of interest to declare (none declared).

AI Disclosure Statement

No artificial intelligence (AI) tools were used in the preparation of this manuscript.

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Author Contribution

X.M. and L.C.: were responsible for the conceptualization, investigation, formal analysis, and writing of the original draft, and approving the version for publication, and are accountable for the aspects of the study that this entailed. X.M. was responsible for the funding acquisition and approving the version for publication and is accountable for the aspects of the study that this entailed. X.Y. and L.Y.: were responsible for the supervision, writing, review & editing, and approving the version for publication and are accountable for the aspects of the study that this entailed. M.Z., Y.Q., S.H., J.H., X.X., E.T., L.L., and Y.F. were responsible for the data curation and methodology, approving the version for publication, and are accountable for the aspects of the study that this entailed. Q.D., L.W., and J.Y. were responsible for the resources and validation, approving the version for publication, and are accountable for the aspects of the study that this entailed.

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Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request, subject to legal and ethical restrictions.

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Figures

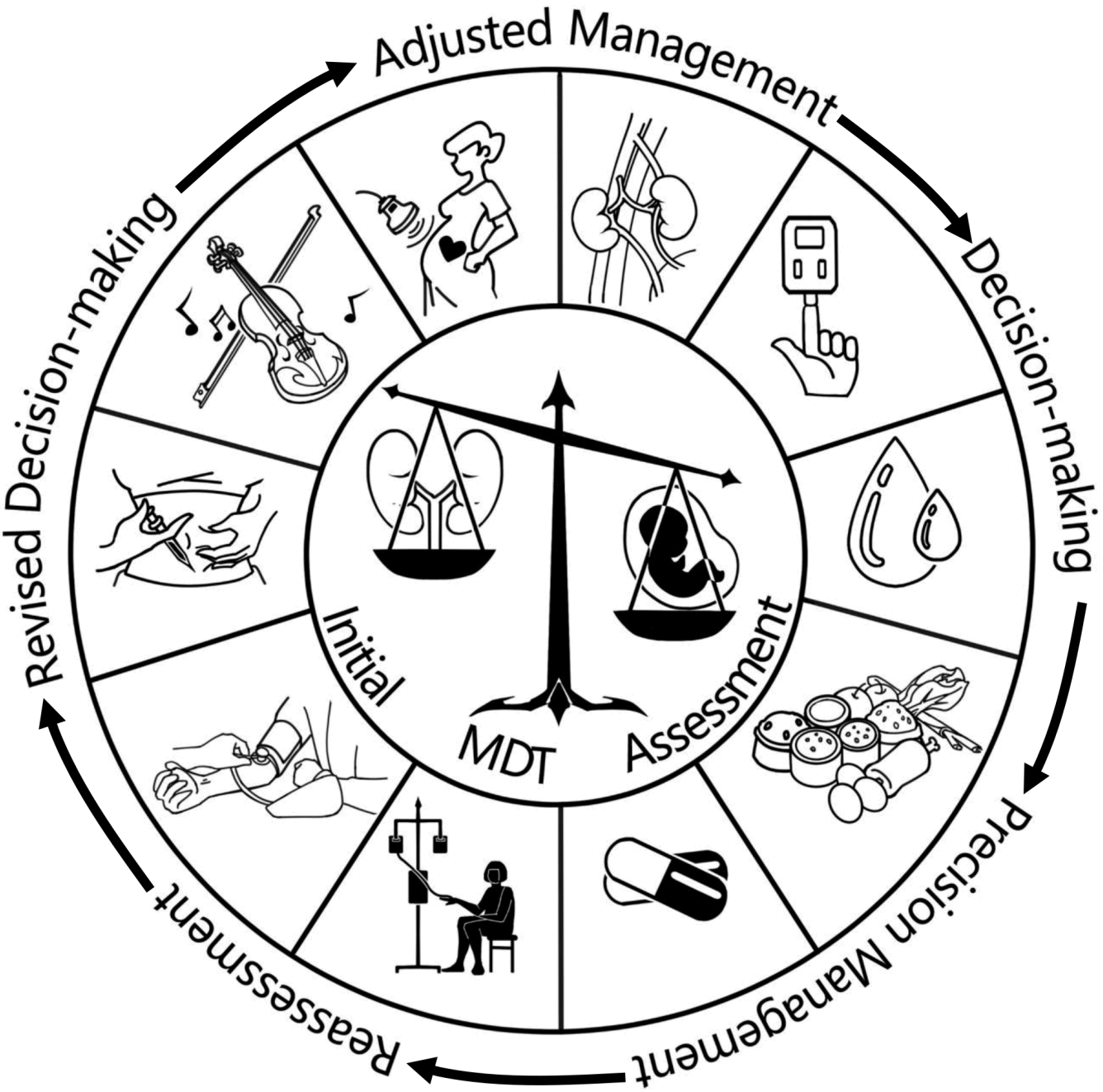


Figure 1

Dynamic cyclic shared decision-making model for MDT management in CKD pregnancy.

Alt text: The clinical pathway follows a continuous loop of six phases: multidisciplinary initial assessment → decision-making → precision management → reassessment → revised decision-making → adjusted management. A central balance scale represents the core objective of balancing maternal-fetal safety with patient autonomy through multidisciplinary team (MDT) coordination.

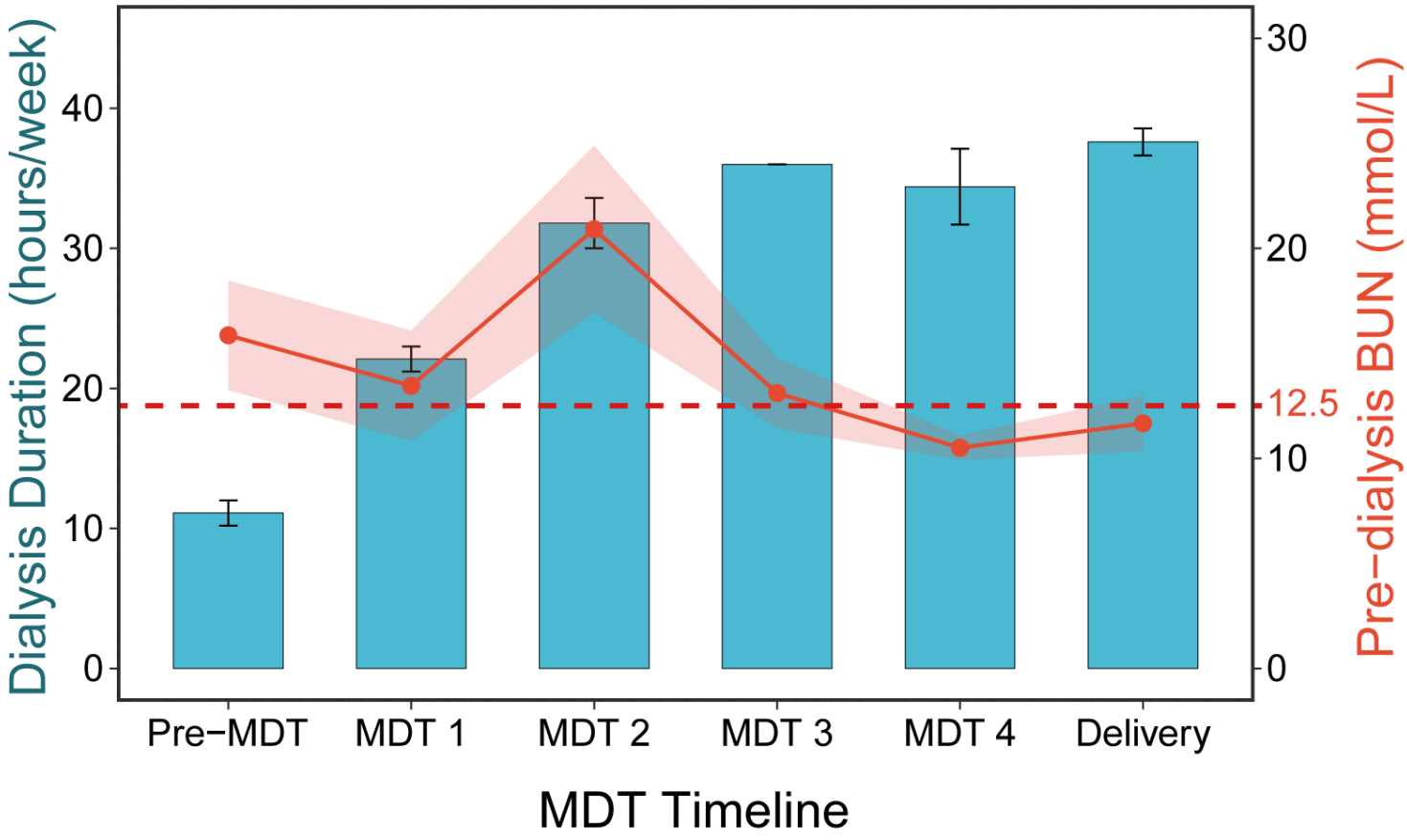


Figure 2

Intensified dialysis strategy and metabolic control.

Alt text: This dual-axis chart shows the progressive adjustment of dialysis duration (blue bars, left Y-axis) and the corresponding changes in pre-dialysis blood urea nitrogen (BUN) levels (red line, right Y-axis) across different MDT consultation phases. Data are presented as mean±standard deviation. The dotted horizontal line indicates the target pre-dialysis BUN threshold of 12.5 mmol/L. The weekly dialysis hours increased substantially from pre-pregnancy (11.10 h) to delivery (37.60 h).

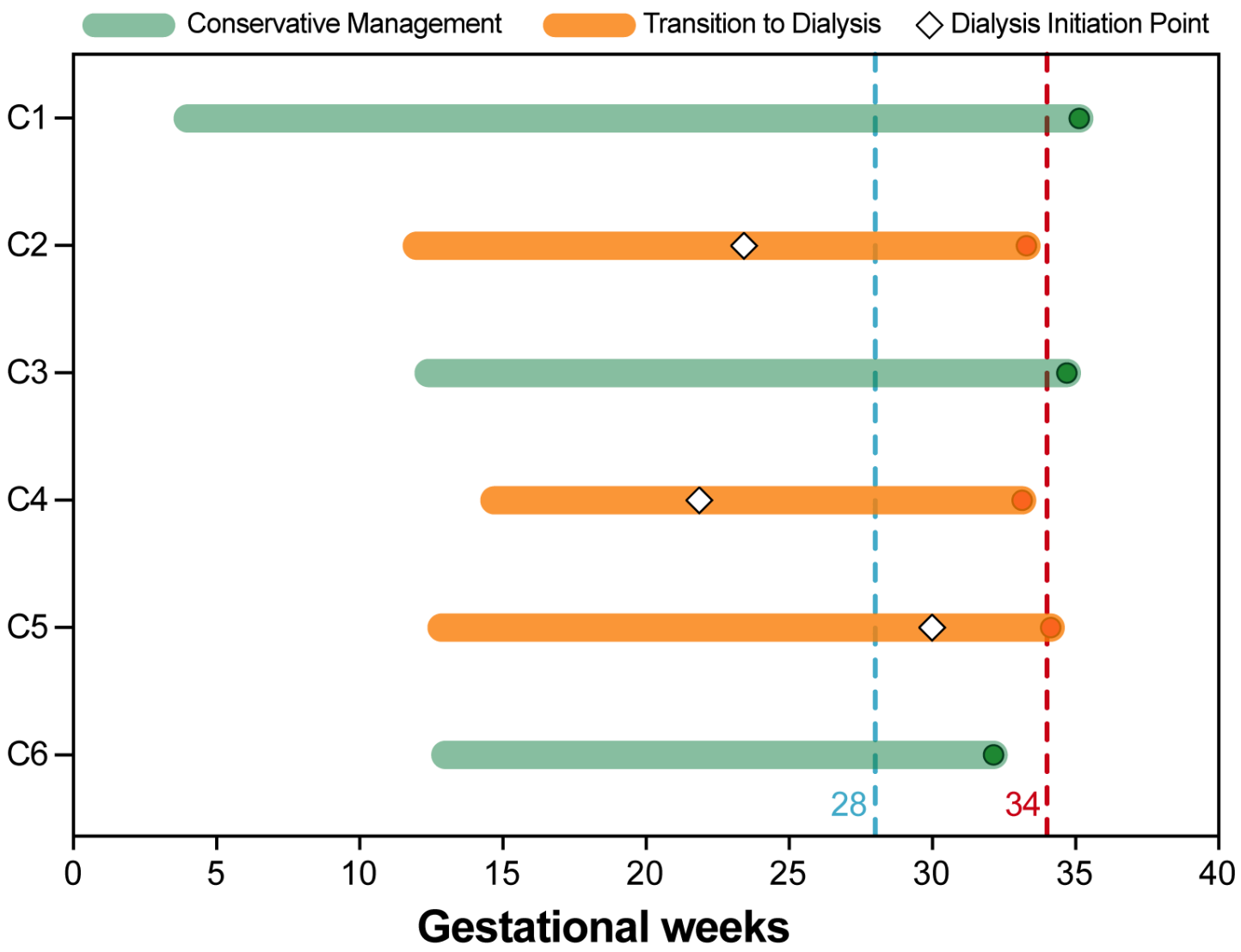


Figure 3

Clinical trajectory and decision-making in CKD stage 4-5 pregnancies.

Alt text: The Gantt-style chart depicts the clinical course of six patients (C1– C6) in the advanced CKD group. Green bars indicate periods of conservative management, while orange bars represent transition to hemodialysis. White diamonds mark the specific gestational age at dialysis initiation for patients C2, C4, and C5. Solid circles at the end of each bar indicate the gestational age at delivery. The blue and red vertical dashed lines highlight key obstetric milestones at 28 and 34 gestational weeks, respectively. Patients C1 and C3 maintained conservative management throughout pregnancy without dialysis initiation. Patient C6 underwent conservative management until emergency delivery at approximately 32 gestational weeks without dialysis initiation.

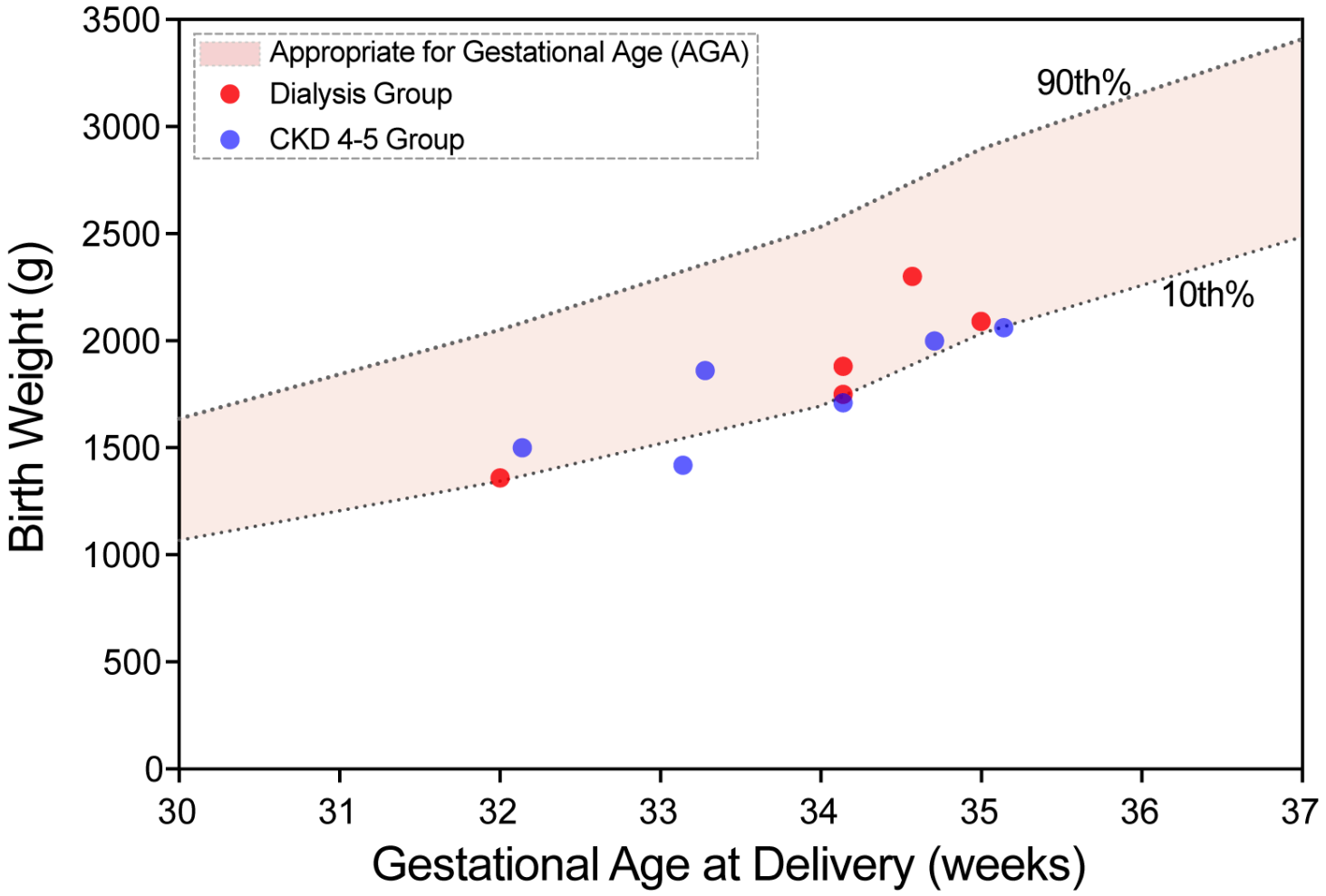


Figure 4

Neonatal outcomes on growth chart.

Alt text: This scatter plot displays the birth weight of 11 live births plotted against gestational age at delivery, stratified by group (red dots: dialysis group, n=5; blue dots: CKD 4-5 group, n=6). The pink shaded area represents the appropriate for gestational age (AGA) range, defined as birth weight between the 10th and 90th percentiles for gestational age. All neonates in the dialysis group fell within the AGA range, whereas two neonates in the CKD 4-5 group fell below the 10th percentile, consistent with small-for-gestational-age (SGA) status.