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ORIGINAL ARTICLE

Effects of antiviral therapy and drug withdrawal on postpartum hepatitis in pregnant women with chronic HBV infection

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Abstract

Objective To investigate the effect of antiviral therapy and drug withdrawal on the incidence of hepatitis B after delivery in pregnant women with chronic hepatitis B virus (CHB) infection who received tenofovir disoproxil fumarate (TDF) treatment.
Methods Eligible CHB pregnant women were enrolled, and received TDF at 32 weeks gestation. The drug was stopped immediately or at 6 weeks after delivery. The HBV biomarkers and clinical biochemical parameters were monitored during gestation and 24 weeks after delivery.
Results There were 264 women completed the observation, including 96 untreated subjects in control group. Among 168 treated subjects, 131 cases stopped drug immediately after delivery and 37 cases delayed the drug withdrawal at 6 weeks after delivery. The incidence of postpartum hepatitis in control, immediate drug withdrawal, and delayed drug withdrawal were 28.1% (27/96), 23.7% (31/131), and 24.3% (9/37), showing no significant difference ($\chi^2 = 0.607$, $p = 0.738$). No factor was found to be associated with the occurrence of postpartum hepatitis. It's noteworthy that 96.3% of postpartum hepatitis in control group and 92.3% of postpartum hepatitis in immediate drug withdrawal group occurred within 12 weeks after delivery. While in delayed drug withdrawal group, the rate of postpartum hepatitis occurred within 12 weeks after delivery was 77.7%.
Conclusion Withdrawing antiviral drug immediately or at 6 weeks after delivery did not affect the incidence of postpartum hepatitis in CHB women, but delaying drug withdrawal might delay the onset of postpartum hepatitis.
Clinical trial registration number: NCT03214302.

Keywords Antiviral therapy · Hepatitis B virus · Mother-to-child transmission · Postpartum hepatitis · Tenofovir dipivoxil fumarate

Introduction

Hepatitis B virus (HBV) infection is a global public health issue that can lead to chronic liver disease, cirrhosis, liver failure and liver cancer [1–4]. In China, there are approximately 28 million patients with chronic hepatitis B, with nearly 1 million new cases in 2020. About 84%–92% of hepatocellular carcinoma (HCC) in China is related to chronic HBV infection and 330, 000 people die of HCC every year [5–7]. Mother-to-child transmission of HBV is an important reason for the high prevalence of chronic HBV infection. To improve the blocking effect of mother-to-child transmission of HBV, antiviral therapy during pregnancy has been widely promoted in pregnant women with HBV infection. Many studies have confirmed that antiviral treatment in the last 1/3 of pregnancy for pregnant women with high HBV DNA content could significantly improve the blocking rate of HBV vowel transmission compared with pregnant women without antiviral treatment [5, 8–10].

Although short-course antiviral therapy is currently recommended to reduce the risk of mother-to-child transmission in pregnant women with chronic HBV infection with high viral load and HBsAg above 4 log10 IU/mL, some

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pregnant women are reluctant to take antiviral drugs because of concerns about the safety of breastfeeding. A considerable proportion of patients with chronic HBV infection have postpartum hepatitis after delivery, with a proportion as high as 50% [11], especially within 6 months after delivery [12], and some patients present with severe chronic hepatitis B and liver failure [13]. Our previous findings suggest that HBV DNA positivity at delivery and postpartum alanine aminotransferase (ALT) elevation in chronic HBV infection patients without antiviral therapy are independent predictors of acute exacerbation of chronic hepatitis B [14]. However, the predictors of acute exacerbation of chronic hepatitis B after short-term antiviral therapy in pregnant women with chronic HBV infection are still limited. Whether withdrawal of antiviral therapy after delivery will affect the occurrence of postpartum hepatitis is unclear. In this study, we observed the incidence of postpartum hepatitis in pregnant women with chronic HBV infection who were treated with or without antiviral drugs, and explored the impact of different timing of stopping antiviral treatment on the occurrence of hepatitis after delivery.

Some studies reported the recurrence of postpartum hepatitis in patients with chronic HBV infection, focusing on the blocking effect of antiviral therapy during pregnancy on mother-to-child transmission of HBV [15–19]. In these studies, inconsistent timing of postpartum drug discontinuation among pregnant women might influence the development of postpartum hepatitis [15–19]. We published a large sample retrospective study in 2018 showing that abnormal postnatal liver function was common in both non-HBV-infected and HBV-infected women, and abnormal postnatal liver function in HBV-infected women occurred in those with viral load greater than 10^6 IU/ml [14]. Currently, there are few studies on the occurrence and influencing factors of postpartum hepatitis in pregnant women with chronic HBV infection. In this prospective study, we studied the occurrence of postpartum hepatitis in untreated pregnant women with chronic HBV infection, pregnant women who received TDF treatment for the prevention of mother-to-child transmission of HBV during pregnancy and stopped treatment immediately after delivery or 6 weeks after delivery. The results will more accurately reveal the effect of TDF treatment and drug withdrawal during pregnancy on the occurrence of postpartum hepatitis.

Patients and methods

Subjects and study design

This is a prospective observational cohort study of HBeAg-positive and HBV-DNA positive pregnant women. Eligible mothers with chronic HBV infection who underwent prenatal examination and delivered at Beijing Ditan Hospital between January 1, 2017 and December 30, 2019 were enrolled. This study was approved by the Ethics Committee of Beijing Ditan Hospital Affiliated to Capital University of Medical Sciences (Jing Di Lun Ke Zi 2017 No. 004-02), and was registered with Clinical Trials (NCT03214302).

Inclusion criteria were: HBeAg positive and HBV DNA $> 10^6$ IU/ml; No anti HBV drugs were taken before entering the group; No pregnancy induced hypertension, premature rupture of membranes, prenatal bleeding and other diseases; No history of amniocentesis during pregnancy; No other virus infections (HCV, HIV, CMV, *etc*); No hepatic fibrosis and cirrhosis.

After enrollment, pregnant women were divided into groups according to their willingness to receive antiviral treatment or not. The group without antiviral treatment during pregnancy was set as control. In the treated group, tenofovir dipivoxil antiviral therapy was started at 32 weeks of gestation and discontinued immediately or at 6 weeks after delivery. Adverse reactions, especially renal impairment, were closely monitored during TDF antiviral therapy.

Both Chinese and American guidelines recommended 24 weeks of postpartum follow-up for all HBV-infected mothers [20, 21]. Delivery and pregnancy complications were examined at 6 weeks postpartum. Blood routine examination, liver function, renal function, coagulation and other biochemical indicators, serum HBV DNA content and serological indicators were examined at 6 weeks, 12 weeks, and 24 weeks postpartum. Liver function was rechecked 1 month later in patients with ALT > 40 U/L at 12 weeks postpartum.

Definition of the onset of hepatitis after drug withdrawal was: ALT is 2 times higher than the upper limit of normal (40 U/L), HBV DNA is positive, and other diseases leading to abnormal liver function are excluded. 5 ULN ≤ ALT < 10 ULN (normal ALT ≤ 40 U/L) is defined as ALT flare, and ALT ≥ 10 ULN is defined as ALT exacerbation [22].

All newborns born to mothers with chronic HBV infection were injected with HBIG 200 IU and 10 micrograms of hepatitis B vaccine within 2 hours of birth, and then injected with 10 micrograms again at 1 and 6 months of birth.

Biochemical examination

HBV DNA, HBsAg, HBeAg and liver function were detected at 30-32 weeks of pregnancy, 4 weeks of antiviral therapy, before delivery and 2, 6, 12 and 24 weeks after delivery. Liver function and renal function were detected by Hitachi automatic biochemical analyzer. Serum HBV DNA load was detected by Roche (Cobas AmpliPrep/Cobas TaqMan 96) automatic real-time fluorescence quantitative PCR detection reagent (detection limit: 20 IU/ml); HBsAg/anti-HBs level and HBeAg/anti-HBe were detected by Abbott architac i2000 microparticle chemiluminescence

reagent. The detection range of HBsAg level was 0.05–250 IU/ml. If the HBsAg level was greater than 250 IU/ml, it'd be automatically diluted 500 times. The actual HBsAg level was calculated by multiplying the test value by 500. HBsAg < 0.0 5 IU/ml was defined as the disappearance of HBsAg.

Statistical analysis

The continuous variables were described by mean, standard deviation, maximum, minimum, median and interquartile range. The classified data are statistically described by frequency and rate. Chi-square analysis, Fisher test, *t* test and Wilcoxon nonparametric test were used for comparison between groups.

Chi-square test, Mantel–Haenszel hierarchical analysis, trend chi-square analysis, and analysis of covariance were used to find the correlation with the occurrence of hepatitis after drug withdrawal.

Because there are many factors affecting the failure of HBV mother-to-child transmission interruption and the occurrence of hepatitis after delivery, unconditional logistic regression analysis was conducted, in which the success of HBV mother-to-child transmission interruption or the occurrence of hepatitis is taken as the dependent variable, and study factors are taken as the independent variables. Stepwise regression method was used for variable selection.

Results

Patient enrollment and deposition

A total of 397 HBeAg-positive pregnant women with chronic HBV infection and age 30.74 ± 3.85 years were enrolled during the study, of whom 112 received no antiviral treatment (Control group) and 251 were treated with tenofovir dipivoxil (Treated group). In the Control group, 106 women delivered and 96 were followed up till the onset of postpartum hepatitis or till 24 weeks postpartum. In the Treated group, 232 delivered and 168 were followed up till the onset of postpartum hepatitis or till 24 weeks postpartum. Among them, 131 cases stopped taking drug immediately after delivery and 37 cases stopped taking drug 6 weeks after delivery (Fig. 1). All subjects enrolled in this study were HBeAg-positive pregnant women. They could hardly recall their hepatitis B vaccination status a long time ago.

Changes of biochemical indexes and HBV DNA during pregnancy

There was no difference in clinical biochemical parameters between the two groups at baseline. The HBV DNA content in Treated group was significantly lower than that in Control group at 4 weeks of antiviral treatment and before delivery, suggesting that tenofovir dipivoxil had good antiviral effect (Table 1).

Changes of HBV DNA content during pregnancy and after delivery

A total of 264 pregnant women were followed up for HBV DNA levels after delivery, 96 (36.4%) of whom were in the Control group and 168 (63.6%) were treated with tenofovir dipivoxil.

The HBV DNA content in the Control group remained at a relatively stable high level during pregnancy and after delivery. In the Treated group, HBV DNA decreased significantly at 4 weeks of treatment and continued to decrease during pregnancy. The virus quickly rebounded to high levels after 6 weeks of discontinuation (Table 2). However, there was still a decrease in overall viral levels compared with baseline (Fig. 2), owning to occurrence of hepatitis in some patients.

Occurrence of postpartum hepatitis and treatment

A total of 67 patients' ALT reached the diagnostic level of hepatitis after delivery, including 28.1% (27/96) of patients in the Control group and 23.8% (40/168) in the Treated group (Table 3). There was no significant difference between the two groups ($p>0.1$). There was also no significant difference in the incidence and prevalence of hepatitis between patients with immediate withdrawal and delayed treatment withdrawal. 96.3% of postpartum hepatitis in control group and 92.3% of postpartum hepatitis in immediate drug withdrawal group occurred within 12 weeks after delivery. While patients stopped taking drug 6 weeks after delivery, 77.7% of Hepatitis occurred within 12 weeks after delivery. There was not significant difference of the rates of postpartum hepatitis occurred within 12 weeks after delivery ($\chi^2 = 2.876$, $p = 0.237$) (Table 4).

5 ULN ≤ ALT < 10 ULN (normal ALT ≤ 40 U/L) is defined as ALT flare, and ALT ≥ 10 ULN is defined as ALT exacerbation [22]. Among patients who developed postpartum hepatitis, ALT flare occurred in 7 cases (25.92%) in the control group, 9 cases (29.03%) in the immediate withdrawal group and 1 case (11.11%) in the delayed withdrawal group ($\chi^2 = 1.190$, $p = 0.551$). ALT exacerbation was observed in 3 (11.11%) cases, 2 (6.45%) cases, and 1 (11.11%) case, respectively ($\chi^2 = 0.444$, $p = 0.801$). Bilirubin levels were normal in all patients with postpartum hepatitis and no patients had severe hepatitis. A total of 60 patients were treated with antiviral therapy after the diagnosis of hepatitis, including 32 patients

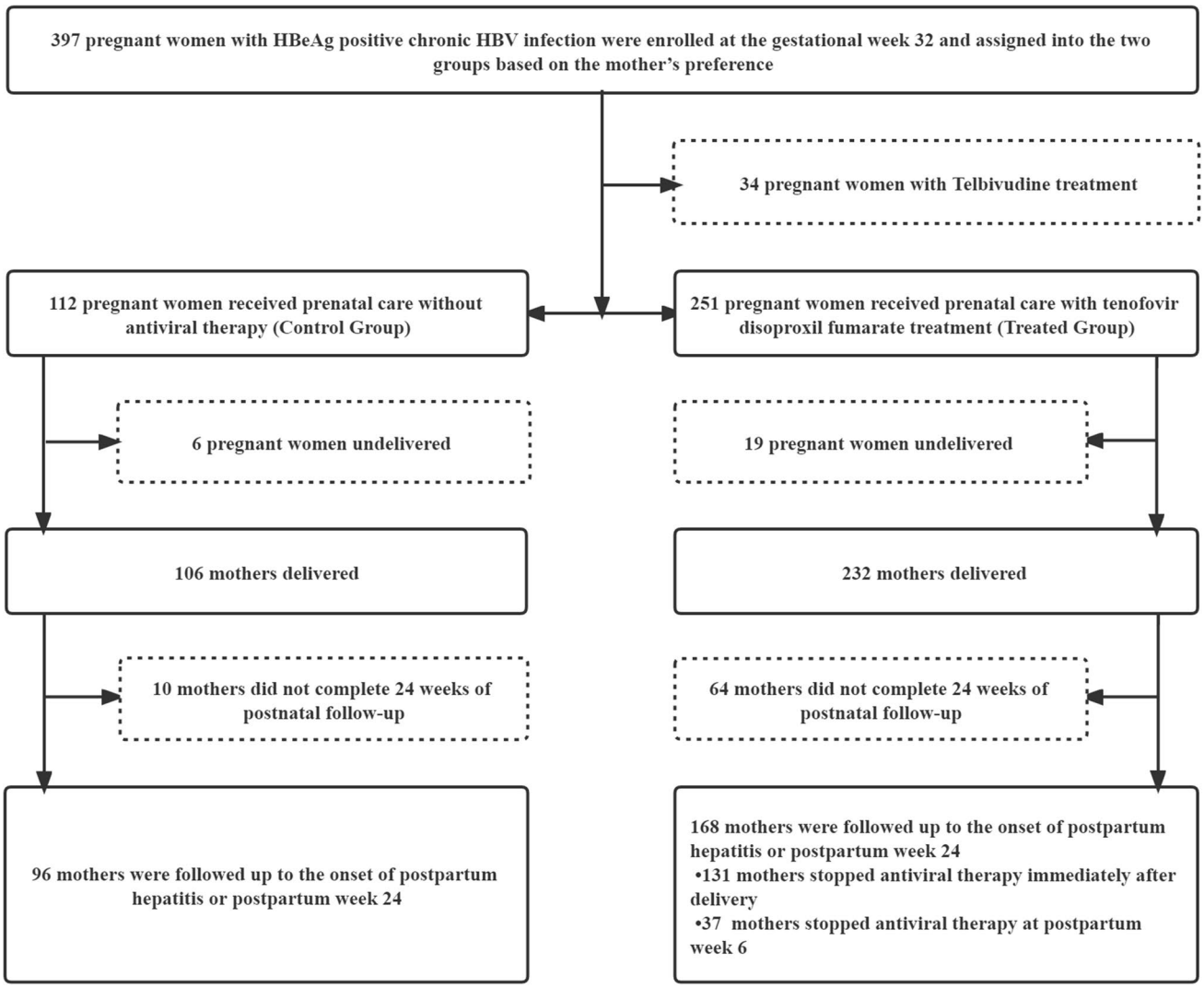

Fig. 1 Patient enrollment and deposition

treated with TDF and 28 patients treated with PEG-IFN or PEG-IFN combined with TDF.

The results of logistic regression analysis showed that the occurrence of hepatitis after delivery was not related to the patient's age, antiviral treatment, DNA content before enrollment and before delivery, and whether to stop antiviral drug immediately (Table 5).

HBV markers at birth and blocking effect of HBV mother-to-child transmission in newborns

A total of 346 newborns were delivered, including 189 males and 157 females, with body length 50.07 ± 1.07 cm, weight 3311.78 ± 424.04 g, Apgar1 score 9.97 ± 0.26, Apgar 5 score 9.99 ± 0.22, Apgar 10 score 10.00 ± 0.00. There were 7 cases of fetal malformation, including 5 cases of syndactyl, 1 case of genital malformation and 1 case of cryptorchidism. In 326 patients who obtained HBV serum markers in venous blood at birth, 41.4% (135) were HBsAg positive (HBsAg > 0.05 IU/ml) and HBsAg level was 0.14 (0.08, 0.41) IU/ml. 96.3% (314) were HBeAg positive (HBeAg > 1.0 S/CO), the HBeAg level was 64.46(18.15, 169.72) S/CO. 98.5% were anti-HBe negative (anti-HBe > 1.0 S/CO). 98.5% (321) were anti-HBc positive (anti-HBc > 1.0 S/CO). Serum HBV DNA content was detected in 321 cases, 14.0% positive (HBV DNA ≥ 20 IU/ ml), and HBV DNA content was 3.47 ± 1.33 log IU/ml.

Table 1 Clinical biochemical parameters during pregnancy

	Baseline enrollment (31–32 weeks of gestation)				After enrollment (antiviral therapy 4 w)				Before delivery			
	Control	Treated	*T* test	*p* value	Control	Treated	*T* test	*p* value	Control	Treated	*T* test	*p* value
Age(years)	29.99 ± 3.60	31.35 ± 3.95	2.805	0.005	/	/	/	/	/	/	/	/
HBV DNA (log_{10} IU/mL)	7.99 ± 0.62	8.03 ± 0.51	0.676	0.500	7.55 ± 0.80	5.20 ± 0.72	–9.910	< 0.001	7.87 ± 1.20	4.50 ± 1.03	–23.928	< 0.001
HBeAg–positive, %	100%	100%	–	–	100%	100%			100%	100%		
ALT (U/L)	22.17 ± 14.80	23.46 ± 20.03	0.051	0.960	20.71 ± 27.69	23.75 ± 18.81	1.050	0.295	18.41 ± 11.80	20.30 ± 9.73	1.770	0.078
AST (U/L)	21.60 ± 14.61	22.44 ± 6.21	0.239	0.812	20.85 ± 13.03	23.63 ± 11.04	2.091	0.038	21.47 ± 9.22	22.72 ± 6.29	2.105	0.036
TBIL (μmol/L)	7.11 ± 2.41	7.74 ± 2.59	1.909	0.057	7.62 ± 3.44	7.99 ± 2.56	0.932	0.352	7.29 ± 2.68	7.48 ± 2.66	0.321	0.748
DBIL (μmol/L)	1.72 ± 0.76	1.771.23	0.157	0.875	1.70 ± 1.03	1.91 ± 0.87	1.396	0.164	1.68 ± 1.26	1.72 ± 0.82	0.062	0.951
ALB (g/L)	39.03 ± 3.28	37.09 ± 2.07	–5.525	< 0.001	36.75 ± 2.44	36.24 ± 2.66	–2.714	0.008	35.77 ± 2.86	35.86 ± 3.06	–0.446	0.656
GGT (U/L)	10.15 ± 7.81	9.60 ± 6.73	–0.957	0.339	9.79 ± 6.77	9.37 ± 5.61	–0.997	0.320	10.06 ± 5.47	9.29 ± 4.86	–0.273	0.786
ALP (U/L)	70.55 ± 34.25	76.80 ± 23.13	1.600	0.112	129.88 ± 52.41	149.66 ± 346.69	0.607	0.545	140.52 ± 32.73	159.07 ± 51.51	1.797	0.078
TBA (μmol/L)	3.25 ± 2.60	4.11 ± 8.91	0.531	0.596	3.70 ± 3.35	7.66 ± 41.40	0.902	0.368	8.90 ± 7.71	78.36 ± 536.73	–1.155	0.253
BUN (μmol/L)	3.08 ± 0.78	3.96 ± 11.64	0.662	0.509	2.92 ± 0.62	3.10 ± 0.80	0.994	0.321	3.91 ± 3.35	3.64 ± 0.90	–1.147	0.252
Cr (μmol/L)	44.33 ± 5.78	45.63 ± 11.95	0.530	0.597	46.67 ± 5.19	50.90 ± 23.20	0.890	0.375	50.53 ± 8.63	55.51 ± 41.58	1.166	0.245
PHOS (mmol/L)	1.11 ± 0.10	1.18 ± 0.65	0.865	0.388	1.15 ± 0.13	1.13 ± 0.13	–1.075	0.284	1.13 ± 0.15	1.10 ± 0.17	–1.382	0.168
PTA (%)	109.99 ± 13.45	113.40 ± 10.34	2.089	0.041	116.68 ± 9.95	116.79 ± 10.59	0.102	0.919	117.03 ± 17.82	111.41 ± 15.73	–2.732	0.007
INR	0.97 ± 0.05	1.35 ± 6.00	0.498	0.619	0.96 ± 0.05	0.93 ± 0.05	–2.019	0.045	0.94 ± 0.04	0.96 ± 0.06	0.743	0.458

Notes: HBV DNA: hepatitis B virus deoxyribose nucleic acid; HBeAg: hepatitis B e antigen; ALT: alanine aminotransferase; AST: aspartate aminotransferase; TBil: total bilirubin; DBil: direct bilirubin; ALB: Albumin; GGT: glutamyl transpeptidase; ALP: alkaline phosphatase; TBA: total bile acid; BUN: urea nitrogen; Cr: creatinine; PHOS: phosphorus; PTA: prothrombin time activity; INR: international normalized ratio

Table 2 HBV DNA levels in HBV-positive patients during pregnancy and after delivery

HBV DNA level (log_{10} IU/mL)	Control	Immediate withdrawal	Delayed withdrawal	*T* test/*p* value Control vs. Immediate withdrawal	*T* test/*p* value Control vs. Delayed withdrawal	*T* test/*p* value Immediate withdrawal vs. Delayed withdrawal
Before antiviral therapy	7.99 ± 0.62	8.05 ± 0.51	7.98 ± 0.52	–0.708/0.479	0.077/0.939	0.648/0.518
4 weeks after antiviral therapy	7.55 ± 0.80	5.24 ± 0.62	5.21 ± 0.94	11.226/ < 0.001	6.966/ < 0.001	0.207/0.837
Before delivery	7.87 ± 1.20	4.51 ± 0.99	4.53 ± 0.96	22.875/ < 0.001	15.275/ < 0.001	–0.016/0.987
6 weeks after delivery	7.87 ± 0.93	7.98 ± 0.73	4.80 ± 1.79	–0.866/0.388	9.339/ < 0.001	10.212/ < 0.001
12 weeks after delivery	7.41 ± 1.50	7.83 ± 1.21	7.43 ± 1.55	–1.276/0.211	–0.049/0.961	1.336/0.184
24 weeks after delivery	7.13 ± 2.11	7.34 ± 2.03	7.10 ± 2.13	–0.535/0.593	0.056/0.956	0.476/0.635

Notes: Control: no antiviral treatment during pregnancy

Immediate withdrawal: withdrawal of antiviral drugs immediately after delivery

Delayed withdrawal: withdrawal of antiviral drugs at 6 weeks after delivery

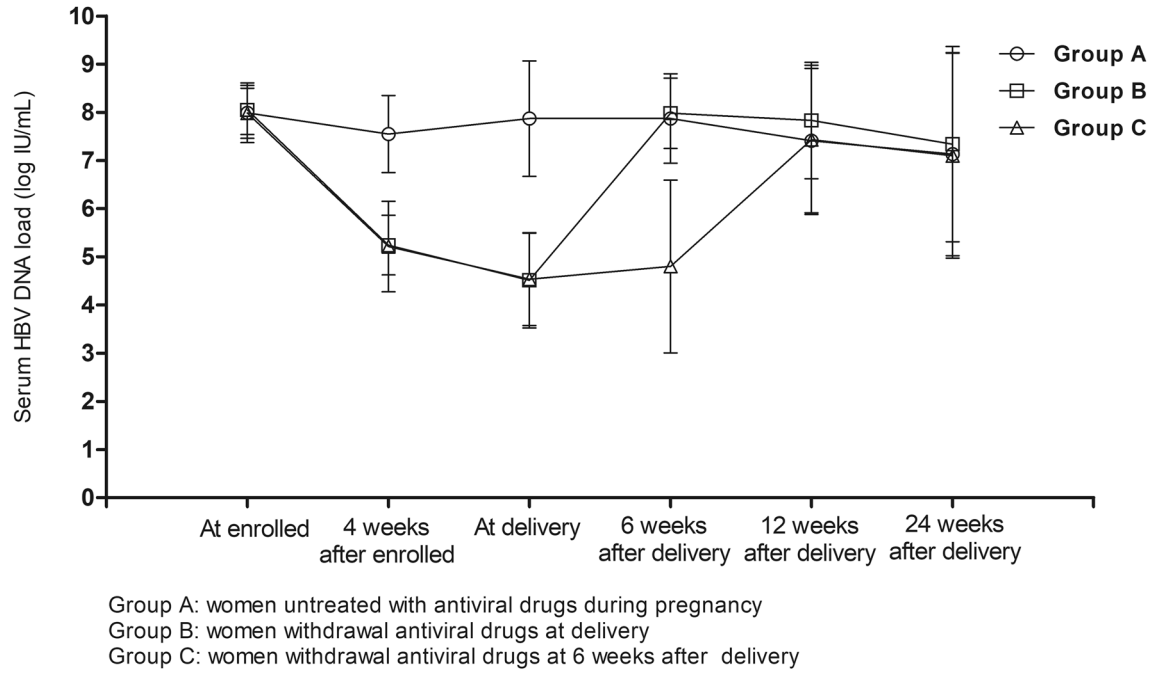

Fig. 2 Changes of HBV DNA content in pregnant women infected with HBV during pregnancy and postpartum

All newborns in this study received anti-HBV HBIG 100 IU injection and 10 μg hepatitis B vaccine within 6 hours after birth, and returned to the community to receive hepatitis B vaccine at 1 and 6 months after birth. In this study, a total of 262 newborns received the follow-up results of blocking HBV mother-to-child transmission, and the success rates of blocking was significantly different in the treatment group (155/156, 99.35%) and the control group (96/106, 90.56%)(χ^2=12.132, $p < 0.001$).

Discussion

Guidelines recommend short-course antiviral therapy to reduce the risk of mother-to-child transmission of chronic hepatitis B virus in pregnant women with high viral load [5, 8–10, 23]. Unfortunately, some patients have postpartum chronic hepatitis B after the end of short-course antiviral therapy. The aim of the study was to examine the timing of

Table 3 Incidence of postpartum hepatitis in different population groups

	Control ($n=96$)	Immediate withdrawal ($n=131$)	Delayed withdrawal ($n=37$)	χ^2/p value control vs. immediate withdrawal	χ^2/p value control vs. delayed withdrawal	χ^2/p value immediate withdrawal vs. delayed withdrawal	χ^2/p value Control vs. Treated
Incidence of hepatitis% (*n*)	28.1% (27)	23.7% (31)	24.3% (9)	0.580/0.446	0.195/0.658	0.007/0.934	0.601/0.438

Notes: Control: no antiviral treatment during pregnancy
Immediate withdrawal: withdrawal of antiviral drugs immediately after delivery
Delayed withdrawal: withdrawal of antiviral drugs at 6 weeks after delivery

drug withdrawal on occurrence of hepatitis after delivery in pregnant women with chronic HBV infection.

Antiviral therapy during pregnancy is an important measure to improve the blocking rate of mother-to-child transmission of HBV. However, HBV infected pregnant women with significant hepatitis, liver fibrosis or cirrhosis during pregnancy must continue antiviral therapy even after delivery, so we excluded these patients from our study [20, 21, 24, 25]. Currently, there is no consensus on when to stop antiviral drugs after delivery and its effect on the occurrence of postpartum hepatitis in these pregnant women who take antiviral drugs during pregnancy to prevent mother-to-child transmission of HBV [20, 21, 24, 25]. The aim of this study was to investigate the effect of withdrawal of TDF after delivery on the occurrence of postpartum hepatitis and hepatitis development in pregnant women who had been using TDF for prevention of HBV mother-to-child transmission during pregnancy, thus HBV-infected pregnant women with significant hepatitis, liver fibrosis or cirrhosis during pregnancy were excluded. Meanwhile, in order to reduce the pregnancy complications (such as gestational hypertension) and delivery complications (such as postpartum hemorrhage) on the safety of TDF use, occurrence of postpartum hepatitis and deterioration of liver function, patients with gestational hypertension, premature rupture of membranes, prenatal bleeding and other pregnancy and/or delivery complications were excluded in this study. Patients with other causes of liver disease, liver fibrosis and cirrhosis were also excluded. Adverse reactions, especially renal impairment, were closely monitored during TDF antiviral therapy.

TDF is recommended as the first choice for preventing mother-to-child transmission of HBV because it can effectively inhibit HBV replication, with little drug resistance and high safety in pregnancy [25, 26]. Studies have shown that on the basis of regular neonatal immunization, if the serum HBV DNA of pregnant women was reduced to 10^6 IU/ ml before delivery, the mother-to-child transmission of HBV could be effectively blocked [27–30]. Some studies did not recommend antiviral therapy during pregnancy for blocking mother-to-child transmission of HBV in pregnant women with HBVDNA $< 10^6$ IU/ml [31]. Although most current guidelines recommend antiviral therapy for prevention of mother-to-child transmission of HBV from 28 weeks of gestation, TDF can reduce HBV DNA by more than 3 log (HBV DNA $< 10^6$ IU/ml) in pregnant women after 4 weeks of treatment due to its strong inhibition of virus replication [32]. To minimize the risk of fetal exposure to TDF and reduce the side effects of drugs on pregnant women, antiviral therapy was started at 32 weeks of gestation in this study.

Our study results showed that the success rate of mother-to-child block in tenofovir group at 32 weeks of gestation was 99.35%, which was significantly higher than that in Control group (90.56%). At the same time, HBV DNA

Table 4 Occurrence time of postpartum hepatitis

Group	Patients with hepatitis (n)	6 week	12 week	24 week
Control group	27	18 (66.7%)	8 (29.6%)	1 (3.7%)
Immediate withdrawal	31	14 (45.2%)	14 (45.2%)	3 (9.7%)
Delayed withdrawal	9	3 (33.3%)	4 (44.4%)	2 (22.2)
Total	67	35 (52.23%)	26 (38.80%)	6 (8.95%)

Note: 91.04% (61/67) of infections occurred within 12 weeks postpartum

Control: no antiviral treatment during pregnancy

Immediate withdrawal: withdrawal of antiviral drugs immediately after delivery

Delayed withdrawal: withdrawal of antiviral drugs at 6 weeks after delivery

Table 5 Factors related to postnatal hepatitis

Univariate analysis	OR	95%CI	*p* value
Age	0.957	0.891–1.027	0.221
Gestational weeks	1.009	0.800–1.271	0.942
Mode of delivery (self-delivery)	0.774	0.569–1.053	0.102
Delivery times	1.237	0.740–2.069	0.417
HBV DNA level at enrollment	0.757	0.481–1.191	0.228
HBV DNA level before delivery	0.981	0.845–1.140	0.806
Antiviral therapy	0.785	0.448–1.376	0.398
Withdrawal of treatment immediately after delivery	0.872	0.575–1.321	0.517

levels were significantly lower in the treated group at 4 weeks of antiviral treatment and before delivery than those in the untreated group, suggesting that tenofovir dipivoxil has a good antiviral effect [23, 33]. Our study showed that HBV DNA remained at a relatively stable high level during pregnancy and after delivery in the Control group. After 4 weeks of treatment, HBV DNA was significantly reduced in the tenofovir group, and the virus quickly rebounded to a high level after 6 weeks of withdrawal. But there was still a decrease in HBV DNA levels after delivery compared with baseline, which was associated with the occurrence of hepatitis in some patients. Because the high estrogen and progesterone of pregnant women can inhibit the function of immune cells of pregnant women, the immunity against HBV can also be inhibited during pregnancy. After delivery, due to the decrease of hormone levels, the inhibition of immune function is relieved, thus inducing the immune response to HBV, causing damage to liver tissue and leading to the occurrence of hepatitis.

In this prospective study, the incidence of postpartum hepatitis B in HBeAg-positive pregnant women with chronic HBV infection was 23.8%-28.1%, which is consistent with the incidence of postpartum hepatitis in our previous large retrospective study [14]. In our study, more than 90% of postpartum hepatitis occurred within 12 weeks after delivery in women without antiviral therapy or patients treated but withdrawal drug immediately at delivery, while it was 77.7 % in women with delayed withdrawal drug after delivery. It was suggested that, in pregnancy women who take drugs for blocking mother-to-child transmission of HBV, delayed withdrawal drug after delivery might delay the occurrence of postpartum hepatitis in some subjects.

In contrast, majority of postpartum hepatitis occurred within 12 weeks after withdrawal of antiviral therapy in the treated group. Chronic hepatitis B occurs in some patients with chronic HBV infection after delivery, and studies have shown that the rate of postpartum hepatitis is as high as 50% [11], mostly occurring in the early postpartum [12], especially within 6 months after delivery [11]. It is characterized by a sudden elevation of glutamic-pyruvic transaminase to more than five times the upper limit of normal, and the occurrence of postpartum hepatitis is associated with a human type I leukocyte antigen restriction, cytotoxic T-cell-mediated immune response to HBV [34]. Studies have also shown that immune changes during pregnancy, such as suppression of Th1 responses and induction of Th2 immunity, lead to impaired immune responses to HBV, stimulating viral activity, and reduction of CD8 T cells, which are associated with postpartum hepatitis [13, 35].

In 2018, we reported that HBV DNA positivity at delivery and elevated postpartum ALT were independent predictors of acute exacerbation of chronic hepatitis B in patients with chronic HBV infection without antiviral therapy [14]. Other previous studies have shown that age, HBeAg positivity, baseline ALT level, baseline HBV DNA level, and gestational order are not associated with the onset of chronic hepatitis B after childbirth [19]. Our study showed that the incidence of postpartum hepatitis B was not associated with age, antiviral therapy, DNA content before enrollment and before delivery, and timing of discontinuation of antiviral therapy. For patients receiving antiviral therapy during pregnancy, immediate and delayed discontinuation of antiviral therapy after delivery had no significant effect on the incidence of postpartum hepatitis. It is suggested that the occurrence of hepatitis cannot be predicted by antiviral treatment

during pregnancy, HBV DNA level before delivery and the time of drug withdrawal.

In conclusion, withdraw of antiviral treatment immediately or at 6 weeks after delivery did not affect the incidence of hepatitis after delivery. Above 90% of hepatitis occurred within 12 weeks after delivery in those without antiviral treatment and who immediately stopped antiviral treatment after delivery. Delaying drug withdrawal might delay the onset of postpartum hepatitis. Our results also suggest that postpartum or 12 weeks after drug withdrawal is the key follow-up period to monitor the occurrence of hepatitis. However, due to the number of completed follow-up subjects is limited in this study, the conclusions need to be further verified. What's more, because monitoring for only 24 weeks after delivery may overlook the incidence of late flare, it's recommended to observe the incidence of hepatitis at 48 weeks of postpartum in future studies.

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Author contributions ML and YX contributed to the study design and the data analysis. ML, WY, and YX contributed to the recruitment, enrolment, and assessment of participants, as well as data collection. LZ, YL, FS, YL, LY, and WD contributed to following up with the patients. XB, TJ, and LY managed all aspects of laboratory support. ML wrote the first draft of the manuscript. YX revised the manuscript. YX is the guarantor of the article. All authors approved the final version of the manuscript.

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Data availability The data that support the findings of this study are available from the corresponding author upon reasonable request.

Declarations

Conflict of interest Minghui Li, Fangfang Sun, Xiaoyue Bi, Yanjie Lin, Liu Yang, Tingting Jiang, Wen Deng, Yao Lu, Lu Zhang, Wei Yi and Yao Xie have no conflict of interest.

Ethics approval This study was approved by the Ethics Committee of Beijing Ditan Hospital Affiliated to Capital University of Medical Sciences (Jing Di Lun Ke Zi 2017 No. 004-02), and was registered with Clinical Trials (NCT03214302).

Informed consent These patients were fully informed of the risks and signed informed consent.

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