Clinical and Experimental Obstetrics & Gynecology

Clin. Exp. Obstet. Gynecol. **2022**; 49(2): 045
http://doi.org/10.31083/j.ceog4902045

Original Research

Clinical data analysis of nine years of experience with twin pregnancy: a tertiary hospital-based retrospective study

Yuan Ting[1], Zhang Ting[1], Wang Yan-Yan[1], Li Xue-Lan[1], Han Zhen[1,*]

[1]Department of Obstetrics & Gynecology, First Affiliated Hospital of Xi'an Jiaotong University, 710061 Xi'an, Shaanxi, China
*Correspondence: hanamy02@163.com (Han Zhen)
Academic Editor: George Daskalakis
Submitted: 17 March 2021 Revised: 26 April 2021 Accepted: 28 May 2021 Published: 11 February 2022

Abstract

Background: The incidence of twin pregnancy has been increasing worldwide and in China. This study provided a comprehensive analysis of the clinical data of twins in a Chinese tertiary hospital and summarized the clinical characteristics. **Methods**: A retrospective collection of data was carried out for 717 cases of twins in the Obstetrics Department of the First Affiliated Hospital of Xi'an Jiaotong University from 2011 to 2020. A comprehensive analysis of baseline information and maternal and perinatal outcomes was conducted, and the twin birth rate of the study population was also calculated. **Results**: The average twin delivery rate was 2.61%. A total of 206 cases were monochorionic, and 511 cases were dichorionic. Premature delivery, hypertensive disorder complicating pregnancy and premature rupture of membranes were the three most common complications. Caesarean section rates from 2011 to 2019 were maintained at 70%–80%. A total of 144 cases (20.08%) of 717 twin cases were complicated twins. Birthweight discordance $\geq$25% accounted for 13.53% of cases. Adverse neonatal outcomes with higher incidences were neonatal respiratory distress syndrome, small for gestational age and 1 min Apgar score $\leq$7. **Conclusions**: Twin pregnancy has different and unique clinical features. Obstetricians should pay close attention to its clinical management to obtain better perinatal outcomes.

Keywords: Chinese; Outcome; Perinatal; Retrospective; Twin

1. Introduction

In recent years, with an increase in advanced-age pregnancies and the application of assisted reproductive technology, the incidence of twin pregnancy has been increasing worldwide and in China [1–3]. However, twin pregnancies are high-risk pregnancies that are prone to be complicated with maternal and foetal complications. Currently, there are few twin studies with respect to Chinese tertiary hospitals. This study was designed to perform a descriptive analysis of twin pregnancies in a Chinese tertiary hospital, summarize the clinical characteristics of twin pregnancies, lay a foundation and indicate key directions for clinical diagnosis, treatment and further scientific studies.

2. Methods

2.1 Data collection

A total of 747 cases of twin pregnancy in the Obstetrics Department of the First Affiliated Hospital of Xi'an Jiaotong University from January 2011 to March 2020 were retrospectively retrieved from the medical record system. Of these cases, 30 were excluded due to one of the following conditions: maternal complications involving acute internal or surgical diseases, unclear chorionicity, or inaccessible records because of patient discharge from another department. In total, 717 cases with complete information and clear chorionicity were entered into the database.

The collected clinical information included the following three aspects: baseline information: maternal age, gravidity, parity, last menstruation period (LMP), pre-pregnancy weight, pregnancy weight change, height and chorionicity. Maternal information: maternal chronic diseases including thyroid disease, chronic kidney disease, connective tissue disease, viral hepatitis, and anaemia; maternal obstetrical complications including hypertensive disorder, pregnancy with diabetes, intrahepatic cholestasis of pregnancy, premature delivery, placenta previa, placental abruption, premature rupture of membranes (PROM), placental implantation, and postpartum haemorrhage; delivery outcomes including gestational week at the last admission, reason for admission, delivery week, delivery mode, and length of hospital stay. For delivery mode, the indications for emergency caesarean section included severe pre-eclampsia, cardiac failure, threatened labour or preterm labour from a scarred uterus, foetal distress, placental abruption, placenta previa, and breech presentation with PROM. The indications for elective caesarean section included scarred uterus, mild pre-eclampsia, gestational hypertension, intrahepatic cholestasis of pregnancy, women with assisted reproductive technology, women aged more than 35 years, and individual preference. The indications for vaginal delivery included inevitable abortion, PROM, threatened preterm labour, and estimated suitable foetal weights in the second trimester or early third trimester. The indications for artificial abortion (artificial abortion could

be carried out at less than 32 weeks in the case of a scarred uterus and with no gestational week limitations in the case of a uterus without scarring) included pregnancy termination due to maternal complications or diseases (severe pre-eclampsia, severe renal dysfunction, etc.) and twin-to-twin transfusion syndrome (TTTS), intrauterine foetal death (IUFD), and foetus with congenital malformations. Iatrogenic preterm birth refers to the occurrence of some complications or comorbidities in the mother or foetus, and the pregnancy needs to be terminated.

Perinatal information: neonatal outcomes including sex, foetal position, birth weight, small for gestational age (SGA) or not, very low birth weight (VLBW) or not, Apgar score, admission to neonatal intensive care unit (NICU) or not and length of hospital stay; neonatal complications, such as neonatal asphyxia, intracranial haemorrhage, neonatal respiratory distress syndrome (NRDS), and neonatal death; and the development of complicated twin pregnancy (CTP) or not, such as TTTS, selective intrauterine growth restriction (sIUGR), twin growth discordance, single intrauterine foetal death (sIUFD), structural malformation, and chromosomal abnormalities.

In addition, the twin birth rates of recent years were calculated according to the delivery records from the delivery room (including cases of induced labour at more than 28 weeks).

2.2 Judgement criteria

2.2.1 Gestational age

The gestational age was calculated according to the LMP if it was clearly provided; if the LMP was not clearly provided or if menstruation was irregular, the gestational age was calculated according to the gestational age of the larger twin as indicated by ultrasound in early pregnancy [4]; when the LMP was clearly provided, but the gestational age differed from the gestational age estimated from early ultrasound by more than 10 days, the gestational age was corrected according to the ultrasound [5]; for cases of *in vitro* fertilization-embryo transfer, the gestational age was calculated according to the day of egg retrieval or embryo transfer.

2.2.2 Chorionicity

Chorionicity [4] was judged based on the number of gestational sacs, the number of placentas and the 'T' or 'λ' sign in the first and second trimesters, the sex of twins, etc. Chorionicity was confirmed by placental examination after delivery.

2.2.3 Weight discordance

Twin weight discordance was defined as [(larger twin weight—smaller twin weight)/larger twin weight] (%) [4].

2.2.4 Perinatal adverse outcomes

TTTS [6], sIUGR [4] and growth discordance [7] were diagnosed by the corresponding criteria. Similarly, SGA, hypertensive disorder, pregnancy with diabetes, intrahepatic cholestasis of pregnancy, premature delivery, PROM, placenta previa, placental abruption, placental implantation and postpartum haemorrhage were diagnosed by the corresponding criteria [8], and VLBW, neonatal asphyxia, NRDS and intracranial haemorrhage were diagnosed by the corresponding criteria [9].

2.3 Research establishment and registration

The research was approved by the Ethics Committee of the First Affiliated Hospital of Xi'an Jiaotong University (No. XJTU1AF2015LSL-073), and a clinical research project (No. XJTU1AF-CRS-2015-003) was established. Registration has also been completed on the website clinicaltrials.gov (ID: NCT02732717). This was in accordance with the Helsinki Declaration (as revised in Tokyo 2004). Written informed consent was unnecessary due to the retrospective, observational design of the study.

2.4 Statistical analyses

The data collected from the study subjects were verified and double entered into a data management system. The parameters are presented as the mean $\pm$ SD or the median (min–max) and percentages, as appropriate. The statistical analyses were performed using the chi-square, Fisher's exact, Student's *t* and Mann-Whitney U tests, as appropriate. All of the reported *P*-values were 2-tailed, and values <0.05 were considered statistically significant. The statistical analyses and graphs were generated using SPSS 25.0 (IBM, Armonk, NY, USA) and Microsoft Excel 2007 (Microsoft, Redmond, WA, USA).

3. Results

3.1 Twin birth rate (2015–2019)

The numbers of deliveries in the study population from 2015 to 2019 were 2545, 2784, 3288, 2437, and 3318, respectively, of which the numbers of twin births were 71, 72, 83, 76, and 73, respectively. The twin birth rates were calculated as 2.79%, 2.59%, 2.52%, 3.12%, and 2.20%, respectively, and the average annual twin birth rate was 2.61% (data before 2015 were not provided because singleton birth data before 2015 were not accurate and were incomplete due to the breakdown of the old record system).

3.2 Clinical analysis of 717 twin pregnancies

There were 206 (28.73%) monochorionic twins (5 monochorionic monoamniotic twins included) and 511 (71.27%) dichorionic twins, and the maternal age was 29.35 $\pm$ 4.78 years. All baseline information is shown in Table 1.

Regarding obstetrical complications, there were 433 premature births (60.39%), of which 326 (75.29%) pre-

Table 1. Baseline information of 717 twin pregnancies.

Baseline information	Result
Chorionicity (n%)	
Monochorionicity	206 (28.73)
Dichorionicity	511 (71.27)
Maternal age (n%, y)	
≤24	100 (13.95)
25–29	307 (42.82)
30–34	199 (27.75)
≥35	111 (15.48)
Average maternal age ($\bar{x} \pm s$, y)	29.35 ± 4.78
Gravidity [M (min–max), times]	1 (0–6)
Nulliparity (n%)	500 (69.73)
Scarred uterus (n%)	73 (10.18)
Medical history (chorionic diseases, etc.) (n%)	
No	482 (67.22)
Thyroid diseases	33 (4.60)
Renal diseases	24 (3.35)
Hepatic diseases	32 (4.46)
Endocrine and connective tissue diseases	10 (1.39)
Cardiovascular diseases	8 (1.11)
Hematological diseases	10 (1.39)
Polycystic ovarian syndrome	30 (4.18)
Myoma and ovarian cyst	32 (4.46)
History of ectopic pregnancy	21 (2.93)
Others	45 (6.28)

Table 2. Maternal outcomes of 717 twin pregnancies.

Maternal outcome	Result
Gestational weeks for admission ($\bar{x} \pm s$, w)	34.55 ± 3.68
Obstetrical complication (n%)	
Hypertensive disorders	204 (28.45)
Gestational hypertension	22 (10.78)
Pre-eclampsia/eclampsia	176 (86.27)
Pregnancy with chronic hypertension	1 (0.49)
Chronic hypertension superimposed on pre-eclampsia	5 (2.45)
Intrahepatic cholestasis	70 (9.76)
Gestational diabetes	20 (2.79)
Cardiac dysfunction	31 (4.32)
Placental abruption	10 (1.39)
Placental previa	15 (2.09)
Placental adhesion or implantation	14 (1.95)
Premature rupture of membranes	157 (21.90)
Before 37 weeks	137 (87.26)
After 37 weeks	20 (12.74)
Total preterm labor	433 (60.39)
Preterm labor (according to cause)	
Spontaneous	107 (24.71)
Iatrogenic	326 (75.29)
Preterm labor (according to weeks)	
28–31^{+6}	48 (11.09)
32–33^{+6}	79 (18.24)
34–36^{+6}	306 (70.67)
Umbilical cord abnormality	28 (3.91)
Postpartum hemorrhage	30 (4.18)
Gestational weeks at delivery ($\bar{x} \pm s$, w)	34.88 ± 3.60
Delivery mode (n%)	
Caesarean section	544 (75.87)
Vaginally	151 (21.06)
Artificial abortion	22 (3.07)
Days of hospitalization ($\bar{x} \pm s$, d)	9.16 ± 5.26

mature births resulted from iatrogenic preterm labour, and 306 (70.67%) preterm births occurred at 34–36^{+6} weeks. When the twins were complicated with PROM (45%), pre-eclampsia (23%), foetal distress (15%), labour (15%), or other complications (placenta previa, placenta abruption, etc., accounting for 2%), iatrogenic premature delivery may occur.

In monochorionic twins, 47 cases (34.56%) were spontaneous preterm births, and 89 cases (65.44%) were iatrogenic premature births; however, 60 cases (20.20%) were spontaneous preterm births, and 237 cases (79.80%) were iatrogenic premature births in dichorionic twins. Monochorionic twins were more likely to have spontaneous preterm birth, and dichorionic twins were more likely to have iatrogenic preterm birth ($P = 0.001$).

A total of 204 (28.45%) cases were complicated with hypertensive disorders, of which pre-eclampsia/eclampsia and gestational hypertension accounted for 86.27% and 10.78%, respectively. Among pre-eclampsia cases, 53 cases (30.11%) were early onset, 123 cases (69.89%) were late onset, 32 cases (18.18%) were mild type, and 144 cases (81.82%) were severe type.

There were 157 (21.90%) cases with PROM, of which 87.26% occurred before 37 weeks. Most of the cases of preterm PROM terminated the pregnancy immediately or within 1–2 days.

Seventy (9.76%) cases with intrahepatic cholestasis were also identified. The incidences of other diseases, including gestational diabetes, cardiac dysfunction, placental abruption, placenta previa, placental adhesion or implantation, postpartum haemorrhage and umbilical cord abnormalities (such as knots, torsion, presentation and prolapse), were all less than 5%. Of the 717 twin pregnancies, a total of 544 (75.87%) cases were terminated by caesarean section (Table 2).

For total deliveries, 521 (72.67%) cases were terminated at 34–38 weeks. For deliveries at less than 33 weeks, caesarean section rates were approximately 30%, while after 33 weeks, caesarean section rates were at least 60%, and even as high as more than 90% up to 39 weeks (caesarean section rate = total caesarean section number/total delivery number %). At less than 33 weeks, most of the

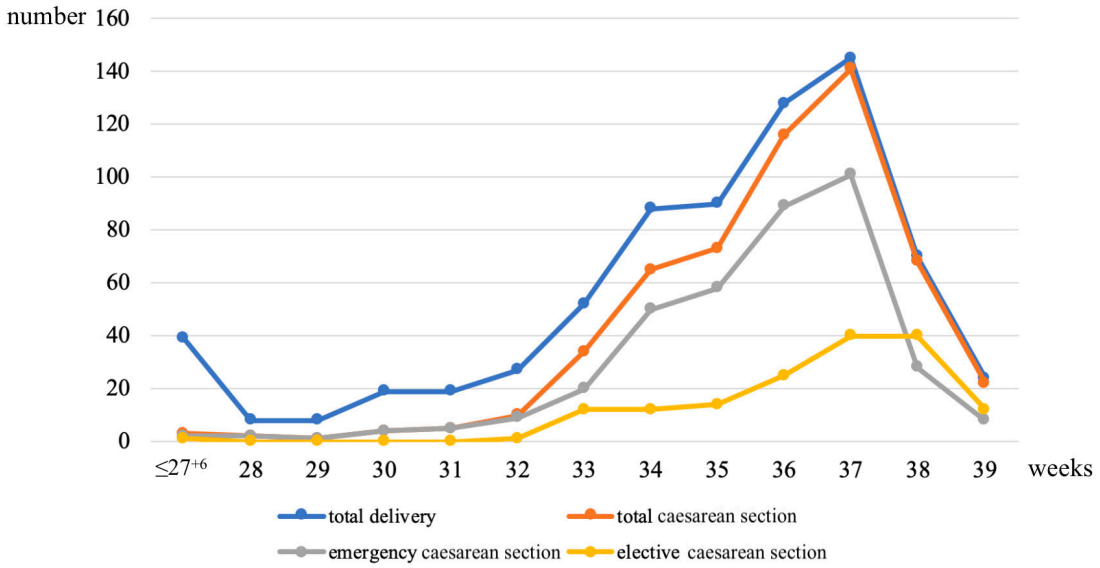

Fig. 1. Numbers of total delivery, total caesarean section, emergency caesarean section and elective caesarean section according to gestational weeks among 717 twins.

caesarean sections were emergent, while beyond 33 weeks, some cases were determined to have elective caesarean sections. Emergency caesarean section rates were approximately 70% between 33 and 37 weeks. After 38 weeks, emergency caesarean section rates decreased to approximately 40% (emergency caesarean section rate = emergency caesarean section number/total caesarean section number %) (Fig. 1).

The changes in the caesarean section rate from 2011 to 2019 were provided. Overall, the total caesarean section rate was maintained at 70%–80%; however, the rate in 2013 was 62%. The emergency and elective caesarean section rates were almost 60%–80% and 20%–40%, respectively (Fig. 2).

A total of 144 (20.08%) of the 717 twin pregnancies developed CTP, of which there were 22 cases (15.28%) with TTTS, 37 cases (25.69%) with sIUGR, 57 cases (39.58%) with growth discordance, 36 cases (25.00%) with sIUFD, and 19 cases (13.19%) with complicated structural malformation or chromosomal abnormalities. In addition, 121 cases (84.03%) were complicated with one CTP, 19 cases (13.19%) with two CTPs, and 4 cases (2.78%) with three CTPs.

There were 650 cases with both twin survivals, producing an incidence rate of 90.66%, and the incidences of one twin survival and both twin deaths were each approximately 5%. The actual twin survival rate was 92.82%, which was calculated based on the actual survival number (1331) and expected survival number (calculated as $717 \times 2 = 1434$). The birth weight parameters were for 650 cases with both twin survivals. The larger and smaller twin weights were 2384.6 ± 560.8 g and 2083.0 ± 526.9 g, respectively. Among the 1331 surviving neonates, 989 (74.31%) were transferred to the NICU for observation or treatment. Regarding adverse outcomes, NRDS, SGA and 1 min Apgar scores ≤ 7 had relatively higher incidence rates, which were 13.22%, 11.80%, and 10.52%, respectively. The incidence rates of outcomes according to three durations (out of the live births) are also provided (Table 3).

For details of perinatal death (103 cases), 53 cases (51.46%) had PROM, preterm birth or inevitable abortion; 40 cases (38.83%) had IUFD, sIUGR or TTTS; 6 cases (5.82%) had hypertension; and 4 cases (3.88%) had foetal malformations.

Based on the smoothed centiles figure, the 50th percentile and 10th percentile curves of larger twins approximately corresponded to the 90th percentile and 50th percentile curves of smaller twins in both monochorionic and dichorionic twins. For dichorionic twins, the curves were smoother and elevated gradually with gestational week, while the curves fluctuated and decreased after 38 weeks in monochorionic twins. Dichorionic twin birth weights in a gestational week were more than or equivalent to the birth weights of monochorionic twins (Fig. 3).

The median (min–max) birth weight discordance was 10.09% (0.00%–58.12%). A discordance interval of 5% was set, and the discordances and their corresponding incidences were $<5\%$ (27.08%), 5%–10% (22.15%), 10%–15% (18.61%), 15%–20% (14.00%), 20%–25% (4.62%), 25%–30% (5.38%), 30%–35% (4.00%), and $>35\%$ (4.15%). A gradual decreasing trend was observed. Birth weight discordance $\geq 25\%$ accounted for 13.53% of cases.

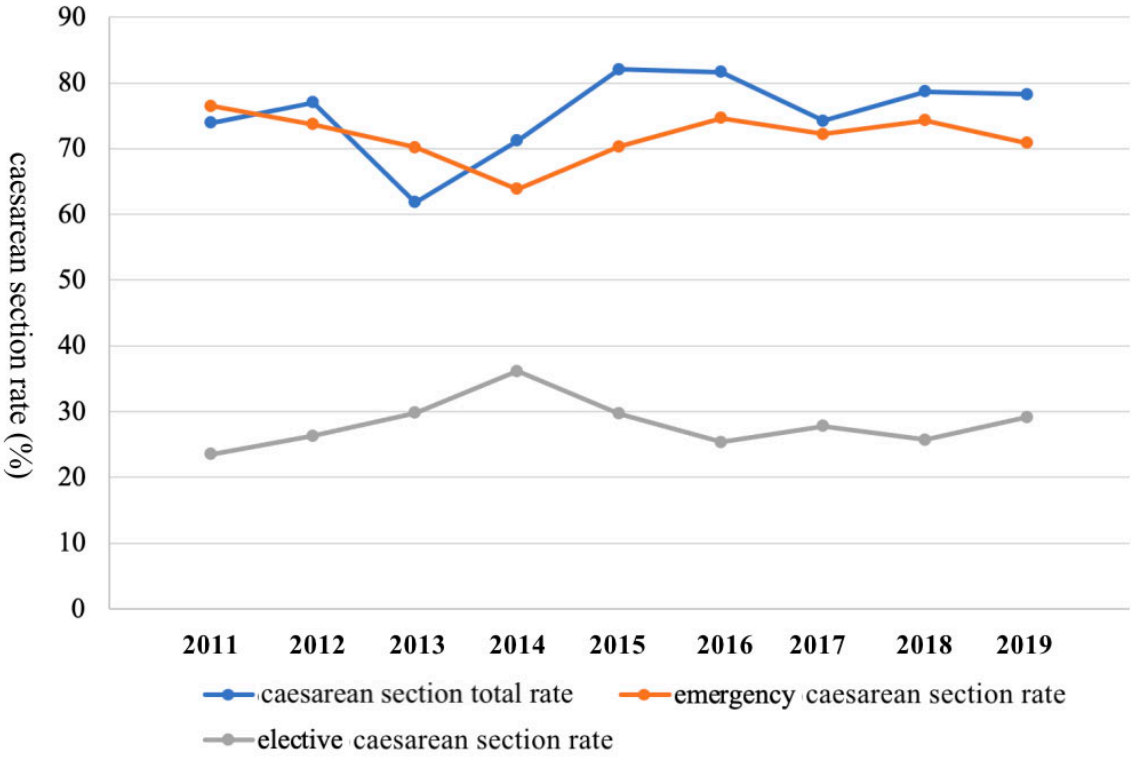

Fig. 2. Changes of the caesarean section rates from 2011 to 2019. 12 cases of the 717 twin pregnancies were delivered between January and March 2020, the total deliveries were 705 in the graph, of which, the total of caesarean section was 534. Caesarean section total rate was calculated according to the caesarean section number/the delivery number and emergency or elective caesarean section rate was calculated according to emergency or elective caesarean section number/caesarean section total number in each year.

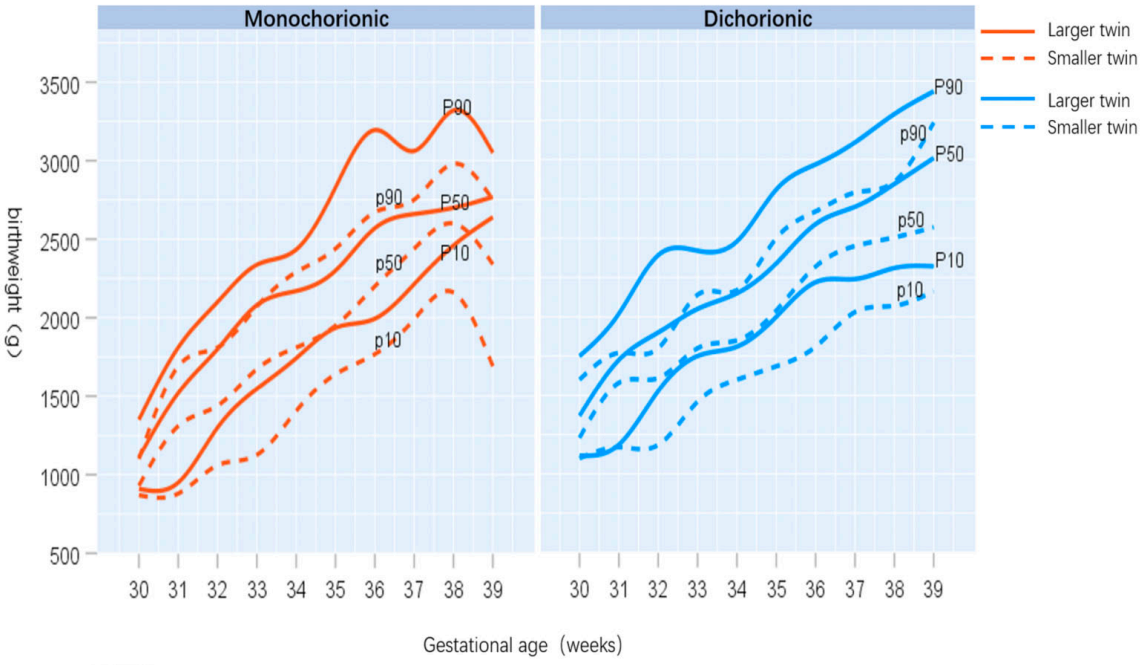

Fig. 3. Smoothed centiles of birth weight for gestational age according to chorionicity among both twin survivals.

Table 3. Perinatal outcomes of 717 twin pregnancies.

Perinatal outcome	Result
Complicated twin (n%)	144 (20.08)
Perinatal survival situation (n%)	
Both survivals	650 (90.66)
One survival	31 (4.32)
Both deaths	36 (5.02)
Twin actual survival (n%)	1331 (92.82)
Larger twin birth weight ($\bar{x} \pm s$, g)	2384.6 $\pm$ 560.8
Smaller twin birth weight ($\bar{x} \pm s$, g)	2083.0 $\pm$ 526.9
Absolute difference of weight ($\bar{x} \pm s$, g)	305.7 $\pm$ 264.8
Discordance of weight [M (min–max), %]	10.09 (0–58.12)
Sex of both twin survivals (n%)	
Male-male	212 (32.62)
Female-female	245 (37.69)
Male-female or female-male	193 (29.69)
Survival neonate transferred to NICU[a] (n%)	989 (74.31)
Days of hospitalization in NICU[a] [M (min-max), d]	9 (3–90)
Neonatal adverse outcome (<34 w, 34–37 w, $\geq$37 w, n%)	
1 min Apgar $\leq$7	70 (32.26), 55 (9.17), 15 (2.92)
Small for gestational age	46 (21.20), 67 (11.17), 44 (8.56)
Very low birth weight	80 (36.87), 12 (2.0), 2 (0.39)
Neonatal respiratory distress syndrome	121 (55.76), 49 (8.17), 6 (1.17)
Intracranial hemorrhage	22 (10.14), 24 (4.0), 1 (0.19)
Neonatal death	29 (13.36), 6 (1.0), 1 (0.19)

[a] NICU, neonatal intensive care unit.

4. Discussion

In recent years, the incidence of twin pregnancy has shown an upward trend worldwide and in China. The recent twin birth rate in the Chinese population was 2.61%. From the perspective of epidemiology, twin pregnancy has become more common in the current obstetrical clinical management.

In this study, monochorionic twins accounted for 28.73%, and dichorionic twins accounted for 71.27%. According to previous data, the incidence of monochorionic twins in natural pregnancies was approximately 1/250 [10], accounting for 20% of all twins. However, with the application of assisted reproductive technology, the current incidence has increased 2–12 times [11]. The rate of monochorionic twins in the present study was different from that in previous reports, and different nations, races and sample sizes may account for this discrepancy.

In addition, in this study, 717 women were 29.35 $\pm$ 4.78 years old, women between the ages of 25–34 years accounted for approximately 70%, and approximately 70% of the women were experiencing their first deliveries. These results were somewhat different from previous results. Otta *et al*. [12] believed that the incidence of twin pregnancy increased with the age of the mother, with dichorionic twins being particularly common. Kullima *et al*. [13] found that 60% of twin pregnancies occurred in the maternal age group of 20–29 years. Aduloju *et al*. [14] showed that more than 50% of mothers had delivered multiple times previously. Some of the reasons that may account for these differences include diverse birth conditions in different countries and regions, varied sample sizes among different studies, and exclusions of some factors, such as the application of assisted reproductive technology.

Twin pregnancy is a high-risk pregnancy, which increases the risks of obstetrical complications. In this study, preterm birth, hypertensive disorder and PROM were the three most common complications, with incidence rates of 60.39%, 28.45% and 21.90%, respectively.

In the 717 twins, the gestational weeks at delivery were concentrated between 34–38 weeks (72.67%). According to the 2013 birth information published by the National Center for Health Statistics (NCHS), the delivery weeks of singleton births were focused at 37–40 weeks (75.91%) [1]; thus, it appeared that there was a large difference in the delivery week between twins and singletons, which seemed reasonable. Twin pregnancies were more likely to deliver earlier.

However, the rate of total preterm birth in the study population exceeded 60%, of which 75% of the cases were iatrogenic preterm births, 10% occurred before 32 weeks,

less than 20% of the cases occurred at 32–33^{+6} weeks, and 70% were at 34–36^{+6} weeks. In 2013, 132,324 twin pregnancies were delivered in the United States, of which 56.56% were preterm births, and 11.31% of the cases occurred before 32 weeks. This group of data was similar to the results of this study. These two sets of data corresponding to singletons in the USA in 2013 were 9.71% and 1.54%, respectively [1]. Compared with singletons, twin pregnancies had earlier delivery weeks and a higher incidence of preterm birth; preterm birth is definitely an important reason that increases the risk of neonatal morbidity and mortality. The common investigations to prevent preterm birth in twins included cervical cerclage with ultrasound monitoring, progesterone use, cervical pessary use, bed rest and uterine monitoring. Currently, there is a lack of effective, evidence-based interventions for the prevention of preterm birth in twin pregnancies [15].

Hypertensive disorder is the main threat to the health of mothers and foetuses. Hypertensive disorder was demonstrated to be one of the three most common complications, with an incidence rate of 28.45% in the current study. However, the incidence was higher than the incidence rate of 22% in a previous literature report [16]. Some reasons may account for the discrepancy. First, there were four types of hypertensive disorders included in the current study, while only pre-eclampsia and gestational hypertension were included in the previous study. Second, our hospital was a tertiary organization that managed pregnant women with hypertension, especially those with severe conditions.

Pre-eclampsia accounted for the largest proportion (nearly 86%) of hypertensive disorder types. Among pre-eclampsia, most cases were of late onset and severe type. According to a previous study by our group, there were poor perinatal outcomes (such as preterm birth, iatrogenic preterm birth, intrauterine growth restriction, neonatal neurological complications, and reduced birth weights) for twins complicated with pre-eclampsia compared with normotensive twins [17].

According to Fig. 1, we thought that if the pregnancies were terminated before 33 weeks, vaginal delivery was more common. Most of these cases were terminated vaginally or through artificial abortion due to PROM, inevitable abortion, sIUFD, etc. Some cases had emergency caesarean sections before 33 weeks due to pre-eclampsia, scarred uterus, etc. After 33 weeks, caesarean section rates were higher due to obstetrical complications and large baby weight.

Emergency caesarean section rates were higher (approximately 70%) between 33 and 37 weeks, mostly due to the higher incidence rates of obstetrical complications (pre-eclampsia, foetal distress, PROM, threatened preterm labour, etc.) and twin complications (TTTS, IUFD, sIUGR, etc.) in this time period. When the twins survived through that duration, the emergency caesarean section rate decreased, and more than half of cases were terminated with elective caesarean sections between 38 and 39 weeks.

The caesarean section rate has been maintained at a level of 70%–80% in recent years. However, in 2013, there was a 'low valley', with a sudden decrease in the rate to 62%. This decrease may be related to an increase in vaginal deliveries (35%) due to PROM and threatened premature birth in that year. The delivery modes of 717 twins were caesarean section, vaginal delivery and artificial abortion, which accounted for 75.87%, 21.06% and 3.07%, respectively. In the study population, caesarean section was the main delivery mode for the majority of women in our hospital, which was perhaps related to the fact that some women were with severe obstetrical complications in this tertiary hospital, or had conceived by assisted reproductive technology to achieve such a desired pregnancy. Choosing an optimal delivery mode for twins is an important issue in clinical management.

In 2013, a multi-centre randomized trial by the Twin Birth Study Collaborative Group randomly assigned 1398 and 1406 pregnant women to a planned caesarean section group and planned vaginal delivery group, respectively. The final caesarean section rates were 90.7% and 43.8%, respectively. Neonatal adverse outcomes in both groups were followed up, and it was found that a planned caesarean section did not significantly change (reduce or increase) the risks of perinatal death and serious neonatal complications for the twins who were born between 32–38^{+6} weeks when the first foetus was head position [18]. Based on this background, in 2016, the Twin Birth Study Collaborative Group conducted a subsequent study investigating long-term mortality and neurodevelopment in 4,603 children and found no significant difference between the planned caesarean section group and the planned vaginal delivery group [19]. Currently, there is no authoritative evidence supporting planned caesarean section for improving the short-term and long-term outcomes of twin pregnancies. Mostly according to the policies in the world and in China, our choice of delivery mode was comprehensively decided by chorionicity, maternal history, complications, foetal position, local medical care level and clinical experiences and techniques. Vaginal delivery may be attempted more with increasing clinical experience.

For neonatal adverse outcomes, the incidences of 1 min Apgar score $\leq$7, SGA, and NRDS were all between 10%–20%, and the incidences of VLBW were 7.06%, which were similar to the data from NCHS [1]. These outcomes mostly occurred before 37 weeks, and 1 min Apgar $\leq$7, NRDS, and VLBW were more common before 34 weeks.

Based on Fig. 3, the common features were similar to those in previous research [20], of which monochorionic twins were consistently smaller than dichorionic twins after 27 weeks of gestation. The sample size of the birth weight curves was not large enough in the current study, which

could be the main reason for the imperfect curve and the decreasing trend after 38 weeks in monochorionic twins. Of course, there would be some differences in curves among various races and regions.

The incidence of weight discordance exhibited a gradual decrease in the range of 5% to 35%, which was consistent with what was reported in other literature [21]. Growth discordance was demonstrated to be a risk factor for intrauterine death, especially when at least one foetus was small for gestational age (SGA) [22]; growth discordance also increased the risk of neonatal asphyxia [23] and affected the long-term neurodevelopment of the smaller twin [24]. From 20 weeks, discordance in estimated foetal weight should be calculated and documented at each scan. If discordance reaches 25% or more, a referral should be made to a tertiary-level foetal medicine unit for assessment, increased foetal surveillance, including foetal Doppler, and planning of delivery when appropriate [4].

The limitations of the study included the absence of some clinical information due to the retrospective study design and the limited record system (such as the method of fertilization, twin family history, and BMI) and the inability to compare twins and singletons in the same population. Research on malformations of twins from natural conception and *in vitro* procedures would be welcome.

It should be pointed out that, in the present article, comparisons between monochorionic and dichorionic twins were not presented because these contents are the main text of another published article by our team, which was why we did not show them here. The aim of this study was to show an overview of the population twin outcome, not to provide a comparison. Studies on twin perinatal outcome comparisons between monochorionic and dichorionic twins are certainly meaningful and welcome.

5. Conclusions

In conclusion, an overview of the baseline characteristics, maternal outcomes and perinatal outcomes in the Chinese twin population was provided, including 717 cases in nearly ten years, which may be helpful for obstetrical management. Obstetricians should pay greater attention to the clinical management of twin pregnancies to obtain better maternal and foetal outcomes. This study provided more information for twin clinical studies from the perspective of the Chinese twin population.

Author contributions

YT reviewed the relevant literatures, organized and wrote the manuscript. LXL and HZ conceived of the study, designed of it and provided some part of data. ZT and WYY accomplished parts of figures and tables and contributed in writing the manuscript. All authors read and approved the final manuscript.

Ethics approval and consent to participate

The research has been approved by the Ethics Committee of the First Affiliated Hospital of Xi'an Jiaotong University (Grant No. XJTU1AF2015LSL-073) and the clinical research project (NO. XJTU1AF-CRS-2015-003) has been set up. It is in accordance with the Helsinki Declaration of 1975, as revised in 2000. Registration has also been completed on the website clinicaltrials.gov (ID: NCT02732717). The written informed consent was unnecessary due to the retrospective, observational study.

Acknowledgment

Thanks to all of the members in our team.

Funding

This study was supported by the Health and Family Planning Commission Project of Shaanxi Province (NO. 2016D063) from HZ and Science and Technology Planning Project of Shaanxi Province (NO. 2020JQ-523) from YT.

Conflict of interest

The authors declare no conflict of interest.

References

[1] Martin JA, Hamilton BE, Osterman MJK, Driscoll AK. Births: Final Data for 2018. National Vital Statistics Reports. 2019; 68: 1–47.

[2] Smits J, Monden C. Twinning across the Developing World. PLoS ONE. 2011; 6: e25239.

[3] Lu X, Zhang J, Liu Y, Wang T, Lu Y, Li Z. Epidemiology of twin births in southeast China: 1993-2005. Twin Research and Human Genetics. 2013; 16: 608–613.

[4] Khalil A, Rodgers M, Baschat A, Bhide A, Gratacos E, Hecher K, *et al*. ISUOG Practice Guidelines: role of ultrasound in twin pregnancy. Ultrasound in Obstetrics & Gynecology. 2016; 47: 247–263.

[5] Shivkumar S, Himes KP, Hutcheon JA, Platt RW. An ultrasound-based fetal weight reference for twins. American Journal of Obstetrics and Gynecology. 2015; 213: 224.e1–224.e9.

[6] Quintero RA, Morales WJ, Allen MH, Bornick PW, Johnson PK, Kruger M. Staging of twin-twin transfusion syndrome. Journal of Perinatology. 2000; 19: 550–555.

[7] Kilby MD, Bricker. Management of monochorionic twin pregnancy. BJOG: An International Journal of Obstetrics and Gynaecology. 2016; 124: e1–e45.

[8] Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS, Hoffman BL, *et al*. Williams Obstetrics. New York: McGraw-Hill Education. 2014.

[9] Clarence W. Gowen. Fetal and neonatal medicine. Philadelphia: Elsevier. 2015.

[10] Chalouhi GE, Essaoui M, Stirnemann J, Quibel T, Deloison B, Salomon L, *et al*. Laser therapy for twin-to-twin transfusion syndrome (TTTS). Prenatal Diagnosis. 2011; 31: 637–646.

[11] Bebbington M. Twin-to-twin transfusion syndrome: current understanding of pathophysiology, in-utero therapy and impact for future development. Seminars in Fetal and Neonatal Medicine. 2010; 15: 15–20.

[12] Otta E, Fernandes ES, Acquaviva TG, Lucci TK, Kiehl LC, Varella MA, *et al*. Twinning and multiple birth rates according to

maternal age in the city of Sao Paulo, Brazil: 2003-2014. Twin Research and Human Genetics. 2016; 19: 679–686.

[13] Kullima AA, Audu BM, Geidam AD. Outcome of twin deliveries at the University of Maiduguri Teaching Hospital: a 5-year review. Nigerian Journal of Clinical Practice. 2011; 14: 345–348.

[14] Aduloju OP, Olofinbiyi B, Olagbuji BN, Ade-Ojo IP, Akintayo A. Obstetric outcome of twin gestations in a tertiary hospital South-western Nigeria. Journal of Maternal-Fetal & Neonatal Medicine. 2015; 28: 900–904.

[15] Murray SR, Stock SJ, Cowan S, Cooper ES, Norman JE. Spontaneous preterm birth prevention in multiple pregnancy. Obstetrician & Gynaecologist. 2018; 20: 57–63.

[16] Taguchi T, Ishii K, Hayashi S, Mabuchi A, Murata M, Mitsuda N. Clinical features and prenatal risk factors for hypertensive disorders in twin pregnancies. The Journal of Obstetrics and Gynaecology Research. 2014; 40: 1584–1591.

[17] Yuan T, Wang W, Li X, Li C, Li C, Gou W, *et al*. Clinical characteristics of fetal and neonatal outcomes in twin pregnancy with preeclampsia in a retrospective case-control study: a STROBE-compliant article. Medicine. 2016; 95: e5199.

[18] Barrett JFR, Hannah ME, Hutton EK, Willan AR, Allen AC, Armson BA, *et al*. A Randomized Trial of Planned Cesarean or Vaginal Delivery for Twin Pregnancy. New England Journal of Medicine. 2013; 369: 1295–1305.

[19] Asztalos EV, Hannah ME, Hutton EK, Willan AR, Allen AC, Armson BA, *et al*. Twin Birth Study: 2-year neurodevelopmental follow-up of the randomized trial of planned cesarean or planned vaginal delivery for twin pregnancy. American Journal of Obstetrics and Gynecology. 2016; 214: 371.e1–371.e19.

[20] Premkumar P, Antonisamy B, Mathews J, Benjamin S, Regi A, Jose R, *et al*. Birth weight centiles by gestational age for twins born in south India. BMC Pregnancy and Childbirth. 2016; 16: 64.

[21] Tan H, Wen SW, Fung Kee Fung K, Walker M, Demissie K. The distribution of intra-twin birth weight discordance and its association with total twin birth weight, gestational age, and neonatal mortality. European Journal of Obstetrics, Gynecology, and Reproductive Biology. 2005; 121: 27–33.

[22] D'Antonio F, Odibo AO, Prefumo F, Khalil A, Buca D, Flacco ME, *et al*. Weight discordance and perinatal mortality in twin pregnancy: systematic review and meta-analysis. Ultrasound in Obstetrics & Gynecology. 2018; 52: 11–23.

[23] Jahanfar S, Lim K, Ovideo-Joekes E. Birth weight discordance and adverse perinatal outcomes. Journal of Perinatal Medicine. 2017; 45: 603–611.

[24] Halling C, Malone FD, Breathnach FM, Stewart MC, McAuliffe FM, Morrison JJ, *et al*. Neuro-developmental outcome of a large cohort of growth discordant twins. European Journal of Pediatrics. 2016; 175: 381–389.