Twin Research and Human Genetics
Volume 16 ▌ Number 3 ▌ pp. 727–731 ▌ © The Authors 2013 ▌ doi:10.1017/thg.2013.22

Perinatal Outcomes in Preterm Growth-Restricted Twins: Effects of Gestational Age and Fetal Condition

Sebastián Manzanares,[1] Mar Sanchez-Gila,[1] María D. Moreno-Martinez,[1] Alejandro Ramirez-Arredondo,[2] and Alicia Pineda[1]
[1]Obstetrics and Gynecology Department, Virgen de las Nieves University Hospital, Granada, Spain
[2]Neonatology Department, Virgen de las Nieves University Hospital, Granada, Spain

Objective: To evaluate the perinatal outcome of intrauterine growth-restricted preterm twins and contribution of prematurity to morbidity and mortality. *Study design:* A case–control study of 211 preterm twins: 108 growth-restricted twins matched with 103 normal growth twins of the same gestational age. Mortality and morbidity rates were compared between groups. *Result:* Fetal and overall perinatal mortality rates of growth-restricted fetuses were higher than normal growth ones. Respiratory distress syndrome incidence was lower and neurologic sequelae incidence higher in growth-restricted twins. No differences were observed between groups with respect to neonatal mortality, low Apgar score, neonatal intensive care unit admission, periventricular hemorrhage, sepsis, jaundice, and hematologic or metabolic disorders. *Conclusion:* Adverse perinatal outcomes of preterm twins complicated with intrauterine growth restriction are represented by a higher antepartum mortality rate, but once born alive, neonatal outcomes seem to be associated only with gestational age at birth, excluding a protective effect on lung maturation and a higher risk of long-term neurologic sequelae.

Keywords: twins, intrauterine growth restriction, perinatal mortality, neonatal morbidity

Twin pregnancies are increasing in incidence in developed countries, partly due to the increased use of artificial reproductive technologies and, to a lesser extent, due to the increase in mean maternal age (Blondel et al., 2002). Twin pregnancies have higher perinatal mortality and morbidity rates than singletons (Amaru et al., 2004; Hawrylyshyn et al., 1982; Spellacy et al., 1990) and this is largely associated with the increased rates of preterm birth and delivery of small for gestational age (SGA) babies (Ghai & Vidyasagar, 1988; Kiely, 1990). Reports on the risk of adverse perinatal outcomes attributable to intrauterine growth restriction (IUGR) in twins have been conflicting, and there is no consensus about the contribution of prematurity to morbidity and mortality (Baker et al., 1997; Buekens & Wilcox, 1993; Kilpatrick et al., 1996; Yinon et al., 2005).

The aim of this study was to evaluate the perinatal outcomes of an IUGR pre-term twins group compared with a matched group of normal growth twins of the same gestational age in order to assess whether prematurity or fetal condition is the main risk factor associated with higher morbidity and mortality.

Subjects and Methods

Perinatal outcomes in a group of 108 IUGR preterm twins (from 24th to 36th week of gestation) were evaluated and compared with a group of 103 normal growth twins, matched for gestational age at delivery, included as the next normal growth twin born. All deliveries were attended at the Virgen de las Nieves University Hospital, Granada, Spain, between January 2003 and June 2011. The local ethics committee approved the study design.

We defined IUGR as birth weight below the 10th centile for gestational age, according to specific growth charts for twins (Voigt et al., 1996). Pregnancies with major fetal

RECEIVED 6 June 2012; ACCEPTED 4 February 2013. First published online 2 April 2013.

ADDRESS FOR CORRESPONDENCE: Sebastián Manzanares, Obstetrics and Gynecology Department, Virgen de las Nieves University Hospital, Fuerzas Armadas Av. 18014, Granada, Spain. E-mail: sebastian.manzanares.galan@gmail.com

anomalies, aneuploidies, or findings consistent with twin-to-twin transfusion syndrome were excluded.

Maternal characteristics (age and parity), pregnancy data (chorionicity, antenatal steroid therapy, and gestational age at delivery), and delivery data (route of delivery, birth order, and birth weight) were compared between the two groups in order to consider possible confounding variables. Gestational age was assessed during the first trimester of pregnancy by considering the date of the last menstrual period, the date of ovum pick-up in in vitro fertilization cases and first trimester ultrasound biometry. Chorionicity was also assessed by first trimester ultrasound and confirmed with post-delivery placental examination.

The primary outcome for the study was perinatal mortality rate (PMR), defined as stillbirths or neonatal deaths occurring within 4 weeks of delivery. Secondary perinatal outcomes evaluated included rates of low Apgar score (below 5 at 1 minute or below 7 at 5 minutes), admission to the neonatal intensive care unit (NICU), respiratory distress syndrome (RDS), intraventricular hemorrhage (IVH), clinical sepsis, jaundice (serum bilirubin > 15 mg/dl), hematologic disorder (anemia as serum hemoglobin < 10 g/dl, thrombocytopenia as platelet count < 150,000/μl, or polycythemia as hematocrit > 60%), metabolic disorder (hypoglycemia as serum glucose < 40 mg/dl, hypocalcaemia as serum ionic calcium < 1 mmol/L), and neurologic sequelae (as any kind of psychomotor impairment or sensorial deficit). Furthermore, the rate of survival with any neonatal complication or sequelae was studied.

Sample size was determined assuming a 30% incidence of at least one perinatal death or neonatal morbidity in IUGR preterm twins and 10% in normal preterm twins, and a 10% incidence of lost cases. As such, a global sample of at least 180 fetuses provides 90% power for a two-sided test and a type 1 error of 0.05.

Statistical analysis was performed using SPSS version 19. Continuous variables were compared using Student's *t* test and dichotomous variables using the χ^2 Pearson test with continuity correction and Fisher's exact test in cases in which expected frequencies less than 5 were more than 20%. Odds ratios (OR), as estimate of the relative risk of an event, and 95% confidence intervals (CI) are reported for each mortality rate. A 95% CI from which 1.0 is excluded indicated an OR statistically significant. A *p* value of <.05 was considered significant in all tests.

Results

Summary maternal, pregnancy, and delivery descriptive data are displayed in Table 1. Groups were similar with regard to maternal age, parity, gestational age at delivery, chorionicity, antenatal steroid administration, birth order, fetal gender, or cesarean section rates. As expected, the groups were different with respect to mean birth-weight, with the IUGR group being lighter.

TABLE 1

Maternal and Delivery Data

	IUGR	Normal growth	*p*
Maternal age (years)[a]	32.5 ± 5.6	33.7 ± 5.5	ns
Parity (% nulliparous)	53.3	46.7	ns
Gestational age (weeks)[a]	33.17 ± 2.84	32.88 ± 2.88	ns
Chorionicity (% dichorionic)[b]	47.1	52.9	ns
Antenatal steroid therapy	50.6	49.4	ns
Born second	56.6	43.4	ns
Fetal gender (% male)	48.3	51.7	ns
Birth weight (g)[a]	1,308.2 ± 392.3	1,826.8 ± 438.7	<.001
Cesarean birth (%)[b]	51.1	48.9	ns

Note: [a]Mean ± *SD*;[b]proportion ns (not significant). IUGR = intrauterine growth restriction.

TABLE 2

Perinatal Mortality

	IUGR *n* (%)	Normal growth *n* (%)	*p*	OR (95% CI)
Fetal mortality	10 (10.2)	0 (0)	<.005	2.05 (1.78–2.36)
Neonatal mortality	6 (6.1)	3 (2.9)	ns	2.17 (0.52–8.94)
Perinatal mortality	16 (16.2)	3 (2.9)	<.005	5.79 (1.63–20.5)

Note: ns = not significant. IUGR = intrauterine growth restriction.

TABLE 3

Neonatal Morbidity

	IUGR *n* (%)	Normal growth *n* (%)	*p*
Low Apgar score	4 (2.4)	6 (3.6)	ns
NICU admission	43 (43.9)	33 (32)	ns
RDS	17 (17.3)	32 (31.1)	<.05
IVH	3 (3.1)	5 (4.9)	ns
Sepsis	9 (9.2)	7 (6.8)	ns
Jaundice	25 (25.5)	24 (23.3)	ns
Neurologic sequelae	8 (8.2)	2 (1.9)	<.05
Hematologic disorders	24 (24.5)	19 (18.4)	ns
Metabolic disorders	16 (16.3)	12 (11.7)	ns
Any neonatal morbidity	54 (55.1)	47 (45.6)	ns

Note: ns = not significant.
IUGR = intrauterine growth restriction; IVH = intraventricular hemorrhage; NICU = neonatal intensive care unit; RDS = respiratory distress syndrome.

Perinatal mortality data are displayed in Table 2. A higher fetal mortality (102 per 1,000 vs. no cases) was observed in IUGR preterm twins versus normal growth ones of similar gestational age (OR 2.05, 95% CI 1.78–2.36). Overall perinatal mortality rate was also higher (162 per 1,000 vs. 29 per 1,000, OR 5.79, 95% CI 1.63–2.05). However, no significant differences were observed in neonatal mortality.

The data on neonatal morbidity in born-alive fetuses are displayed in Table 3. IUGR fetuses showed a lower incidence of RDS and a higher incidence of neurologic sequelae (Table 4). All the other conditions studied demonstrated no significant difference between IUGR preterm twins versus normal growth ones, neither any condition alone nor for survival rate without any morbidity in the neonatal period, nor low Apgar score or NICU admission rates.

https://doi.org/10.1017/thg.2013.22 Published online by Cambridge University Press

TABLE 4

Neurologic Sequelae

Case	Group	Diagnosis	Follow-up
1	IUGR	Neurodevelopmental delay	3 years
2	IUGR	Neurodevelopmental delay	2 years
3	IUGR	Neurodevelopmental delay	7 years
4	IUGR	Neurodevelopmental delay	1 year
5	IUGR	Neurodevelopmental delay	1 year
6	IUGR	Porencephaly, epilepsy	7 years
7	IUGR	Language delay, hearing loss	6 years
8	IUGR	Language delay, hearing loss	6 years
9	Normal	Encephalomalacia, epilepsy, language delay	6 years
10	Normal	Retinopathy	5 years

Note: IUGR = intrauterine growth restriction.

Discussion

Perinatal outcomes in twins attributable to IUGR are not clear. IUGR, a term describing infants who have failed to reach their intrauterine growth potential secondary to a pathological cause (Muhlhausler et al., 2011), is a well-established risk factor for fetal demise (Bryan, 1986; Grobman & Peaceman, 1998). However, some studies have reported reduced PMRs in low-birth-weight twins (Bleker et al., 1979; McCarthy et al., 1981; Williams et al., 1982), and others find a similar outcome when adjusting for gestational age (Baker et al., 1997; Buekens & Wilcox, 1993; Haimovich et al., 2011; Kilpatrick et al., 1996). Nevertheless, most studies that examined the effect of IUGR on morbidity and mortality in preterm infants were carried out among newborn populations from singleton pregnancies (McIntire et al., 1999; Tyson et al., 1995), and very few have addressed the issue of twinning. Of these, most of them have focused on the fact of discordant twins (Amaru et al., 2004; Blickstein & Keith, 2004; Demissie et al., 2002; Fraser et al., 1994; Yinon et al., 2005).

Moreover, twins are born lighter than singletons, with the normal distribution of birth weight for these infants shifted to the left of the normal singleton distribution (Alexander et al., 1998). So, despite the use of singleton nomograms among various investigators, we believe, as others do (Yinon et al., 2005), that to evaluate the intrauterine growth of twins it is more appropriate to use twin-specific growth curves, because these specific curves tend to show decreased growth velocity compared with singletons starting at 30–32 weeks, and its use avoids including small but appropriately grown twins.

In this study, using these specific charts, after matching for gestational age and excluding confounding variables, we found that perinatal mortality in IUGR twins was higher than in normal growth twins. Nevertheless, in our data as in other studies (Fraser et al., 1994), the increase in perinatal mortality is restricted to the risk of dying in utero, probably due to chronic deprivation of nutrients and oxygen related to a fetal pathologic condition. Neonatal mortality did not show significant differences between groups. This finding is consistent with the concept that the neonatal mortality in growth-restricted twins is mainly related to preterm delivery, rather than to an inherent problem with the IUGR twin fetus or neonate, as is similar in growth-restricted or not preterm fetuses.

As in this study, several papers report lower RDS rates among SGA infants (Cifuentes et al., 2002; Gluck & Kulovich, 1973; Horbar et al., 2002; Procianoy et al., 1980). One possible explanation that has been proposed for these phenomena is that the fetus reacts to distress, increasing the glucocorticoid production, which could enhance lung maturation (Cock et al., 2001; Laatikainen et al., 1988; Perelman et al., 1985). In our data, the RDS rate of the IUGR group was significantly lower than normal growth twins, despite maternal steroid therapy being similar in both groups. Thus, we can conclude from these findings that IUGR confers a protective effect on lung maturation.

The rate of hyperbilirubinemia and jaundice was similar in the IUGR twins and the normal growth group. It has been hypothesized that delayed liver maturation caused by IUGR might contribute to an increased risk of this condition (Flecknell et al., 1981), and a recent study found an increased rate of hyperbilirubinemia in IUGR twins (Haimovich et al., 2011), but these results have not been confirmed in this study.

Reduced oxygen and nutrients supply leads to hypoglycemia, hypocalcaemia, thrombocytopenia, and polycythemia, among others, and has been recognized as a condition associated with IUGR (Haram et al., 2007; Kramer et al., 1990). Meanwhile, pre-mature babies are at an increased risk of anemia and hypoglycemia (Haimovich et al., 2011). No difference between the groups in the incidence of any metabolic or hematological disorders analyzed was identified. So we conclude that they are only related to prematurity and are not associated with IUGR in twins.

Twins are known to have a higher incidence of neurodevelopmental disorders compared with singletons (Kragt et al., 1985), and premature birth, growth retardation, and birth asphyxia are important antecedents of these problems (Ghai & Vidyasagar, 1988). Numerous experimental studies in animals have shown that early undernutrition influences future cognition (Morgane et al., 1993), and several investigations (Hawdon et al., 1990; Hutton et al., 1997; Robertson et al., 1990) raise the hypothesis that infants who suffer growth restriction during the prenatal period, and hence are likely to be deprived of an optimal supply of nutritional substrates, are at risk of impaired neural and cognitive development. In our findings, the incidence of neurologic sequelae in the IUGR group was fourfold that of normal growth twins ($p < .05$). IVH increases with prematurity and, when significant (grade 3 or 4), can result in major neurologic impairments (Vohr et al., 1992); however, in this study, groups were not different in the incidence of this condition.

https://doi.org/10.1017/thg.2013.22 Published online by Cambridge University Press

We also analyzed the presence of any significant diagnosis/morbidity in our study population. We found that 55.1% of IUGR twins had any morbidity, compared with 45.6% in normal growth fetuses. There were no significant differences between two groups. These figures are consistent with other investigators (Fraser et al., 1994; Ghai & Vidyasagar, 1988; Ho & Wu, 1975) and point out that IUGR itself did not seem to be associated with overall neonatal morbidity.

Our study is limited by the size of the groups. Despite a size calculation being carried out, certain outcomes were relatively rare, and the study was underpowered enough to analyze meaningful differences between groups for these outcomes. However, we were able to evaluate the clinically important neonatal morbidity or perinatal death. On the contrary, data may be generalizable only to a similar clinical institution, that is, a tertiary care center that cares for high-risk and preterm fetuses and neonates.

In summary, this study provides data for better understanding of the effect of IUGR on morbidity and mortality rates in preterm twins. Understanding the effect of growth restriction on neonatal performance is of considerable value in terms of obstetric and neonatal decision-making processes, as well as for parental consultation. The importance of our results is that they attempt to establish the impact of growth restriction on perinatal outcome in preterm twins. We have shown that adverse perinatal outcomes of preterm twins complicated with IUGR are represented by a higher stillbirth rate, and this stresses the importance of antenatal recognition. However, once born alive, neonatal outcomes seem to be associated only with gestational age at birth, except for a protective effect on lung maturation and a higher incidence of long-term neurologic sequelae.

References

Alexander, G. R., Kogan, M., Martin, J., & Papiernik, E. (1998). What are the fetal growth patterns of singletons, twins, and triplets in the United States? *Clinical Obstetrics and Gynecology*, *41*, 114–125.

Amaru, R. C., Bush, M. C., Berkowitz, R. L., Lapinski, R. H., & Gaddipati, S. (2004). Is discordant growth in twins an independent risk factor for adverse neonatal outcome? *Obstetrics & Gynecology*, *103*, 71–76.

Baker, E. R., Beach, M. L., Craigo, S. D., Harvey-Wilkes, K. B., & D'Alton, M. E. (1997). A comparison of neonatal outcomes of age-matched, growth-restricted twins and growth-restricted singletons. *American Journal of Perinatology*, *14*, 499–502.

Bleker, O. P., Breur, W., & Huidekoper, B. L. (1979). A study of birth weight, placental weight and mortality of twins as compared to singletons. *British Journal of Obstetrics and Gynaecology*, *86*, 111–118.

Blickstein, I., & Keith, L. G. (2004). Neonatal mortality rates among growth-discordant twins, classified according to the birth weight of the smaller twin. *American Journal of Obstetrics & Gynecology*, *190*, 170–174.

Blondel, B., Kogan, M. D., Alexander, G. R., Dattani, N., Kramer, M. S., Macfarlane, A., & Wen, S. W. (2002). The impact of the increasing number of multiple births on the rates of preterm birth and low birthweight: An international study. *American Journal of Public Health*, *92*, 1323–1330.

Bryan, E. M. (1986). The intrauterine hazards of twins. *Archives of Disease in Childhood*, *61*, 1044–1045.

Buekens, P., & Wilcox, A. (1993). Why do small twins have a lower mortality rate than small singletons? *American Journal of Obstetrics & Gynecology*, *168*, 937–941.

Cifuentes, J., Bronstein, J., Phibbs, C. S., Phibbs, R. H., Schmitt, S. K., & Carlo, W. A. (2002). Mortality in low birth weight infants according to level of neonatal care at hospital of birth. *Pediatrics*, *109*, 745–751.

Cock, M. L., Albuquerque, C. A., Joyce, B. J., Hooper, S. B., & Harding, R. (2001). Effects of intrauterine growth restriction on lung liquid dynamics and lung development in fetal sheep. *American Journal of Obstetrics & Gynecology*, *184*, 209–216.

Demissie, K., Anath, C. V., Martin, J., Hanley, M. L., Macdorman, M. F., & Rhoads, G. (2002). Fetal and neonatal mortality among twin gestations in the United States: The role of intrapair birth weight discordance. *Obstetrics & Gynecology*, *100*, 474–480.

Flecknell, P. A., Wootton, R., John, M., & Royston, J. P. (1981). Pathological features of intra-uterine growth retardation in the piglet: Differential effects on organ weights. *Diagnostic Histopathology*, *4*, 295–298.

Fraser, D., Picard, R., Picard, E., & Leiberman, J. R. (1994). Birth weight discordance, intrauterine growth retardation and perinatal outcomes in twins. *Journal of Reproductive Medicine*, *39*, 504–508.

Ghai, V., & Vidyasagar, D. (1988). Morbidity and mortality factors in twins. An epidemiologic approach. *Clinics in Perinatology*, *15*, 123–140.

Gluck, L., & Kulovich, M. V. (1973). Lecithin/sphingomyelin ratios in amniotic fluid in normal and abnormal pregnancy. *American Journal of Obstetrics & Gynecology*, *115*, 539–546.

Grobman, W. A., & Peaceman, A. M. (1998). What are the rates and mechanisms of first and second trimester pregnancy loss in twins? *Clinical Obstetrics and Gynecology*, *41*, 36–45.

Haimovich, Y., Ascher-Landsberg, J., Azem, F., Mandel, D., Mimouni, F. B., & Many, A. (2011). Neonatal outcome of preterm discordant twins. *Journal of Perinatology Medicine*, *39*, 317–322.

Haram, K., Svendsen, E., & Myking, O. (2007). Growth restriction: Etiology, maternal and neonatal outcome. A review. *Current Women's Health Review*, *3*, 145–160.

Hawdon, J. M., Hey, E., Kolvin, I., & Fundudis, T. (1990). Born too small: Is outcome still affected? *Developmental Medicine & Child Neurology*, *32*, 943–953.

Hawrylyshyn, P. A., Barkin, M., Bernstein, A., & Papsin, F. R. (1982). Twin pregnancies: A continuing perinatal challenge. *Obstetrics & Gynecology*, *59*, 463–466.

Ho, S. K., & Wu, P. Y. (1975). Perinatal factors and neonatal morbidity in twin pregnancy. *American Journal of Obstetrics & Gynecology*, *122*, 979–987.

https://doi.org/10.1017/thg.2013.22 Published online by Cambridge University Press

Horbar, J. D., Badger, G. J., Carpenter, J. H., Fanaroff, A. A., Kilpatrick, S., LaCorte, M., ... Soll, R. F. (2002). Trends in mortality and morbidity for very low birth weight infants, 1991–1999. *Pediatrics*, *110*, 143–151.

Hutton, J. L., Pharoah, P. O. D., Cooke, R. W. I., & Stevenson, R. C. (1997). Differential effects of preterm birth and small gestational age on cognitive and motor development. *Archives of Disease in Childhood Fetal & Neonatal Edition*, *76*, F75–F81.

Kiely, J. L. (1990). The epidemiology of perinatal mortality in multiple births. *Bulletin of the New York Academy of Medicine*, *66*, 618–637.

Kilpatrick, S. J., Jackson, R., & Croughan-Minihane, M. S. (1996). Perinatal mortality in twins and singletons matched for gestational age at delivery at > or = 30 weeks. *American Journal of Obstetrics & Gynecology*, *174*, 66–71.

Kragt, H., Huisjes, H. J., & Touwen, B. C. (1985). Neurological morbidity in newborn twins. *European Journal of Obstetrics & Gynecology and Reproductive Biology*, *19*, 75–79.

Kramer, M. S., Olivier, M., McLean, F. H., Willis, D. M., & Usher, R. H. (1990). Impact of intrauterine growth retardation and body proportionality on fetal and neonatal outcome. *Pediatrics*, *86*, 707–713.

Laatikainen, T. J., Raisanen, I. J., & Salminen, K. R. (1988). Corticotrophin releasing hormone in amniotic fluid during gestation and labor and in relation to fetal lung maturation. *American Journal of Obstetrics & Gynecology*, *59*, 891–895.

McCarthy, B. J., Sachs, B. P., Layde, P. M., Burton, A., Terry, J. S., & Rochat, R. (1981). The epidemiology of neonatal death in twins. *American Journal of Obstetrics & Gynecology*, *141*, 252–256.

McIntire, D. D., Bloom, S. L., Casey, B. M., & Leveno, K. J. (1999). Birth weight in relation to morbidity and mortality among newborn infants. *The New England Journal of Medicine*, *340*, 1234–1238.

Morgane, P. J., Austin-LaFrance, R., Bronzino, J., Tonkiss, J., Díaz-Cintra, S., Cintra, L., Kemper, T., & Galler, J. R. (1993). Prenatal malnutrition and development of the brain. *Neuroscience & Biobehavioral Reviews*, *17*, 91–128.

Muhlhausler, B. S., Hancock, S. N., Bloomfield, F. H., & Harding, R. (2011). Are twins growth restricted? *Pediatrics Research*, *70*, 117–122.

Perelman, R. H., Farrell, P M., Engle, M. J., & Kemnitz, J. W. (1985). Development aspects of lung lipids. *Annual Review of Physiology*, *47*, 803–822.

Procianoy, R. S., Garcia-Prats, J. A., Adams, J. M., Silvers, A., & Rudolph, A. J. (1980). Hyaline membrane disease and intraventricular haemorrhage in small for gestational age infants. *Archives of Disease in Childhood*, *55*, 502–505.

Robertson, C. M. T., Etches, P. C., & Kyle, J. M. (1990). Eight-year school performance and growth of preterm, small for gestational age infants: A comparative study with subjects matched for birthweight or for gestational age. *Journal of Pediatrics*, *116*, 19–26.

Spellacy, W. N., Handler, A., & Ferre, C. D. (1990). A case–control study of 1253 twin pregnancies from a 1982–1987 perinatal data base. *Obstetrics & Gynecology*, *75*, 168–171.

Tyson, J. E., Kennedy, K., Broyles, S., & Rosenfeld, C. R. (1995). The small for gestational age infant: Accelerated or delayed pulmonary maturation? Increased or decreased survival? *Pediatrics*, *95*, 534–538.

Vohr, B., Coll, C. G., Flanagan, P., & Oh, W. (1992). Effects of intraventricular hemorrhage and socioeconomic status on perceptual, cognitive, and neurologic status of low birth weight infants at 5 years of age. *Journal of Pediatrics*, *121*, 280–285.

Voigt, M., Schneider, K. T., & Jährig, K. (1996). Analysis of a 1992 birth sample in Germany. 1: New percentile values of the body weight of newborn infants. *Geburtshilfe Frauenheilkd*, *56*, 550–558.

Williams, R. L., Creasy, R. K., Cunningham, G. C., Hawes, W. E., Norris, F. D., & Tashiro, M. (1982). Fetal growth and perinatal viability in California. *Obstetrics & Gynecology*, *59*, 624–632.

Yinon, Y., Mazkereth, R., Rosentzweig, N., Jarus-Hakak, A., Schiff, E., & Simchen, M. (2005). Growth restriction as a determinant of outcome in preterm discordant twins. *Obstetrics & Gynecology*, *105*, 80–84.

https://doi.org/10.1017/thg.2013.22 Published online by Cambridge University Press