Original Research

Prenatal Management of Monoamniotic Twin Pregnancies

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OBJECTIVE: To evaluate antenatal surveillance strategies and the optimal timing of delivery for monoamniotic twin pregnancies.

METHODS: Obstetric and perinatal outcomes were retrospectively retrieved for 193 monoamniotic twin pregnancies. Fetal and neonatal outcomes were compared between fetuses followed in an inpatient setting and those undergoing intensive outpatient follow-up from 26 to 28 weeks of gestation until planned cesarean delivery between 32 and 35 weeks of gestation. The risk of fetal death was compared with the risk of neonatal complications.

RESULTS: Fetal deaths occurred in 18.1% of fetuses (70/386). Two hundred ninety-five neonates from 153 pregnancies were born alive after 23 weeks of gestation. There were 17 neonatal deaths (5.8%), five of whom had major congenital anomalies. The prospective risk of a nonrespiratory neonatal complication was lower than the prospective risk of fetal death after 32 4/7 weeks of gestation (95% confidence interval 32 0/7–33 4/7). The incidence of death or a nonrespiratory neonatal complication was not significantly different between fetuses managed as outpatients (14/106 [13.2%]) or inpatients (15/142 [10.5%]; P=.55). Our statistical power to detect a difference in outcomes between these groups was low.

CONCLUSIONS: The in utero risk of a monoamniotic twin fetus exceeds the risk of a postnatal nonrespiratory complication at 32 4/7 weeks of gestation. If close fetal surveillance is instituted after 26–28 weeks of gestation and delivery takes place at approximately 33 weeks of gestation, the risk of fetal or neonatal death is low, no matter the surveillance setting.

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Monoamniotic twins are at high risk of intrauterine and neonatal death with perinatal mortality ranging between 10 and 40%.[1–6] This high perinatal mortality rate is partially the result of an increased incidence in congenital anomalies (up to 26%)[1] as well as to twin-reversed-arterial-perfusion sequence and conjoined twinning.[7] Another contributor to perinatal mortality in monoamniotic twins is the fact that two fetuses share a single placenta and a single amniotic cavity. This is invariably associated with umbilical cord entanglement[8,9] and large vascular intertwin anastomoses at the placental level[10] leading to cord accidents, acute blood volume shifts from one fetus to the other, and, more rarely, twin–twin transfusion syndrome.

In an attempt to improve perinatal survival, monoamniotic pregnancies are monitored closely for fetal well-being. Typically, ultrasound scans are performed

every 2 weeks from 16 weeks of gestation onward through 26–28 weeks of gestation to diagnose twin–twin transfusion syndrome or discordant growth. Once viability is reached, surveillance is increased even further.[11] This often includes multiple ultrasound scans per week in addition to intermittent or continuous fetal heart rate monitoring.[11,12] There is, however, little evidence supporting either the optimal intrauterine surveillance strategy or its setting (inpatient compared with ambulatory outpatient), although some reports suggest that inpatient surveillance may be associated with improved fetal outcomes.[3,4,13]

In uncomplicated monoamniotic twin pregnancies, delivery by cesarean is usually planned between 32 and 34 weeks of gestation because, at that gestation, the prospective risk of intrauterine fetal death is felt to outweigh the risk of neonatal death.[8] However, studies balancing detailed neonatal outcomes compared with intrauterine risks to help with determining the optimal timing of delivery are lacking.

In the present study, we aim to identify the optimal surveillance protocol and timing of delivery by analyzing results from different large referral centers that manage their monoamniotic twins according to different protocols.

MATERIAL AND METHODS

We retrospectively reviewed all consecutive monoamniotic twin pregnancies managed between January 2003 and December 2012 at eight university hospitals in this multicenter cohort study. All cases, irrespective of gestational age at referral, were included in this analysis. The Research Ethics Board at each participating center approved the study protocol. All centers have extensive experience with the management of monoamniotic twins and all have a level 3 neonatal intensive care unit (NICU) associated with their perinatal unit. In all cases, monoamnionicity was diagnosed on ultrasound scan and confirmed by examination of the placenta and membranes at the time of delivery. Conjoined twins, pregnancies with twin-reversed-arterial-perfusion sequence, and higher-order multiples with monoamniotic pair were excluded.

Surveillance of monoamniotic twins after 26–28 weeks of gestation varied between hospitals, but all followed the general principles for monoamniotic twin management as outlined in the introduction. In four units, patients were primarily admitted to the hospital from 26 to 28 weeks of gestation until delivery for close surveillance, whereas in two units, patients were managed as outpatients. In two centers, the choice of surveillance setting (inpatient compared with outpatient) was left to the patient after detailed counseling. None of the centers changed its management protocol during the study period. Frequency of monitoring was closely related to the surveillance setting and varied between weekly ultrasound scans and fetal heart rate monitoring (cardiotocogram) in an outpatient setting and ultrasound scans every 2 days in combination with three cardiotocograms daily for inpatients. In all units, glucocorticoids were administered for fetal lung maturation at approximately 26–28 weeks of gestation, irrespective of the mode of surveillance. Timing of delivery in otherwise uncomplicated monoamniotic twins varied between centers from 32 0/7 to 34 6/7 weeks of gestation.

For this study, we retrieved the following antenatal variables: diagnosis of twin–twin transfusion syndrome (defined as polyhydramnios in combination with polyuria, evidenced by an enlarged bladder, in one fetus and oliguria, evidenced by an empty bladder, in the other), occurrence of single or double intrauterine fetal death, administration of glucocorticoids for pulmonary maturation, hospital admission during pregnancy, and reason for admission ("elective" for fetal surveillance compared with "indicated" for fetal or maternal obstetric complications such as preterm labor, fetal growth restriction, or preeclampsia), number of ultrasound scans and cardiotocograms per week after viability, gestational age at delivery, reason for delivery (categorized as "elective," "termination of pregnancy," or "indicated" such as for fetal distress or labor), and mode of delivery (vaginal compared with caesarean delivery). Brief hospital admissions for delivery or glucocorticoid administration were not recorded.

At discharge from the NICU, the following characteristics were recorded for all liveborn neonates: congenital anomalies, birth weight, Apgar scores, gender, need for and duration of ventilation, mode of ventilation (intubation or continuous positive airway pressure), respiratory distress syndrome more than grade I, death before discharge from the NICU, culture-proven sepsis, necrotizing enterocolitis, retinopathy of prematurity more than grade II, intraventricular hemorrhage more than grade I, or cystic periventricular leukomalacia.

The primary outcome of this study was the risk of intrauterine fetal death or a composite adverse neonatal outcome defined as a nonrespiratory neonatal complication (death before discharge from the NICU, culture-proven sepsis, necrotizing enterocolitis, retinopathy of prematurity more than grade II, intraventricular hemorrhage more than grade I, or cystic periventricular leukomalacia).

The number of "potentially preventable deaths" was calculated as the number of intrauterine fetal

deaths beyond 28 weeks of gestation (which could potentially have been prevented by surveillance-triggered delivery) plus the number of neonatal deaths in nonanomalous fetuses (which could potentially have been prevented by later delivery).

Monoamniotic pregnancies were divided into three groups based on the surveillance and management protocols: group 1–pregnancies managed as outpatients after 28 6/7 weeks of gestation and only admitted for routine obstetric reasons ("primary outpatient"); group 2–pregnancies that were electively admitted for fetal surveillance before 29 weeks of gestation ("elective inpatient"); and group 3–pregnancies admitted before 29 weeks of gestation for fetal or obstetric complications ("complicated").

Data analysis was conducted using Prism for Windows 5.0. Descriptive statistics are presented using mean and standard deviation for normally distributed data and median and range for non-Gaussian data. Birth weight centiles were calculated using the "GRAW" centile calculator.[14] The prospective risk of intrauterine fetal death was calculated as the number of intrauterine fetal deaths occurring after a certain gestational age divided by the number of live fetuses still in utero at that gestational age (fetus at-risk approach). Similarly, the prospective risk of adverse neonatal outcome was calculated as the number of neonatal adverse events occurring after a specific gestational age at birth divided by the number of live fetuses still in utero at that gestational age. The three groups were compared using analysis of variance with Bonferroni's post hoc test for continuous data and Fisher's exact or χ^2 tests for nominal data. All tests were two-sided. A P value $<.05$ was considered significant.

RESULTS

Overall, 193 monoamniotic twin pregnancies (386 fetuses) were identified. The number of pregnancies from each center varied from seven to 71. Mean gestational age at diagnosis of monoamnionicity was 12.9±3.9 weeks. Eleven of 193 pregnancies (5.7%) were conceived using assisted reproductive techniques. Mean maternal age at delivery was 30.3±5.3 years and median parity was one (range one to seven).

Fifty-three fetuses in 45 pregnancies (23.3%) were diagnosed with congenital anomalies, more than one third of which were cardiac defects (Table 1). Seventy fetuses (18.1%) from 42 pregnancies died during pregnancy. Details of fetal losses are presented in Table 2. The prospective risk of noniatrogenic intrauterine fetal death per fetus decreased from 16.3% (61/375) at 11 weeks of gestation to a nadir of 1.4% (4/290) at 28 weeks of gestation (Fig. 1), but then rose again from 32 to 34 weeks of gestation to 5.1%. There were no intrauterine fetal deaths in the 23 pregnancies (18 of which had two live fetuses) that carried beyond 34 1/7 weeks of gestation.

Table 1. List of Fetal Anomalies Observed in 193 Monoamniotic Twin Pregnancies*

Type of Anomaly	n
Central nervous system	12
Cardiovascular	19
Abdominal wall defects	5
Urogenital	4
Musculoskeletal	10
Gastrointestinal tract	3
Other	2

* Some fetuses had multiple anomalies.

The incidence of twin–twin transfusion syndrome was 2.6% (5/193). One of these pregnancies was treated by fetoscopic laser and eventuated in an intrauterine fetal death and a neonatal death of the other fetus as a result of severe preterm birth (23 6/7 weeks of gestation) after preterm prelabor rupture of the membranes. The other was treated by cord occlusion of one fetus and resulted in a single surviving neonate. The three other cases were untreated and resulted in double fetal or neonatal deaths.

Two hundred ninety-five neonates from 153 pregnancies were born alive after 23 weeks of gestation at a mean gestational age of 32.2±2.2 weeks. Birth weight characteristics are presented in Table 3.

Prenatal glucocorticoids for pulmonary maturation were given in 139 of the 153 pregnancies delivering live fetuses after 23 weeks of gestation

Table 2. Details of Fetal Deaths

Fetal Death	Monoamniotic Pregnancies (n=193)	Fetuses (n=386)
Fetal loss	42 (21.8)	70 (18.1)
Spontaneous	35 (18.1)	63 (16.3)
Iatrogenic (anomalies, twin–twin transfusion syndrome)	7 (3.6)	7 (1.8)
Termination of entire pregnancy		
Anomalies	6 (3.1)	12 (3.1)
Social	2 (1.0)	4 (1.0)
Previable preterm PROM	1 (0.5)	2 (0.5)
Brain damage or hydrops in a surviving twin after demise of 1	3 (1.5)	3 (0.8)

PROM, premature rupture of membranes.
Data are n (%).

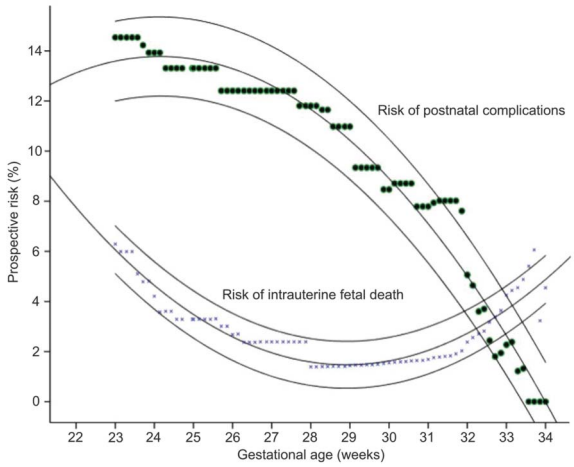

Fig. 1. Regression line (and 95% confidence interval [CI]) of the prospective risk of intrauterine fetal death and postnatal complications between 23 and 34 weeks of gestation. The left and right angles of the polygon formed by the intersection of the 95% CIs of the prospective risk of intrauterine fetal death and the risk of a postnatal complication determine the 95% CI of the "optimal time of delivery."

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(90.8%). Mean gestational age at steroid administration was 27.7±2.0 weeks. Seven cases received a single rescue course of steroids before delivery. Delivery was by cesarean in 148 of 153 pregnancies (96.7%) and five women delivered vaginally (3.3%). In four of the latter, one fetus had died in utero before labor. The overall incidence of preterm birth before 28 and 32 weeks of gestation was 4.6% (7/153 pregnancies) and 35.3% (54/153 pregnancies), respectively. There were five spontaneous preterm births before 28 weeks of gestation (3.3%) and 19 before 32 weeks of gestation (12.4%).

There were 17 neonatal deaths in 295 liveborn neonates (5.8%), including five neonates who had major congenital anomalies and three who received palliative care as a result of severe brain damage as the consequence of the death of their cotwin. Of 282 liveborn neonates without major congenital anomalies and with a plan for active care, eight (2.8%) died as a result of the consequences of prematurity and one (0.35%) as a result of labor-induced birth asphyxia. Neonatal complications in these 282 neonates are presented in Table 4. The prospective risk of a nonrespiratory neonatal complication in nonanomalous neonates decreased sharply after 32 weeks of gestation (Fig. 1). When respiratory distress syndrome was included as a neonatal complication, the risk of any neonatal complication fell below 10% only after 34 weeks of gestation. The curve of the prospective risk of a nonrespiratory neonatal complication crossed the curve of the prospective risk of intrauterine fetal death at 32 4/7 weeks of gestation (95% confidence interval 32 0/7–33 4/7 weeks of gestation) at a level of 3.1% (Fig. 1).

Of 144 ongoing pregnancies with two live fetuses at 26 weeks of gestation, 53 (36.8%) were primarily managed as outpatients beyond 29 weeks of gestation (group 1), 71 (49.3%) were electively admitted for fetal monitoring before 29 weeks of gestation (group 2), and 20 (13.8%) were admitted for obstetric or fetal complications before 29 weeks of gestation (group 3). Detailed characteristics of the three groups are presented in Table 2 and a flowchart is provided in Figure 3. In group 1, 23 of 53 patients (43.4%) were managed as outpatients until their planned delivery, whereas 30 (56.6%) were admitted after 29 weeks of gestation. Seventeen (32.0%) of the latter were admitted for "late" elective surveillance and 13 (24.5%) for fetal or obstetric complications. In those admitted, gestational age at admission was almost 4 weeks later than in group 2 and the monitoring strategy was less intensive (Table 5). Women managed as outpatients

Table 3. Birth Weight Characteristics of 295 Neonates Liveborn After 23 Weeks of Gestation

Variable	Outcome
Birth weight (g)	1,749±442
Birth weight percentile (%)	44±30
Birth weight less than the 3rd percentile	27 (9.2)
Intertwin birth weight discordance (%)	7.9±6.6
Birth weight discordance greater than 25	4 (2.8)

Data are mean±standard deviation or n (%).

Table 4. Neonatal Complications in 282 Liveborn Neonates Without Congenital Anomalies and With a Plan for Active Care

Variable	n (%)
Respiratory support	204 (72.3)
Intubation	70 (24.8)
CPAP	178 (63.1)
Respiratory distress syndrome	120 (42.5)
Surfactant administration	82 (29.1)
Sepsis	29 (10.3)
Necrotizing enterocolitis	8 (2.8)
Intraventricular hemorrhage	5 (1.8)
Periventricular leukomalacia	9 (3.2)
Retinopathy of prematurity	3 (1.1)

CPAP, continuous positive airway pressure.

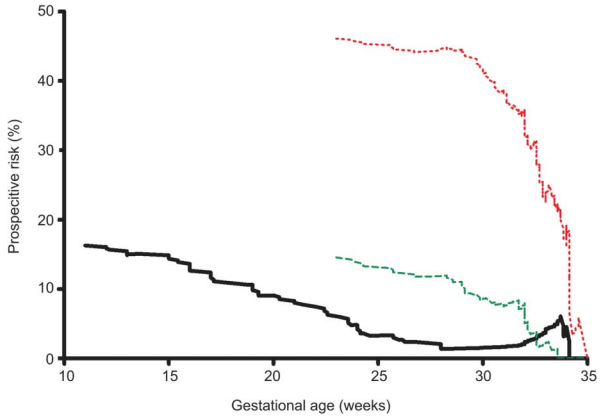

Fig. 2. Prospective risk of intrauterine fetal death and postnatal nonventilatory complications per gestational age in 386 fetuses and 282 liveborn neonates without major anomalies, respectively. *Full bold line*: risk of intrauterine fetal death. *Dashed green line*: risk of composite adverse neonatal outcome. *Dotted red line*: risk of composite adverse neonatal outcome or respiratory distress syndrome.

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delivered on average 5 days later than women managed as elective inpatients.

Five fetuses in group 1 died (two double intrauterine fetal deaths and one single intrauterine fetal death) and two fetuses in group 2 (one double intrauterine fetal death). Among the outpatient cohort, three fetuses died between 26 and 28 weeks of gestation: one double intrauterine fetal death probably occurred as a result of an acute twin–twin transfusion syndrome in already growth-discordant twins; the other fetal death was attributed to a cord accident in normally grown fetuses. Another double intrauterine fetal death occurred in two normally grown fetuses at 34.1 weeks of gestation. In group 2, a double intrauterine fetal death occurred at 33.9 weeks of gestation, 1 day before the scheduled caesarean delivery. Both fetuses had birth weights at the 50th percentile. No fetal deaths occurred between 28 and 33 weeks of gestation in either cohort.

The neonatal outcomes of liveborn neonates from pregnancies with two fetuses alive at 26 weeks of gestation are presented in Table 6. The risk of a nonrespiratory neonatal complication in neonates from pregnancies managed in groups 1 and 2 was similar, but complications were three times higher in group 3 (9.4%, 9.6%, and 32.4%, respectively). Three neonates died in group 1. None had a birth weight below the 10th percentile for gestational age. Causes of death were birth asphyxia (1), severe brain damage after the intrauterine fetal death of the cotwin (1), and prematurity (1). One neonate, from the inpatient cohort, who was born at 33 4/7 weeks of gestation with a normal birth weight for gestational age, died as a consequence of necrotizing enterocolitis.

The incidence of the primary outcome (death or nonrespiratory complication) was not significantly different between fetuses managed as outpatients (14/106 [13.2%]) and those managed as inpatients (15/142 [10.5%]; P=.55). Post hoc power analysis shows that our study had a power of only 9.9% to detect a statistically significant difference for a two-sided type I error of 5%.

The number of "potentially preventable deaths" in group 1 was 5 of 106 fetuses (4.7%). For group 2, this was 3 of 142 fetuses (2.1%); for group 3, this was 1 of 40 (2.5%). These numbers are not significantly different (P=.49). The study had a 29.1% power to detect a clinically significant decrease in mortality of 3% (from 4.7% to 1.7%) between groups 1 and 2.

DISCUSSION

This study confirms previous data showing that monoamniotic twins are at high risk of perinatal death.[1,2,15] However, the causes of death among monoamniotic twins are very different from those among monochorionic diamniotic twins. Indeed, in monochorionic diamniotic twins, death is mainly the result of twin–twin transfusion syndrome and selective fetal growth restriction in one of the fetuses.[16] In our cohort of monoamniotic twins, these complications occurred far less frequently than in diamniotic twins and intrauterine fetal deaths were mainly as a consequence of fetal anomalies and cord entanglement. However, if close surveillance was instituted after 26–28 weeks of gestation, the risk of intrauterine fetal death before 33 weeks of gestation was extremely low (0% in this series) and the risk of neonatal death resulting from prematurity was less than 2%.

Our study addresses the optimal timing of delivery for monoamniotic twins. It appears from the present data that monoamniotic twins delivered at approximately 33 weeks of gestation have the best outcome. Elective preterm delivery before 33 weeks of gestation has already been adopted by many centers[11,17,18]; however, the risk of fetal death has never been directly balanced against risk of neonatal complications in a monoamniotic twin cohort. At 33 weeks of gestation, neonatal respiratory complications can still occur, but these are usually manageable if glucocorticoids for pulmonary maturation have been administered[19] as was the case in greater than 90% of the pregnancies followed in this study. Similarly, the other problems of preterm birth (such as neonatal

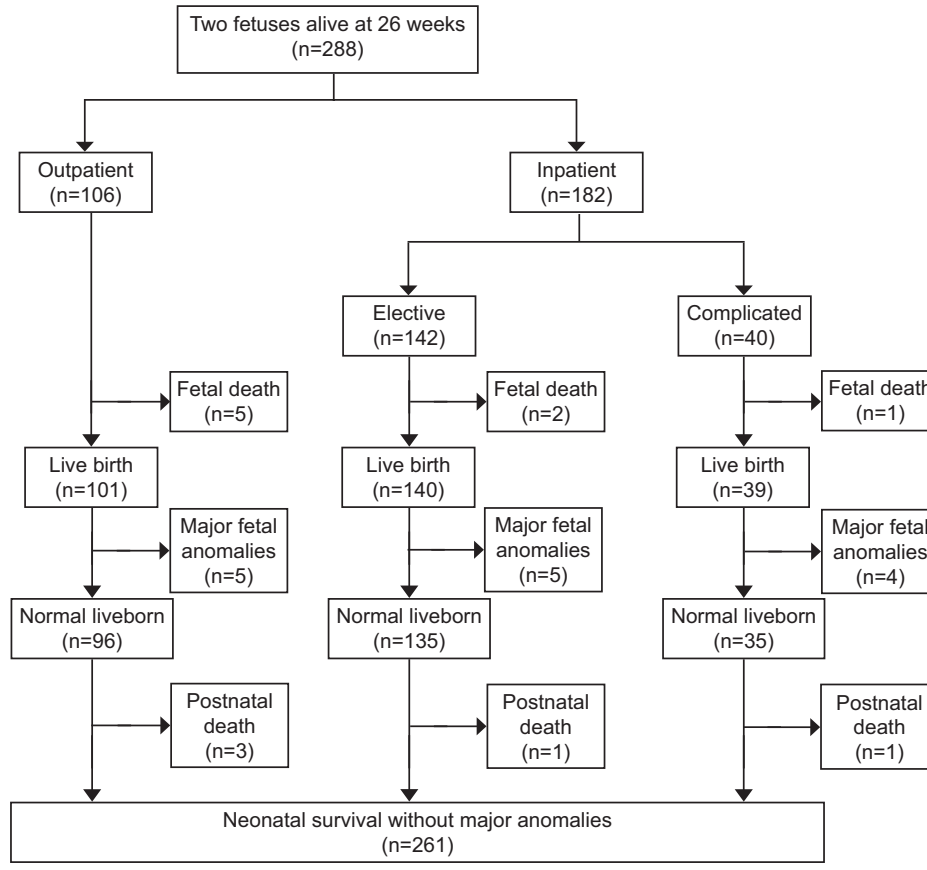

Fig. 3. Flowchart representing the fetuses from pregnancies with two fetuses alive at 26 weeks of gestation.

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feeding issues, infections, and long-term developmental effects[19]) do not outweigh the risk of fetal death.

We showed that in uncomplicated monoamniotic twins, the risk of "potentially preventable death" was not significantly different in patients admitted to the hospital when compared with those managed as outpatients (2.1% compared with 4.7%, respectively). Moreover, when evaluating the causes of death in both groups, it appears that, except for one neonatal death resulting from birth asphyxia in the outpatient group, deaths would not have been prevented by admission at 28 weeks of gestation because they either occurred before 28 weeks of gestation or were unrelated to in utero events. As such, both surveillance settings seem to yield equal outcomes. We emphasize, however, that, although surveillance was somewhat less intensive in outpatients, these pregnancies still were watched very closely with both cardiotocograms (on average four times per week) and ultrasonograms (once to twice per week), that 56% of these pregnancies were admitted for surveillance at some point, and that approximately 20% were delivered for suspected fetal distress. Our results contrast with data from Heyborne et al[3] who reported a significantly higher risk of intrauterine fetal death in women followed as outpatients compared with those followed as inpatients (15% compared with 0%, respectively). However, the Heyborne et al study combined "indicated" admissions after 24 weeks of gestation (which we called "complicated" pregnancies) with the outpatient cohort, which might have worsened the results in the outpatient group. Moreover, the study did not report on the intensity and type of antenatal surveillance in the outpatient cohort. Therefore, their outpatient group may have had less intensive follow-up than ours. Our results also contrast with DeFalco et al[13] who reported an improved fetal survival in 11 monoamniotic twin pregnancies that were admitted to hospital beginning at 24–28 weeks of gestation for continuous fetal monitoring (no fetal deaths) compared with 12 outpatients (three fetal deaths). In that study however, the mother of two fetuses who died in the "outpatient" group at 28 weeks of gestation was actually admitted for continuous fetal monitoring as a result of an abnormal cardiotocogram.

Because inpatient and close outpatient monitoring between 28 and 33 weeks of gestation results in similar fetal and neonatal outcomes, outpatient surveillance is probably the preferred strategy, because

Table 5. Comparison of Pregnancy Outcomes of Pregnancies With Two Fetuses Alive at 26 Weeks of Gestation by Management Setting (n=144)

Outcome	Group 1, Primary Outpatient (n=53)	Group 2, Elective Inpatient (n=71)	Group 3, Complicated (n=20)	*P*
Total no. admitted	30 (56.6)	71 (100)	20 (100)	
Gestational age at admission (wk)	31.2±1.8	27.5±1.1	26.6±1.6	<.01*
Gestational age when starting steroids (wk)	28.9±2.0	27.6±1.6	26.9±1.5	<.01†
Surveillance				
Cardiotocograms/wk	4.2±5.5	16.6±4.8	16.1±6.5	<.01†
Ultrasonograms/wk	1.5±1.0	2.2±0.6	2.3±1.8	<.01†
Reason for delivery				
Elective	25 (47.2)	45 (63.4)	4 (20)	<.01‡
Nonreassuring fetal status	12 (22.6)	15 (21.1)	7 (35)	.45
Indicated delivery	13 (24.5)	10 (14.1)	8 (40)	.04
Termination of pregnancy for IUFD	3 (5.7)	1 (1.4)	1 (5)	.34
Vaginal delivery (including termination of pregnancy)	3 (5.7)	1 (1.4)	2 (10)	.15
Any IUFD	3 (5.7)	1 (1.4)	1 (5)	.34
Single IUFD	1 (1.9)	0 (0)	1 (5)	.12
Double IUFD	2 (3.8)	1 (1.4)	0 (0)	.73
Gestational age delivery (wk, live births)	33.0±1.8	32.2±1.2	30.7±1.9	<.01*

IUFD, intrauterine fetal death.
Data are n (%) or mean±standard deviation unless otherwise specified.
* Bonferroni: all groups different from each other.
† Bonferroni: primary outpatient group different from two other groups.
‡ Bonferroni: complicated group different from two other groups.

it has a significantly lower cost and is far less disruptive to family life, especially if there are other children. Moreover, hospital admission often leads to decreased maternal mobilization, which increases the risk for iatrogenic complications, including venous thromboembolism, especially in multiple pregnancies.[20] However, local or geographic conditions may sometimes make intensive outpatient surveillance impractical or unfeasible and hospital admission is a reasonable alternative in that case.

Our study has several strengths, which are mainly a result of collaboration among a large number of investigators. Data from various centers across North America and Europe allowed us to obtain a large population sample from a limited timespan, thereby making it reflective of contemporary practice in developed countries. Moreover, because we were able to extract individual patient data, we could reliably comment on monitoring strategies and individual patient outcomes. Despite this detail of information being available, we did decide not to stratify outcomes by center because we wanted to ensure maximal participation of the different centers.

Our study was clearly limited by its retrospective study design. For example, we showed a 64% lower incidence of respiratory distress syndrome in the outpatient cohort (29% compared with 45% in inpatients) as a consequence of a more advanced gestational age at birth in this group. This different gestational age at birth, however, is most likely a reflection of hospital policy (hospitals managing their monoamniotic twins as outpatients tended to deliver later) rather than a true consequence of the monitoring strategy. The latter is supported by the fact that the incidence of delivery for nonreassuring fetal status was similar in both the inpatient and outpatient cohorts (21.1% and 22.6%, respectively). Along the same lines, the retrospective design did not allow to control for the management of typical obstetric complications such as preeclampsia or preterm labor. Variations in management among centers could theoretically have influenced gestational age at delivery in the different groups.

Similarly, this study does not allow us to draw conclusions about starting fetal surveillance at earlier gestational ages. Indeed, if surveillance had been started at 24 weeks of gestation, the deaths that occurred between 24 and 28 weeks of gestation in our cohort could potentially have been prevented. On the other hand, however, this very early surveillance could have induced extreme iatrogenic prematurity with its inherent consequences.

Table 6. Neonatal Outcomes of Liveborn Neonates From Pregnancies in Which Two Fetuses Were Alive at 26 Weeks of Gestation (n=280)

Outcome	Group 1, Primary Outpatient	Group 2, Elective Inpatient	Group 3, Complicated	*P*
Total cohort	101	140	39	
Female sex	75 (72.8)	96 (68.1)	25 (64.1)	.36
Birth weight (g)	1,827±407	1,776±291	1,585±384	<.01
Birth weight percentile	38±31	46±28	52±34	.25
Birth weight less than the 3rd percentile	16 (15.8)	2 (1.4)	2 (5.1)	<.01*
Apgar score at 5 min less than 7 (n, %)	16 (16)	7 (1.6)	0 (0)	<.01*
Nonanomalous neonates (n)	96	135	35	
Any nonrespiratory neonatal complication	9 (9.4)	13 (9.6)	12 (34.3)	<.01†
Neonatal death	3 (3.1)	1 (0.7)	1 (2.9)	.33
Sepsis in survivors	3 (3.2)	13 (9.6)	9 (26.5)	<.01†
Intraventricular hemorrhage in survivors	1 (1.0)	0 (0)	3 (8.8)	<.01†
Periventricular leukomalacia in survivors	3 (3.2)	2 (1.5)	3 (8.8)	.11
Necrotizing enterocolitis in survivors	1 (1.0)	6 (4.5)	0 (0)	.20
Respiratory neonatal outcomes				
Respiratory distress syndrome	28 (29.2)	62 (45.9)	21 (61.7)	<.01*
Need for ventilatory support in survivors	61 (63.5)	103 (76.3)	31 (91.2)	<.01†
Duration ventilation in those needing (d)	4	5	6	

Data are n, n (%), or mean±standard deviation unless otherwise specified.
* Post hoc comparison primary outpatient compared with elective inpatient significantly different.
† Post hoc comparison primary outpatient versus elective inpatient not significantly different.

Given the low power of the present study to detect a statistically significant difference in the primary outcome between in- and outpatients (only 9.9%), further studies examining this question are certainly warranted and most ideally this would be addressed in a large randomized trial. However, given the rarity of monoamniotic twins, such a trial will be unlikely to succeed. Indeed, a sample size calculation on the incidence of "potentially preventable deaths" (4.7% in the outpatient cohort, 2.1% in inpatients) shows that for a power of 90% and a two-sided type I error of 5%, 507 monoamniotic twin pregnancies would need to be recruited in each arm of the study.

In the absence of results from a randomized trial, monoamniotic pregnancies will need to be managed based on results from observational studies such as ours. Given the rarity of the primary outcome, however, strong management recommendations cannot be made based on this study. Rather, out data can help in counseling expecting parents that these pregnancies are at high risk of fetal anomalies and death. In the event of both fetuses surviving until 28 weeks of gestation, the risk of intrauterine fetal death can likely be minimized by close inpatient or outpatient surveillance. Elective preterm delivery at approximately 33 weeks of gestation should be considered.

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