Maternal and Fetal Characteristics Associated With Meconium-Stained Amniotic Fluid

Imelda Balchin, MBChB, MD, John C. Whittaker, BSc (Hons), PhD, Ronald F. Lamont, DM, FRCOG, and Philip J. Steer, MD, FRCOG

OBJECTIVE: To estimate the rates of meconium-stained amniotic fluid (AF) and adverse outcome in relation to gestational age and racial group, and to investigate the predictors of meconium-stained AF.

METHODS: We studied 499,096 singleton births weighing at least 500 g, at 24 or more weeks of gestation, from 1988 to 2000. The predictors of meconium-stained AF from 37 weeks of gestation onward were determined using multiple logistic regression.

RESULTS: The crude meconium-stained AF rates in preterm, term, and postterm births were 5.1% (95% confidence interval [CI] 4.9–5.4), 16.5% (95% CI 16.4–16.6), and 27.1% (95% CI 26.5–27.6), respectively; the rates in blacks, South Asians, and whites were 22.6% (95% CI 22.2–23.1), 16.8% (95% CI 16.5–17.1), and 15.7% (95% CI 15.6–15.8), respectively. Independent predictors of meconium-stained AF included being black (odds ratio [OR] 8.4, 95% CI 2.4–28.8), vaginal breech delivery (OR 4.7, 95% CI 4.2–5.3), being South Asian (OR 3.3, 95% CI 1.3–8.3), and being in an advancing week of gestation (OR 1.39, 95% CI 1.38–1.40). More blacks (17.9%, 95% CI 17.3–18.4) and South Asians (11.8%, 95% CI 11.5–12.1) with good outcome and no risk factors for fetal hypoxia had meconium-stained AF than did whites (11.2%, 95% CI 11.1–11.4). Using white neonates born at 40 weeks as reference, the absolute risk of adverse outcome at 41 and 42 weeks were 2% and 5% in whites, 3% and 7%, in South Asians, and 7% and 11% in blacks.

CONCLUSION: Meconium-stained AF rates are different among races and across gestational age, and overall risk of adverse outcomes in meconium stained AF is low.

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LEVEL OF EVIDENCE: II

According to genetic studies, human DNA can be clustered into groups that correspond to their ancestral geographic origins.[1,2] This genetic variation may contribute to health disparities between popula-

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From the Department of Obstetrics and Gynaecology, The Royal London Hospital, Barts and The London NHS Trust, London, United Kingdom; Epidemiology and Statistical Genetics, London School of Hygiene and Tropical Medicine, London, United Kingdom; Obstetrics and Gynecology, Perinatology Research Branch, Eunice Kennedy Shriver *National Institute of Child Health and Human Development, National Institutes of Health, Department of Health and Human Services, Bethesda, Maryland, and Detroit, Michigan; the Department of Obstetrics and Gynecology, Wayne State University, Hutzel Women's Hospital, Detroit, Michigan; and Imperial College Academic Department of Obstetrics and Gynaecology, Chelsea and Westminster Hospital, London, United Kingdom.*

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Corresponding author: Imelda Balchin, Department of Obstetrics & Gynaecology, The Royal London Hospital, Barts and The London NHS Trust, Whitechapel Road, London E1 8PR, United Kingdom; e-mail: balchin@doctors.org.uk.

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tions. For example, the response to antihypertensive treatment varies between black and white patients, such that the recommended treatment differs by racial group.[3,4] "Race" in this context identifies those with common geographical ancestry, where natural selection has resulted in the evolution of local traits. It is important to identify conditions with different prevalence between groups and their risk factors, so that the appropriate management can be applied.

In obstetrics, varying rates of meconium-stained amniotic fluid (AF) has been reported between racial groups.[5–8] Meconium (fetal colonic contents) is usually passed after birth, and the mechanisms underlying passage before birth are unknown. Meconium-stained AF is uncommon in preterm births (occurring in about 5%) but occurs more frequently with advancing gestational age.[9,10] This may be simply an effect of fetal gut maturity, or it may be a reaction to hypoxic stress, which occurs more often as pregnancy advances. Higher rates of stillbirths, low Apgar scores, and hypoxic ischemic encephalopathy has been associated with meconium-stained AF.[11–15] However, most newborns with meconium-stained AF have good outcomes, and the umbilical cord blood pH between preterm newborns with and without meconium-stained AF is not significantly different.[10,16] The objectives of our study were to estimate the rates of meconium-stained AF and adverse outcome in relation to gestational age and racial group, and to investigate the predictors of meconium-stained AF. We have examined the hypothesis that fetal maturity varies between racial groups, and that this difference influences both meconium-stained AF and adverse perinatal outcomes in relation to gestational age and racial group.

MATERIALS AND METHODS

Routine maternity data were collected prospectively from all pregnancies (585,291) booked at 15 maternity units in North West London, from 1988 to 2000. Data collection on 263 variables (including socioeconomic factors, maternal characteristics, and antenatal, intrapartum, and neonatal outcomes) began from the first antenatal visit up to 28 days postpartum. Computer entry by trained clerks or midwives using online validation, prompting, and standard definitions for clinical measurements, produced high-quality data.[17,18] Each year, data from these local units were downloaded into the St. Mary's Maternity Information System and maintained by the Department of Epidemiology and Public Health, Imperial College London. In compliance with Section 60 of the Health and Social Care Act 2001, all direct patient identifiers were removed and analyses were performed on a nonattributable data set. This research was approved by the St. Mary's Local Research Ethics Committee. All analyses were performed using SPSS 16.0 or Microsoft Excel.

The data collected on ethnicity were based on a "self-identification" measure, in line with the UK census. The ethnicity of the neonates was based on maternal ethnicity. Women who self-identified as originating from India, Pakistan, Bangladesh, Sri-Lanka, or other South Asian ethnicity were grouped as South Asian. The black racial group included black British, African, and Caribbean. Women who self-identified as any white ethnicity were grouped as white. All other ethnicities were grouped into "other" as the numbers were too few for a meaningful analysis.

The best estimate of gestational age at delivery was calculated using a combination of fetal biometric ultrasonography and the last menstrual period. Gestational length was estimated from either the first day of the last menstrual period or the first ultrasound fetal biometry performed before 24 weeks of gestation. Last menstrual periods were used provided the women were certain of their menstrual dates and had regular menstrual cycles and there was no significant discrepancy between the estimated dates of delivery (EDDs) by the last menstrual period and ultrasonography. A more detailed description of these methods has been reported previously.[19]

It is known that the average birth weight varies by ethnic group. Compared with newborns of white race, Pakistani, Indian, and Bangladeshi newborns are 280 g to 350 g lighter, and black Caribbean and black African newborns are 70 g to 150 g lighter.[20] Adjusting birth weight by ethnicity results in a better identification of fetal growth restriction than using birth weight alone.[21] To avoid inappropriate classification of small for gestational age, we examined the distribution of birth weight for gestational age by developing centile growth curves specific to each racial group, and allocated a centile value to each birth weight.

To explore the distribution of meconium-stained AF by gestational age, we analyzed women who had singleton live births weighing at least 500 g, at 24 or more completed weeks of gestation. We then studied the crude gestation-specific pattern of meconium-stained AF by racial groups and tested whether the meconium-stained AF rates differed significantly between groups.

Secondly, we investigated the variables associated with meconium-stained AF and whether or not racial group is an independent predictor of this condition. Preterm births, before 37 weeks of gestation,

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were excluded from this part of the analysis owing to the low rate of meconium-stained AF at these gestations. χ^2 tests of association were used for qualitative variables and nonparametric Mann Whitney U tests for quantitative variables. Variables significantly associated with meconium-stained AF ($P<.05$) were selected as predictor variables for the logistic regression analysis (Table 1). A multiple logistic regression model for the outcome variable meconium-stained AF was then created. Interaction terms between gestational age and racial groups improved the model significantly.

Thirdly, we investigated whether variation in the rate of meconium-stained AF by racial group could be explained by hypoxic stress rather than fetal maturity. We analyzed the rate of poor perinatal outcome (Apgar scores less than 7 at 1 or 5 minutes of life or both, transfer to the neonatal unit, early neonatal death, or a combination) in newborns with no congenital anomaly by racial groups and gestational age. In addition, those significant predictors of meconium-stained AF from 37 completed weeks of gestation onward (Table 1) were analyzed to identify their relationship with poor perinatal outcome. We then excluded cases with factors associated with fetal hypoxia (ie, preterm births, congenital malformations, umbilical cord prolapse, birth weight percentiles less than 10 or more than 90, maternal pyrexia, abnormal cardiotocography with operative delivery, malpresentation, or other predictors of meconium-stained AF that were found to be significantly associated with poor perinatal outcome) or cases with poor perinatal outcome. Exclusion of these cases leaves neonates with or without meconium-stained AF and with no known risk factors of fetal hypoxia, who all had a good perinatal outcome. We then investigated these healthy neonates with respect to whether or not the rate of meconium-stained AF differed by gestational age according to racial groups.

RESULTS

There were a total 585,291 cases. We excluded 16,129 cases with unknown best estimate of gestational age at birth, 54,051 miscarriages before 24 completed weeks of gestation or with birth weights less than 500 g, 13,703 multiple pregnancies, and 2,312 stillbirths or induced abortions. Included in the analysis of meconium-stained AF were the remaining 499,096 singleton live births weighing at least 500 g at 24 or more completed weeks of gestation. Of these, there were 351,701 (70.5%) white, 64,874 (13.0%) South Asian, and 30,463 (6.1%) black newborns. Meconium-stained AF was present in 81,405 cases (16.3%, 95%

Table 1. Logistic Regression Model Showing the Predictors of Meconium-Stained Amniotic Fluid at 37 or More Weeks of Gestation

Variable (Reference Group)	Odds Ratio (95% CI)	*P*
Racial group (white)		
Black	8.38 (2.44–28.78)	<.001
South Asian	3.31 (1.32–8.34)	<.001
Mode of delivery (spontaneous vaginal)		
Vaginal breech	4.71 (4.16–5.33)	<.001
Instrumental	1.94 (1.88–2.01)	<.001
Cesarean	1.40 (1.36–1.44)	<.001
Cardiotocogram (normal trace)		
Abnormal trace	2.22 (2.17–2.27)	<.001
No trace	0.54 (0.52–0.57)	<.001
Maternal pyrexia (apyrexia)	1.62 (1.50–1.74)	<.001
Advancing gestational age	1.39 (1.38–1.40)	<.001
Maternal body mass index (20–24 kg/m^2)		
30 or more	1.37 (1.32–1.41)	<.001
25–29	1.16 (1.13–1.19)	<.001
Less than 20	0.86 (0.83–0.89)	<.001
Maternal age (20–29 y)		
40 y or more	1.26 (1.18–1.36)	<.001
30–39 y	1.11 (1.09–1.14)	<.001
Malpresentation (cephalic)	1.25 (1.16–1.35)	<.001
Birth weight (10–90th percentile)		
90th percentile or higher	1.20 (1.16–1.24)	<.001
10th percentile or lower	1.07 (1.03–1.11)	<.001
Maternal hemoglobin (10.5 g/dL or more)		
Less than 9 g/dL	1.18 (1.10–1.27)	<.001
9–10.4 g/dL	1.06 (1.03–1.08)	<.001
Female neonate (male)	1.13 (1.11–1.15)	<.001
Maternal smoker (nonsmoker)	1.10 (1.08–1.14)	<.001
Material deprivation index 3 to 5 (1 to 2)	1.04 (1.02–1.06)	<.01
Rupture of membranes (spontaneous, in labor)		
Artificial	1.04 (1.02–1.06)	<.01
Spontaneous, before labor	0.62 (0.60–0.64)	<.001
None	0.62 (0.55–0.69)	<.001
Interactions		
South Asians* gestational age	0.97 (0.95–0.99)	<.05
Black* gestational age	0.96 (0.93–0.99)	<.01
Method of onset of labor (spontaneous labor)		
Induced labor	0.53 (0.51–0.54)	<.001
No labor	0.24 (0.22–0.26)	<.001

CI, confidence interval.

Nonsignificant variables were maternal diabetes, hypertensive disorders, antepartum hemorrhage, fetal congenital malformations, parity, marital status, "other" ethnic group and late booking for antenatal care (beyond 19 completed weeks of gestation).

* Interaction between two variables.

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Table 2. Rate of Meconium-Stained Amniotic Fluid by Gestational Age at Birth

Gestation in Completed wk	Percentage of Births (n/N)	95% CI
24	9.2 (21/228)	5.5–13.0
25	10.7 (30/280)	7.1–14.3
26	6.5 (23/355)	3.9–9.0
27	6.9 (30/435)	4.5–9.3
28	6.2 (36/580)	4.2–8.2
29	5.2 (33/630)	3.5–7.0
30	5.2 (45/861)	3.7–6.7
31	3.7 (40/1,097)	2.5–4.8
32	4.0 (65/1,610)	3.1–5.0
33	4.6 (103/2,243)	3.7–5.5
34	4.7 (176/3,722)	4.0–5.4
35	4.7 (300/6,449)	4.1–5.2
36	5.5 (689/12,564)	5.1–5.9
37	6.4 (1,932/30,423)	6.1–6.6
38	8.6 (6,254/72,923)	8.4–8.8
39	14.4 (16,405/114,336)	14.1–14.6
40	19.6 (26,216/133,942)	19.4–19.8
41	24.4 (22,566/92,631)	24.1–24.6
42	26.9 (5,665/21,082)	26.3–27.5
43	28.2 (722/2,558)	26.5–30.0
44	36.7 (54/147)	28.9–44.5
Total	16.3 (81,405/499,096)	16.2–16.4

n, number with meconium-stained amniotic fluid; N, number of births; CI, confidence interval.

confidence interval [CI] 16.2–16.4). The crude meconium-stained AF rate differed significantly in neonates born preterm (5.1%, 95% CI 4.9–5.4), at term (16.5%, 95% CI 16.4–16.6), and postterm (27.1%, 95% CI 26.5–27.6), respectively.

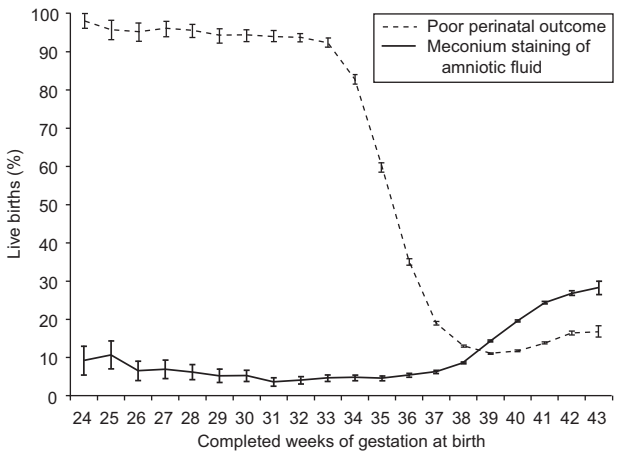

Fig. 1. The rate of meconium-staining of amniotic fluid and the rate of poor perinatal outcome by gestational age at birth, with error bars showing the 95% confidence intervals.

Balchin. Racial Variation in Meconium Passage In Utero. Obstet Gynecol 2011.

Table 2 and Figure 1 demonstrate that although the overall meconium-stained AF rate was lowest among preterm births, before 31 completed weeks of gestation the rate of meconium-stained AF was inversely related to increasing gestational age, with the peak rate at 24 to 25 completed weeks (averaging 10.0%, 95% CI 7.4–12.7) and the lowest rate at 31 completed weeks (3.7%, 95% CI 2.5–4.8). The rate of meconium-stained AF at 24 to 30 completed weeks of gestation (6.47%, 95% CI 5.64–7.30) was statistically significantly higher than the rate of meconium-stained AF at 31 to 36 completed weeks of gestation (4.96%, 95% CI 4.70–5.22). It is a common observation that meconium-stained AF is more likely to occur in fetuses presenting by the breech, and that such malpresentations are more common in preterm births. However, a subgroup analysis of preterm births with cephalic presentation showed that the rate of meconium-stained AF in this group was not significantly different (4.8%, 95% CI 4.6–5.1), and the same pattern of meconium-stained AF with a peak rate at 24 to 25 weeks was observed (9.3%, 95% CI 6.1–12.5). In neonates born at 24 to 30 completed weeks of gestation, the rate of early neonatal death did not differ significantly whether meconium-stained AF was present or absent (odds ratio [OR] 0.98, 95% CI 0.61–1.58).

From 31 completed weeks of gestation, the rate of meconium-stained AF increased with advancing gestational age. From 36 to 42 completed weeks, each weekly increase in the rate of meconium-stained AF was statistically significant. The overall crude rates of meconium-stained AF varied significantly between racial groups as shown in Table 3. The rates of meconium-stained AF were not significantly different before 36 completed weeks of gestation, but from 36 completed weeks onward the rates of meconium-stained AF by racial group differed significantly. In addition, from 38 to 42 weeks, the rates of meconium-stained AF were significantly higher at all gestations in black fetuses in comparison to South Asian fetuses.

After exclusion of preterm births, 468,042 cases remained. Table 1 showed the results of the logistic regression model for meconium-stained AF and its independent predictors, or associations, from 37 completed weeks of gestation onward ($P<.001$). Accounting for confounders, advancing gestational age was an independent predictor of meconium-stained AF (OR 1.39, 95% CI 1.38–1.40). In addition, being black (OR 8.4, 95% CI 2.4–28.8) or South Asian (OR 3.3, 95% CI 1.3–8.3) was an independent predictor of meconium-stained SAF compared with being white. There were significant interactions between both ra-

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Table 3. Group-Specific Rate of Meconium Staining of Amniotic Fluid

Group	Meconium-Stained AF	No Meconium-Stained AF	Total	% Meconium-Stained AF (95% CI)
White	55,250	296,451	351,701	15.7 (15.6–15.8)
South Asian	10,933	53,941	64,874	16.8 (16.5–17.1)
Black	6,904	23,559	30,463	22.6 (22.2–23.1)

AF, amniotic fluid; CI, confidence interval.

cial groups and gestational age. Although the incidence of meconium-stained AF increased with advancing gestational age, this occurred more rapidly for black and South Asian than for white fetuses.

The rate of meconium-stained AF increased significantly with increasing maternal body mass index (BMI, calculated as weight (kg)/[height (m)]^2). The meconium-stained AF rates were 14.2% (95% CI 13.9–4.5), 16.3% (95% CI 16.2–16.5), 18.6% (95% CI 18.4–18.9), and 20.4% (95% CI 19.9–20.8) in women with BMI of less than 20, 20 to 24, 25 to 29 and 30 or more, respectively. The same relationship was observed between maternal BMI and the rate of poor perinatal outcome. The rates of poor perinatal outcome were 11.5% (95% CI 11.2–11.8), 12.2% (95% CI 12.1–12.3), 14.0% (95% CI 13.8–14.2), and 16.8% (95% CI 16.4–17.1), respectively. After exclusion of cases with maternal diabetes, maternal obesity (BMI of 30 or more) was associated with an increased risk of poor perinatal outcome when compared with a normal BMI of 20 to 24 (OR 1.37, 95% CI 1.33–1.42). However, maternal age of 40 or older did not increase the risk of poor perinatal outcome when compared with maternal age of 20 to 29 years (OR 1.06, 95% CI 0.99–1.13). The risk of poor perinatal outcome was slightly increased with maternal smoking when compared with nonsmokers (OR 1.08, 95% CI 1.06–1.10). Fetal female sex was a significant predictor of meconium-stained AF compared with male, but male newborns had a higher rate of poor perinatal outcome when compared with female (OR 1.26, 95% CI 1.24–1.28).

After accounting for birth-weight percentiles, we found that maternal medical complications such as diabetes and hypertensive disorders were not associated with an increased risk of meconium-stained AF. These women were more likely to experience induction of labor and deliver at an earlier gestation when compared with women with no medical problems. For example, the median gestational length in women with preexisting diabetes was 38 completed weeks, whereas in women with no diabetes the median gestational length was 40 completed weeks ($P<.001$). However, maternal anemia was an independent predictor of meconium-stained AF. The odds of meconium-stained AF occurring was highest with maternal hemoglobin levels below 9 g/dL.

After exclusion of preterm births, individuals with risk factors of fetal hypoxia, or both, or individuals with a poor perinatal outcome, or any combination of the three,321,654 cases remained. The rates of meconium-stained AF in these fetuses still increased with advancing gestational age (Fig. 2). In addition, the rate of meconium-stained AF was still highest in black (17.87%, 95% CI 17.30–18.44), followed by South Asian (11.78%, 95% CI 11.47–12.09), and lowest in white fetuses (11.24%, 95% CI 11.11–11.37). At every gestation, the meconium-stained AF rates in black fetuses were still significantly higher than in white fetuses.

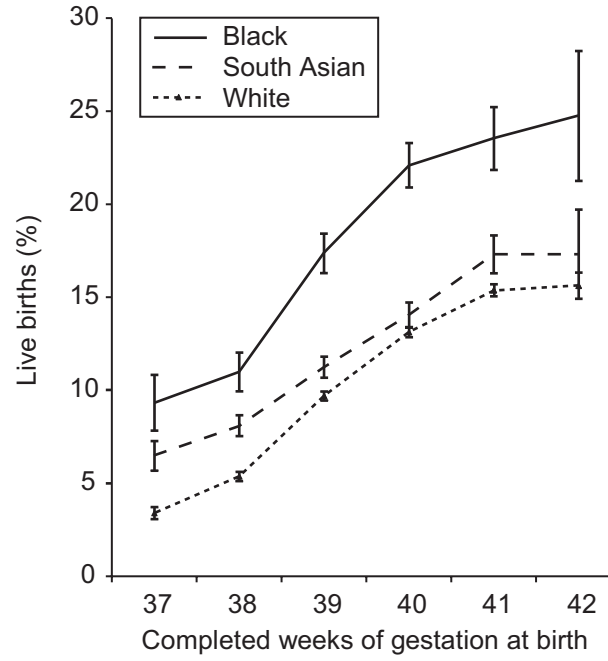

Fig. 2. The rate of meconium-staining of amniotic fluid by gestational age and racial group in cases with no known risk factors for fetal hypoxia and with good perinatal outcome. The error bars represent the 95% confidence interval.

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Of all pregnancies with meconium-stained AF from 37 completed weeks of gestation onward, 22.5% had a poor perinatal outcome compared with 10.9% with no meconium-stained AF (OR 2.39, 95% CI 2.34–2.43; absolute risk 12 per 100). On the other hand, the rate of poor perinatal outcome in newborns with or without meconium-stained AF was almost 100% at the threshold of viability, decreased with advancing gestational age at birth, and reached a nadir of 11.0% at 39 completed weeks of gestation (Fig. 1). For all births from 37 completed weeks of gestation onward, the rate of poor perinatal outcome was 12.9%. Beyond 39 completed weeks of gestation, the rate of poor perinatal outcome began to increase with advancing gestational age (Fig. 3). Using white neonates who delivered at 40 weeks as reference, the excess poor perinatal outcome (absolute risk) at 41 and 42 completed weeks of gestation for white neonates were 2 per 100 and 5 per 100, respectively. The absolute risks were higher in South Asian (3 and 7 per 100, respectively) and highest in black neonates (7 and 11 per 100, respectively). Figure 3 demonstrates that beyond 39 completed weeks of gestation, the rate of poor perinatal outcome began to increase in parallel with the rise in meconium-stained AF rates.

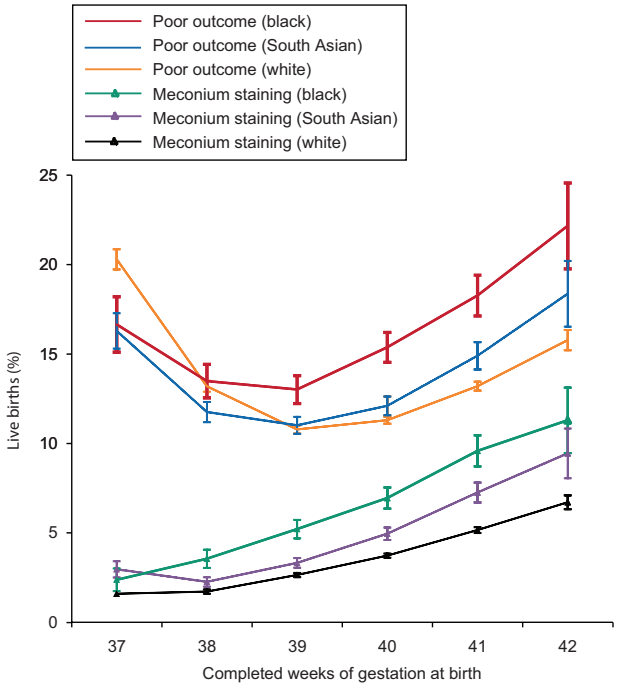

Fig. 3. The percentage of live births with poor perinatal outcome by gestational age at birth and racial group, and the percentage of live births with poor perinatal outcome and meconium-stained amniotic fluid by gestational age and racial group.

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DISCUSSION

There was a "J-shaped" relationship between meconium-stained AF and advancing gestational age, with a nadir at 31 weeks of gestation. Beyond 36 weeks, each advancing week increased the adjusted meconium-stained AF rates significantly, by about 39%. There were 2.4 times more adverse outcomes with meconium-stained AF than without; but the absolute risk was 12 per 100 births. Thus, meconium-stained was mainly associated with fetal maturity rather than hypoxia. Belonging to either black or South Asian racial group independently predicts meconium-stained AF, even after accounting for gestational age, factors associated with fetal hypoxia, adverse perinatal outcome, and socioeconomic factors. The most economical and effective method of categorizing pregnant women is to rely on self-identified ancestry, rather than genetic cluster analysis. In this study, the self-identified groups are clearly different, and this difference suggests earlier fetal maturity rather than a higher incidence of hypoxia in blacks and South Asians compared with whites. Consequently, the adverse effect associated with prolonged pregnancy was observed relatively earlier, and at a steeper rate, in blacks and South Asians than in white neonates. We did not account for racial admixture, but the only effect this will have is to reduce the differences that actually exist to those we have observed. Thus, the true racial differences will be even greater.

The strength of this study is the large sample size and high statistical power. The extensive data collection allowed the identification of pregnancies with adverse outcomes and investigation of risk factors of meconium-stained AF. The calculation of EDDs was robust, based on a combination of last menstrual period and ultrasonography. We accounted for material deprivation using the Carstairs index, which explains many variations in health status.[22,23] Meconium was not classified as "thick" or "thin" because this is subjective and can result in observation bias. Although thin meconium-stained AF is generally considered less harmful than freshly passed, thick meconium, fetal urinary lactate levels suggest that fetuses with thin meconium-stained AF have been subjected to hypoxic stress for a longer period of time than those with thick AF.[24]

A previous study also has reported a higher meconium-stained AF rate at 28 weeks (7.4%) than at 32 weeks of gestation (3.3%), but, owing to the small sample size, this difference was not significant.[10] In

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support of the maturity hypothesis, there is no difference in acid-base status at birth (allowing for gestational age) in pregnancies with or without meconium-stained AF beyond 31 weeks of gestation.[25] Conversely, pregnancies with meconium-stained AF before 32 weeks of gestation have an increased incidence of intra-amniotic infection.[26] In support of variation in the rate of fetal maturity, it is known that black and South Asian neonates born preterm suffer less respiratory distress syndrome compared with white neonates of the same gestational age, with similar observations in female compared with male neonates.[5,27–29] Furthermore, there are several reports of a shorter gestational length in blacks and South Asians compared with white pregnancies.[6,30,31] This suggests early maturation of the fetoplacental unit.

We have shown in a previous study that being South Asian independently predicts stillbirth after 36 weeks, and that the late gestation rise in stillbirth rates begins earlier, and at a steeper rate, compared with white neonates.[15] A similar pattern also was observed in black neonates; however; owing to the smaller sample of black pregnancies and the lower incidence of stillbirths (when compared with perinatal morbidity), this difference was not significant. One explanation for the higher rate of perinatal morbidity at late-term gestation is "relative placental insufficiency," where the placenta can no longer keep up with the demands of the fetus.[32] Additionally, when meconium-stained AF is superimposed on fetal acidemia, there is an increased risk of meconium aspiration syndrome, early-onset respiratory distress in a neonate born through meconium.[33] Furthermore, the presence of meconium-stained AF alone independently increases the risk of neonatal respiratory morbidity.[5]

Other significant predictors of meconium-stained AF include malpresentation or vaginal breech delivery. Because perinatal mortality rate is known to be higher in this group, fetal hypoxia is the likely explanation for the increased rate of meconium-stained AF.[34] Another explanation is that the fetal abdomen is squeezed to a greater extent as it passes through the birth canal than occurs in neonates born with cephalic presentation. Fetal hypoxia (associated with abnormal cardiotocography, operative delivery, extreme birthweight percentile, maternal pyrexia, smoking, and obesity) is probably also an explanation for some cases of meconium-stained AF. We have also reported previously that maternal obesity is an independent predictor antepartum stillbirth.[15]

A Cochrane systematic review of 19 trials, most of which took place in developed countries, has reported that a policy of routine induction of labor at 41 weeks of gestation reduced the risk of perinatal mortality (relative risk [RR] 0.30, 95% CI 0.09–0.99) without increasing the risk of operative delivery.[35] Four trials involving 1,325 women showed that the same policy reduced the risk of meconium aspiration syndrome (RR 0.29, 95% CI 0.12–0.68). Consideration should be given to increased monitoring, or labor induction, earlier than 41 weeks of gestation in South Asian and black women.

REFERENCES

1. Rosenberg NA, Pritchard JK, Weber JL, Cann HM, Kidd KK, Zhivotovsky LA, et al. Genetic structure of human populations. Science 2002;298:2381–5.
2. Jorde LB, Watkins WS, Bamshad MJ, Dixon ME, Ricker CE, Seielstad MT, et al. The distribution of human genetic diversity: a comparison of mitochondrial, autosomal, and Y-chromosome data. Am J Hum Genet 2000;66:979–88.
3. Exner DV, Dries DL, Domanski MJ, Cohn JN. Lesser response to angiotensin-converting-enzyme inhibitor therapy in black as compared with white patients with left ventricular dysfunction. N Engl J Med 2001;344:1351–7.
4. The National Collaborating Centre for Chronic Conditions. Hypertension: management in adults in primary care: pharmacological update. London: Royal College of Physicians; 2006.
5. Balchin I, Whittaker JC, Lamont RF, Steer PJ. Timing of planned cesarean delivery by racial group. Obstet Gynecol 2008;111:659–66.
6. Patel RR, Steer P, Doyle P, Little MP, Elliott P. Does gestation vary by ethnic group? A London-based study of over 122 000 pregnancies with spontaneous onset of labour. Int J Epidemiol 2004;33:107–13.
7. Sriram S, Wall SN, Khoshnood B, Singh JK, Hsieh HL, Lee KS. Racial disparity in meconium-stained amniotic fluid and meconium aspiration syndrome in the United States, 1989–2000. Obstet Gynecol 2003;102:1262–8.
8. Sedaghatian MR, Othman L, Hossain MW, Vidyasagar D. Risk of meconium-stained amniotic fluid in different ethnic groups. J Perinatol 2000;20:257–61.
9. Ahanya SN, Lakshmanan J, Morgan BL, Ross MG. Meconium passage in utero: mechanisms, consequences, and management. Obstet Gynecol Surv 2005;60:45–56.
10. Tybulewicz AT, Clegg SK, Fonfe GJ, Stenson BJ. Preterm meconium staining of the amniotic fluid: associated findings and risk of adverse clinical outcome. Arch Dis Child Fetal Neonatal Ed 2004;89:F328–30.
11. Steer PJ, Eigbe F, Lissauer TJ, Beard RW. Interrelationships among abnormal cardiotocograms in labor, meconium staining of amniotic fluid, arterial cord pH, and Apgar scores. Obstet Gynecol 1989;74:715–21.
12. Carbonne B, Cudeville C, Sivan H, Cabrol D, Papiernik E. Fetal oxygen saturation measured by pulse oximetry during labour with clear or meconium-stained amniotic fluid. Eur J Obstet Gynecol Reprod Biol 1997;72(suppl 1):S51–5.
13. Starks GC. Correlation of meconium-stained amniotic fluid, early intrapartum fetal pH, and Apgar scores as predictors of perinatal outcome. Obstet Gynecol 1980;56(5):604–9.
14. Task Force on Neonatal Encephalopathy and Cerebral Palsy Staff, American College of Obstetricians and Gynecologists with American Academy of Pediatrics Staff. Neonatal enceph-

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alopathy and cerebral palsy: defining the pathogenesis and pathophysiology. Washington, DC: The Americal College of Obstetrician and Gynecologists; 2003. Available at: http://www.acog.org/from_home/Misc/neonatalEncephalopathy.cfm. Retrieved 27 October, 2006.

15. Balchin I, Whittaker JC, Patel RR, Lamont RF, Steer PJ. Racial variation in the association between gestational age and perinatal mortality: prospective study. BMJ 2007;334:833.
16. Nathan L, Leveno KJ, Carmody TJ 3rd, Kelly MA, Sherman ML. Meconium: a 1990s perspective on an old obstetric hazard. Obstet Gynecol 1994;83:329–32.
17. Maresh M, Dawson AM, Beard RW. Assessment of an on-line computerized perinatal data collection and information system. Br J Obstet Gynaecol 1986;93:1239–45.
18. Cleary R, Beard RW, Coles J, Devlin HB, Hopkins A, Roberts S et al. The quality of routinely collected maternity data. Br J Obstet Gynaecol 1994;101:1042–7.
19. Balchin I, Whittaker JC, Steer PJ, Lamont RF. Are reported preterm birth rates reliable? An analysis of interhospital differences in the calculation of the weeks of gestation at delivery and preterm birth rate. BJOG 2004;111:160–3.
20. Kelly Y, Panico L, Bartley M, Marmot M, Nazroo J, Sacker A. Why does birthweight vary among ethnic groups in the UK? Findings from the Millennium Cohort Study. J Public Health (Oxf) 2009;31:131–7.
21. Sanderson DA, Wilcox MA, Johnson IR. The individualised birthweight ratio: a new method of identifying intrauterine growth retardation. Br J Obstet Gynaecol 1994;101:310–4.
22. Carstairs V. Deprivation indices: their interpretation and use in relation to health. J Epidemiol Community Health 1995; 49(suppl 2):S3–8.
23. Dolan SA, Jarman B, Bajekal M, Davies PM, Hart D. Measuring disadvantage: changes in the underpriviledge area, Townsend and Carstairs scores 1981–91. J Epidemiol Community Health 1995;49(suppl 2):S30–3.
24. Ojha RK, Singh SK, Batra S, Sreenivas V, Puliyel JM. Lactate: creatinine ratio in babies with thin meconium staining of amniotic fluid. BMC Pediatr 2006;6:13.
25. Oyelese Y, Culin A, Ananth CV, Kaminsky LM, Vintzileos AM, Smulian JC. Meconium-stained amniotic fluid across gestation and neonatal acid-base status. Obstet Gynecol 2006; 108:345–9.
26. Mazor M, Furman B, Wiznitzer A, Shoham-Vardi I, Cohen J, Ghezzi F. Maternal and perinatal outcome of patients with preterm labor and meconium-stained amniotic fluid. Obstet Gynecol 1995;86:830–3.
27. Berman SM, Tanasijevic M, Alvarez JG, Ludmir J, Lieberman E, Richardson DK. Racial differences in the predictive value of the TDx fetal lung maturity assay. Am J Obstet Gynecol 1996;175:73–7.
28. Floros JO, Fan R, Diangelo S, Guo X, Wert J, Luo J. Surfactant protein (SP) B associations and interactions with SP-A in white and black subjects with respiratory distress syndrome. Pediatr Int 2001;43:567–76.
29. Kavvadia V, Greenough A, Dimitriou G, Hooper R. Influence of ethnic origin on respiratory distress in very premature infants. Arch Dis Child Fetal Neonatal Ed 1998;78:F25–8.
30. Onah HE. Effect of prolongation of pregnancy on perinatal mortality. Int J Gynecol Obstet 2003;80:255–61.
31. Omigbodun AO, Adewuyi A. Duration of human singleton pregnancies in Ibadan, Nigeria. J Natl Med Assoc 1997;89: 617–21.
32. Vorherr H. Placental insufficiency in relation to postterm pregnancy and fetal postmaturity: evaluation of fetoplacental function; management of the postterm gravida. Am J Obstet Gynecol 1975;123:67–103.
33. Ramin KD, Leveno KJ, Kelly MA, Carmody TJ. Amniotic fluid meconium: a fetal environmental hazard. Obstet Gynecol 1996;87:181–4.
34. Hannah ME, Hannah WJ, Hewson SA, Hodnett ED, Saigal S, Willan AR. Planned caesarean section versus planned vaginal birth for breech presentation at term: a randomised multicentre trial. Term Breech Trial Collaborative Group. Lancet 2000;356:1375–83.
35. Gülmezoglu AM, Crowther CA, Middleton P. Induction of labour for improving birth outcomes for women at or beyond term. The Cochrane Database of Systematic Reviews 2006, Issue 4. Art. No.: CD004945. DOI: 10.1002/14651858.CD004945.pub2.

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