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# EFFECT OF PRENATAL ULTRASOUND SCREENING ON PERINATAL OUTCOME

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**Abstract** *Background.* Many clinicians advocate routine ultrasound screening during pregnancy to detect congenital anomalies, multiple-gestation pregnancies, fetal growth disorders, placental abnormalities, and errors in the estimation of gestational age. However, it is not known whether the detection of these conditions through screening leads to interventions that improve perinatal outcome.

*Methods.* We conducted a randomized trial involving 15,151 pregnant women at low risk for perinatal problems to determine whether ultrasound screening decreased the frequency of adverse perinatal outcomes. The women randomly assigned to the ultrasound-screening group underwent one sonographic examination at 15 to 22 weeks of gestation and another at 31 to 35 weeks. The women in the control group underwent ultrasonography only for medical indications, as identified by their physicians. Adverse perinatal outcome was defined as fetal death, neonatal death, or neonatal morbidity such as intraventricular hemorrhage.

*Results.* The mean numbers of sonograms obtained per woman in the ultrasound-screening and control groups were 2.2 and 0.6, respectively. The rate of adverse perinatal outcome was 5.0 percent among the infants of the women in the ultrasound-screening group and 4.9 percent among the infants of the women in the control group (relative risk, 1.0; 95 percent confidence interval, 0.9 to 1.2; P = 0.85). The rates of preterm delivery and the distribution of birth weights were nearly identical in the two groups. The ultrasonographic detection of congenital anomalies had no effect on perinatal outcome. There were no significant differences between the groups in perinatal outcome in the subgroups of women with post-date pregnancies, multiple-gestation pregnancies, or infants who were small for gestational age.

*Conclusions.* Screening ultrasonography did not improve perinatal outcome as compared with the selective use of ultrasonography on the basis of clinician judgment. (N Engl J Med 1993;329:821-7.)

MANY clinicians advocate routine ultrasound screening of the fetus during pregnancy to detect congenital anomalies, multiple-gestation pregnancies, fetal growth disorders, and placental abnormalities and to assess fetal age.[1-3] Although the detection of these conditions is enhanced by ultrasonography, a beneficial effect on perinatal outcome has not been substantiated.[4-12] The predominantly negative findings of past studies have provoked considerable interest in the United States,[2,3,13,14] where concern about unnecessary testing, overtreatment, and cost is growing. The National Institutes of Health Consensus Conference on Ultrasound Imaging in Pregnancy, held in 1984,[15] and the American College of Obstetricians and Gynecologists, in 1988,[16] both concluded that large clinical trials were needed to assess the role of ultrasonography for screening in pregnancy.

The Routine Antenatal Diagnostic Imaging with Ultrasound (RADIUS) trial was a practice-based, multicenter study of pregnant women at low risk for adverse outcomes of pregnancy that was designed to test the hypothesis that routine screening with standardized ultrasonography on two occasions would reduce perinatal morbidity and mortality.

## METHODS

Pregnant women were recruited at 92 participating obstetrical practices and 17 family practices in six states. Women who had an indication for ultrasonography, such as diabetes mellitus, chronic hypertension, an uncertain menstrual history, a discrepancy between uterine size and gestational age based on menstrual dates, or vaginal bleeding, before 18 weeks' gestation were excluded. The specific eligibility and exclusion criteria are listed in Table 1. These criteria resulted in the selection of women generally at low risk for adverse perinatal outcomes. Among the 109 practices were 81 private practices, 15 academic practices, and 13 health maintenance organization (HMO) practices whose patients delivered their babies at 48 hospitals. The protocol was approved by the institutional review committees at each of the collaborating universities.

The physicians in the participating practices registered all wom-

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*The investigators and institutions that participated in the Routine Antenatal Diagnostic Imaging with Ultrasound (RADIUS) trial are listed in the Appendix.

en who presented for a prenatal visit (the first prenatal visit was preferred), who were English speakers, and who were 18 years of age or older. Eligible women who gave informed consent were randomly assigned to the ultrasound-screening group or the control group according to a microcomputer-based randomization sequence, after stratification by practice site to control for potential confounding by differences among practices.[17] For the women in the ultrasound-screening group, one sonogram was obtained at 18 to 20 weeks of gestation and a second at 31 to 33 weeks. The allowable ranges of gestational ages for the first and second sonograms were 15 to 22 weeks and 31 to 35 weeks, respectively. The women in the control group underwent ultrasonography only when it was ordered by a physician for medical reasons that developed after randomization. With the exception of scheduling the two screening sonograms and the performance of indicated ultrasonography in designated laboratories, the care of the patients was left to the clinical judgment of the participating physicians, regardless of group assignment.

All ultrasound examinations, whether assigned for screening purposes or clinically indicated, were performed in 1 of the 28 ultrasound laboratories participating in the RADIUS trial, and the results were recorded on a standard data-collection form. The findings were reported to the woman's physician in the same manner as if the physician had ordered the test. Performance of ultrasonography outside RADIUS laboratories — for instance, on labor and delivery wards or in physicians' offices — was discouraged except in emergencies. The sonograms were obtained with Accuson (model 128 or 128XP) or Ultra-mark (model 4 or 8) scanning equipment. The RADIUS laboratories were staffed by 91 physician-sonologists (listed in the Appendix) and 60 technicians, all but 1 of whom were registered diagnostic medical sonographers.

The standardized evaluation of the sonograms included the assessment of placental location, amniotic-fluid volume, uterine and adnexal pathology, the number of fetuses, and sonographic biometry of the fetus (biparietal diameter, head circumference, abdominal circumference, and femur length), as well as a detailed anatomical survey of the intracranial anatomy, spine, heart (four-chamber view), stomach, cord insertion, diaphragm, kidneys, bladder, and extremities of the fetus. The results were reported by mail to participating physicians in the conventional format used by each laboratory. Generally, physicians were notified immediately by telephone of important abnormalities. The findings were documented by x-ray or thermal images in 26 RADIUS laboratories and by videotape in 2 laboratories. A single investigator provided in-service training and reviewed the first 25 sonograms obtained by each RADIUS sonographer and sonologist. Each review included an assessment of the quality of the image, the thoroughness of the narrative report, and the accuracy of the RADIUS data-collection form. Feedback was provided to each sonographer and sonologist, and when necessary, additional training and review were conducted. The same investigator also reviewed all sonographically identified fetal abnormalities as well as all medically indicated sonograms. These quality-control measures led to a second reading of 19 percent of the 14,534 sonograms read first by other sonologists in the study.

Ultrasound results, pregnancy outcomes, and neonatal outcomes were determined by abstracting the antenatal medical records and inpatient hospital records of antepartum, delivery, and neonatal admissions of all the women in the study, unless the pregnancy ended in a miscarriage. All sonograms, whether obtained in a RADIUS laboratory or not, were recorded when an ultrasound report or a notation of ultrasound findings was present in the record. Neonatal outcomes were documented before discharge or up to six weeks of age if the infant was still hospitalized.

We established procedures to ensure the quality of the abstracted data, including standardized definitions, guidelines for coding, manual review of data forms, and re-abstraction of a sample of records of medically complicated pregnancies. In addition, we reviewed the final outcome of all pregnancies that ended in induced abortion, stillbirth, neonatal death, or admission to a neonatal intensive care unit.

Adverse perinatal outcome, the primary outcome variable, included fetal or neonatal death, severe neonatal morbidity, or moderate neonatal morbidity. The conditions included in these categories are listed in Table 2. Infants were classified according to the most severe outcome.

**Table 1. Eligibility and Exclusion Criteria in the Study of Prenatal Ultrasonography.**

| |
|---|
| **Eligibility criteria** |
| Age >17 years |
| English-speaking |
| Last menstrual period known within 1 week |
| Gestational age <18 weeks |
| No plans to change providers |
| **Exclusions for known conditions** |
| Previous ultrasonography during this pregnancy |
| Previous stillbirth |
| Irregular menstrual cycle* |
| Last menstrual period induced by an oral contraceptive agent |
| Fertility-drug use in current cycle |
| Discrepancy between size and dates >3 weeks |
| Previous small-for-gestational-age infant |
| Diabetes mellitus |
| Chronic hypertension |
| Chronic renal disease |
| **Exclusions for suspected problems or planned reasons** |
| Pelvic mass |
| Fetal death |
| Ectopic pregnancy |
| Molar pregnancy |
| Multiple gestation |
| Planned termination of pregnancy |
| Planned amniocentesis |
| Planned cervical cerclage |
| Planned ultrasonography for reasons other than screening |

*The cycle was considered irregular when the interval between menses varied by more than two weeks.

The goal for the sample size — 15,500 women at low risk for adverse perinatal outcome — was based on the following assumptions: the proportion of women in the control group with an adverse perinatal outcome would be at least 5 percent; the change in this percentage would be 20 percent or more in the ultrasound-screening group; the rate of noncompliance with the screening protocol would be 10 percent or less; and the level of significance (two-sided) would be 5 percent.

Statistical Analysis System software was used for all data management and analysis.[18] Dichotomous base-line characteristics in the two groups were compared with Fisher's exact test and polychotomous characteristics with the chi-square test. Continuous base-line characteristics and the distribution of birth weights in the groups were compared with the Wilcoxon rank-sum test.[19] The point estimate of the relative risk of an adverse perinatal outcome (the ratio of the risk of adverse perinatal outcome among the infants of the women in the ultrasound-screening group to the risk among the infants of the women in the control group) and the corresponding 95 percent confidence intervals were used to indicate the magnitude of the difference between the groups.[20] Fisher's exact test was used to compare the cumulative incidence of adverse perinatal outcome in the two groups. All reported P values are two-sided. Because of the nonindependence of infants in a multiple-gestation pregnancy, the relative risk was recalculated with simultaneous adjustment for the type of gestation (single or multiple). For this analysis, a pregnancy was considered to have had an adverse outcome if one or more of the infants had an adverse perinatal outcome.

Analysis of the primary outcome variables included all randomly assigned women not lost to follow-up, with all women retained in their assigned group regardless of whether their care conformed to the assigned ultrasound regimen (intention-to-treat analysis). Preg-

Table 2. Definitions of Adverse Perinatal Outcomes.

| |
|---|
| Perinatal mortality |
| Fetal death or neonatal death up to 28 days of age* |
| Severe morbidity |
| Grade IV retinopathy of prematurity |
| Bronchopulmonary dysplasia† |
| Mechanical ventilation required for more than 48 hours |
| Intestinal perforation due to necrotizing enterocolitis |
| Grade III or IV intraventricular hemorrhage |
| Subdural or cerebral hemorrhage |
| Spinal cord injury |
| Neonatal seizures‡ |
| Placement of chest tube |
| Documented neonatal sepsis§ |
| Stay of more than 30 days in a special care nursery¶ |
| Moderate morbidity |
| Presumed neonatal sepsis‖ |
| Oxygen required for more than 48 hours |
| Necrotizing enterocolitis without perforation |
| Grade I or II intraventricular hemorrhage |
| Fracture of clavicle or other bones |
| Facial-nerve injury |
| Brachial-plexus injury |
| Stay of more than 5 days in a special care nursery¶ |

*Fetal deaths included all deaths of a fetus weighing more than 500 g or with a gestational age of more than 20 weeks if weight was not recorded. Fetal deaths due to elective termination were not counted as adverse perinatal outcomes.

†Indicated by continuous oxygen use for the first 28 days of life.

‡Occurring after 24 hours of age or treated with anticonvulsant drugs.

§Documented by positive bacterial cultures of cerebrospinal fluid, pleural fluid, or blood or by a positive herpes culture from any source on neonate.

¶In a level II or III nursery or neonatal intensive care unit.

‖Indicated by antibiotic therapy for more than four days.

nancies ended by induced abortion were included in the denominator for adverse perinatal outcome rate but not the numerator.

## Results

A total of 15,530 women entered the study between November 1, 1987, and May 31, 1991. Figure 1 shows the disposition of the women from registration through study entry. The base-line demographic characteristics and risk factors in the two groups were similar (Table 3).

A total of 252 women (1.6 percent) were lost to follow-up, and 127 (0.8 percent) had a spontaneous miscarriage. The reasons for which women were lost to follow-up, and their frequency, were similar in the ultrasound-screening and control groups. In addition, the women lost to follow-up in the two groups were similar with respect to their base-line characteristics. Subsequent analyses were performed on the 15,151 remaining women in the ultrasound-screening group (n = 7617) and the control group (n = 7534) who had induced abortions or delivered one or more live or stillborn infants.

In the ultrasound-screening group, 94 percent of the women underwent ultrasonography at both 15 to 22 weeks and 31 to 35 weeks of gestation; only 2 percent of the women in the control group underwent ultrasonography at both times. The mean number of sonograms obtained was 2.2 per woman in the ultrasound-screening group and 0.6 per woman in the control group; 55 percent of the latter group had no sonograms. The majority of all sonograms were performed in RADIUS laboratories and the findings reported on the ultrasound data-collection form; this was the case for 89 percent of all sonograms (19,233 of 21,630) and 96 percent of the sonograms in the ultrasound-screening group (16,147 of 16,903).

The rates of adverse perinatal outcome were 5.0 percent in the ultrasound-screening group and 4.9 percent in the control group (relative risk, 1.0; 95 percent confidence interval, 0.9 to 1.2; P = 0.85) (Table 4). We found no significant differences between the two groups in any of the variables indicating adverse perinatal outcome that are listed in Table 2. We reestimated the group-specific rates of adverse perinatal outcome on the basis of the number of pregnancies instead of the number of infants. The estimated rate of adverse perinatal outcome of 4.8 percent among pregnancies in the ultrasound-screening group was similar to the rate of 4.7 percent in the control group (relative risk, adjusted for the number of fetuses, 1.0; 95 percent confidence interval, 0.9 to 1.2; P = 0.78) (Table 4).

Gestational age at delivery was determined according to the date of the last menstrual period, unless the gestational age indicated by the biparietal diameter on a sonogram obtained before 26 weeks of gestation differed from that determined from the last menstrual period by more than 10 days. For these pregnancies, the gestational age at delivery was calculated on the basis of the ultrasonographic findings. There were 85 women in the ultrasound-screening group who delivered their infants at 32 weeks of gestation or earlier (1.1 percent) and 73 (1.0 percent) in the control group (relative risk, 1.2; 95 percent confidence interval, 0.8

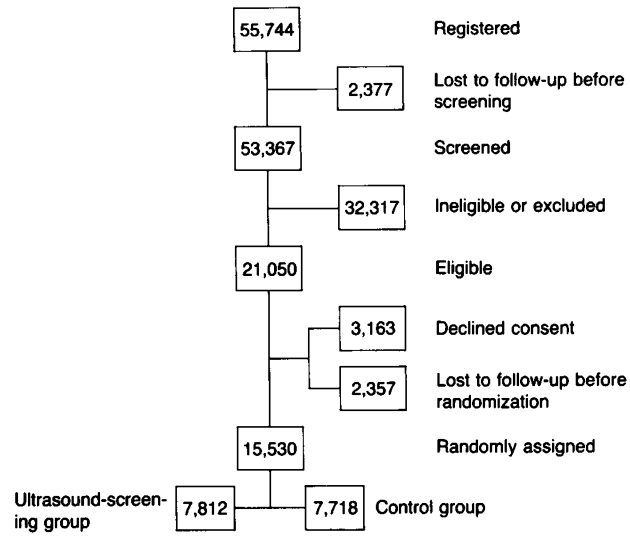


Figure 1. Status of the Pregnant Women Recruited for Study from Registration to the Time of Random Assignment to the Ultrasound-Screening Group or the Control Group.

After randomization, 252 women were lost to follow-up, and 127 had spontaneous miscarriages. The final study group therefore comprised 15,151 women.

to 1.6). There were 421 women in the ultrasound-screening group (5.5 percent) and 445 women in the control group (5.9 percent) who delivered at less than 37 weeks of gestation (relative risk, 0.9; 95 percent confidence interval, 0.8 to 1.1).

The distribution of birth weights was also similar in the two groups (P = 0.39). The mean (±SD) birth weight of the infants whose mothers were in the ultrasound-screening group was 3433±544 g, as compared with 3429±535 g for the infants whose mothers were in the control group (mean difference, 3.6 g; 95 percent confidence interval, 13.5 to 20.8 g).

There were 350 fetuses with at least one major anomaly (2.3 percent) — 187 in the ultrasound-screening group and 163 in the control group (Table 5). Sixty-five fetuses with at least one major anomaly were identified by ultrasonography before delivery in the ultrasound-screening group (34.8 percent sensitivity); 31 (16.6 percent) were detected before 24 weeks, the gestational-age limit for legal abortion in most states. In the control group, 18 fetuses with one or more major anomalies were detected by ultrasonography (11.0 percent); 8 were detected before 24 weeks (4.9 percent).

Table 3. Base-Line Characteristics of the Pregnant Women in the Ultrasound-Screening and Control Groups.*

| Characteristic | Ultrasound Screening (N = 7812) | Control (N = 7718) |
|---|---|---|
| | *no. (%)* | |
| Age (yr) | | |
| <20 | 224 (3) | 208 (3) |
| 20–35 | 7425 (95) | 7349 (95) |
| >35 | 163 (2) | 161 (2) |
| Race | | |
| White | 7257 (93) | 7159 (93) |
| Black | 332 (4) | 360 (5) |
| Other | 223 (3) | 199 (3) |
| Education† | | |
| High-school graduation or less | 2275 (29) | 2308 (30) |
| Some college | 2319 (30) | 2202 (29) |
| College graduation | 3215 (41) | 3203 (42) |
| Prepregnancy weight (kg) | | |
| <45.6 | 137 (2) | 102 (1) |
| 45.6–82.0 | 7071 (91) | 6950 (90) |
| ≥82.1 | 600 (8) | 660 (9) |
| Height (cm) | | |
| <152.4 | 76 (1) | 73 (1) |
| 152.4–177.7 | 7450 (95) | 7344 (95) |
| ≥177.8 | 282 (4) | 293 (4) |
| Current smoking | 1002 (13) | 976 (13) |
| Current alcohol use | 1684 (22) | 1624 (21) |
| Pregnancy history | | |
| Primiparous | 2770 (35) | 2762 (36) |
| Previous pregnancy | 5042 (65) | 4956 (64) |
| Miscarriage‡ | | |
| 1 | 973 (19) | 991 (20) |
| ≥2 | 164 (3) | 155 (3) |
| Induced abortion‡ | | |
| 1 | 832 (17) | 812 (16) |
| ≥2 | 181 (4) | 210 (4) |
| Live-born infant‡ | | |
| Birth weight ≤2.28 kg | 77 (2) | 93 (2) |
| Birth weight 2.29–4.07 kg | 3900 (77) | 3780 (76) |
| Birth weight ≥4.08 kg | 492 (10) | 453 (9) |

*The groups are shown before losses to follow-up or the exclusion of women whose pregnancies ended in miscarriage. Because of rounding, percentages may not total 100.

†Data on education were missing for three women in the ultrasound-screening group and five women in the control group. Data on prepregnancy weight were missing for four and six women, respectively, and data on height for four and eight women, respectively. Percentages are of the group for whom data were available.

‡Percentages are of the women with a previous pregnancy.

Of the 12 abortions performed in the ultrasound-screening group, 9 were for anomalies detected before 24 weeks of gestation, 1 was for unexplained oligohydramnios, and 2 were elective. In the control group, there were nine abortions: four for anomalies detected before 24 weeks of gestation, one for an anomaly detected after 24 weeks, one for unexplained oligohydramnios, one for partial molar pregnancy, and two elective abortions.

Analyses were also performed in the subgroups of women with multiple gestations, infants who were small for gestational age, and post-date pregnancies (42 weeks' gestation or more) to determine whether ultrasound screening was beneficial in these higher-risk groups. There were 68 pregnancies with multiple gestations in the ultrasound-screening group and 61 in the control group. Among multiple pregnancies, the rate of adverse perinatal outcome of 25.0 percent in the ultrasound-screening group was not significantly different from the rate of 37.7 percent in the control group (relative risk, 0.7; 95 percent confidence interval, 0.39 to 1.11; P = 0.13). The birth-weight distribution among the infants in multiple-gestation pregnancies was similar in the two groups (ultrasound-screening group [mean ±SD], 2461±645 g; control group, 2411±620 g; P = 0.41). Among the women with multiple-gestation pregnancies, eight in the ultrasound-screening group delivered at 32 completed weeks of gestation or earlier (11.8 percent), as compared with eight (13.1 percent) in the control group (relative risk, 0.9; 95 percent confidence interval, 0.4 to 2.2). The infants in 29 multiple-gestation pregnancies in the ultrasound-screening group (42.6 percent) and in 27 in the control group (44.3 percent) were delivered at less than 37 weeks of gestation (relative risk, 1.0; 95 percent confidence interval, 0.6 to 1.4).

A total of 346 singleton pregnancies (176 in the ultrasound-screening group and 170 in the control group) resulted in the birth of infants who were small for gestational age, as determined by a birth weight below the 10th percentile according to the weight curve of Brenner et al.[21] The incidence of adverse perinatal outcome among single small-for-gestational-age infants in the ultrasound-screening group was 13.1 percent, as compared with 11.8 percent among similar infants in the control group (relative risk, 1.1; 95 percent confidence interval, 0.6 to 2.0; P = 0.75).

There was also no significant difference in outcome between the two groups among the 592 women who delivered at or after 42 weeks of gestation (245 in the ultrasound-screening group and 347 in the control group). All these women had singleton pregnancies. The rate of adverse outcome among post-date pregnancies in the ultrasound-screening group was 1.6

Table 4. Adverse Perinatal Outcomes in the Ultrasound-Screening and Control Groups.

| Outcome | Singleton Fetuses | | Multiple Gestation | | All | |
|---|---|---|---|---|---|---|
| | Ultrasound screening (N = 7549) | Control (N = 7473) | Ultrasound screening (N = 136) | Control (N = 123) | Ultrasound screening (N = 7685) | Control (N = 7596) |
| | *number (percent)* | | | | | |
| Fetal death | 31 (0.4) | 22 (0.3) | 3 (2.2) | 1 (0.8) | 34 (0.4) | 23 (0.3) |
| Neonatal death | 17 (0.2) | 15 (0.2) | 1 (0.7) | 3 (2.4) | 18 (0.2) | 18 (0.2) |
| Severe morbidity | 88 (1.2) | 82 (1.1) | 11 (8.1) | 13 (10.6) | 99 (1.3) | 95 (1.3) |
| Moderate morbidity | 215 (2.8) | 213 (2.9) | 17 (12.5) | 24 (19.5)* | 232 (3.0) | 237 (3.1) |
| All adverse outcomes | | | | | | |
| Fetuses | 351 (4.6) | 332 (4.4) | 32 (23.5) | 41 (33.3)* | 383 (5.0) | 373 (4.9) |
| Pregnancies† | 351 (4.6) | 332 (4.4) | 17 (25.0) | 23 (37.7) | 368 (4.8) | 355 (4.7) |

*Includes three infants from the only triplet pregnancy in the trial.

†The number of pregnancies shown is the number in which one or more fetuses had an adverse perinatal outcome. The total number of multiple-gestation pregnancies was 68 in the ultrasound-screening group and 61 in the control group.

percent, as compared with 2.6 percent in the control group (relative risk, 0.6; 95 percent confidence interval, 0.2 to 2.0; P = 0.57).

## Discussion

We found that, as compared with the selective use of ultrasonography on the basis of clinician judgment, routinely obtaining two screening sonograms did not reduce perinatal morbidity or mortality among the fetuses of low-risk pregnant women. There were no significant differences in the rate of preterm delivery, distribution of birth weight, or outcomes within the subgroups of women with multiple gestations, small-for-gestational-age infants, and post-date pregnancies. Finally, the detection of major anomalies by ultrasound examination did not alter outcomes.

Previous trials of ultrasound screening have found improved diagnostic outcomes, such as early diagnosis of multiple gestation[4,5,7-9] and detection of errors in the assignment of gestational age,[4,5,7] and differing effects of ultrasound screening on interventions such as induction of labor[4,5,7-9] and on the length of the hospital stay.[4,8,9] The primary question addressed in our study was whether these diagnostic findings and the resulting interventions lead to reductions in perinatal morbidity and mortality. Earlier trials did not answer this question definitively, for several reasons. Some trials did not compare screened and nonscreened groups.[6,7,10-12] In three trials, there was no difference in perinatal outcome, but the study groups were small.[5,8,9] Our larger study confirms the results of these three negative trials.[5,8,9]

Analyses of high-risk subgroups also revealed no significant difference in the frequency of adverse perinatal outcome. A change in the length of gestation and the distribution of birth weight would be expected if an intervention improved perinatal outcome in multiple-gestation pregnancies or among small-for-gestational-age infants, but none was found. Other randomized trials have not demonstrated improved outcomes resulting from interventions in twin pregnancies[22-24] or as a result of ultrasound screening targeted to the detection of intrauterine growth retardation.[10-12]

The screening approach used in this study included a thorough anatomical survey, standardized ultrasound content,[25] and quality-assurance procedures. We studied more than twice as many women as the total number studied in all three previous negative trials.[5,8,9] Because of our large sample, we can state with 95 percent certainty that the greatest effect on the rate of adverse perinatal outcome attributable to ultrasound screening would be a 10 percent reduction or a 20 percent increase. Most patients were at low risk for adverse outcomes, received care from board-certified physicians, and were cared for with the resources typically available to pregnant women in the United States. Whatever the explanation proposed for its lack of effect, the findings of this study clearly indicate that ultrasound screening does not improve perinatal outcome in current U.S. practice.

Table 5. Outcomes of Pregnancies in Which One or More Fetuses Had a Major Anomaly in the Ultrasound-Screening and Control Groups.

| Outcome | Ultrasound Screening (N = 187) | | | Control (N = 163) | | |
|---|---|---|---|---|---|---|
| | Detected at <24 wk (N = 31) | Detected at ≥24 wk (N = 34) | Not detected by ultrasonography (N = 122) | Detected at <24 wk (N = 8) | Detected at ≥24 wk (N = 10) | Not detected by ultrasonography (N = 145) |
| | *number of pregnancies* | | | | | |
| Induced abortion for anomaly* | 9 | 0 | 0 | 4 | 0 | 1† |
| Adverse perinatal outcome | | | | | | |
| Perinatal death | 4 | 2 | 4 | 3 | 3 | 8 |
| Severe morbidity | 2 | 3 | 21 | 0 | 1 | 30 |
| Moderate morbidity | 3 | 5 | 14 | 0 | 2 | 18 |
| No adverse perinatal outcome | 13 | 24 | 83 | 1 | 4 | 88 |

*In the ultrasound-screening group, there were three abortions for anencephaly, four for spina bifida, one for bilateral renal agenesis, and one for cystic hygroma with hydrops. In the control group, the five abortions were for the following: anencephaly, spina bifida, diaphragmatic hernia, urethral atresia, and cystic hygroma with hydrops.

†This woman had three sonograms, but none were performed in a RADIUS laboratory, and the findings were not reported on a study data-collection form; the anomaly was therefore considered "not detected."

In the Helsinki Ultrasound Trial,[4] in contrast to our results, the perinatal mortality rate was lower in the ultrasound-screening group (4.6 vs. 9.0 per 1000, $P<0.05$) because of the detection of anomalies and the subsequent termination of the affected pregnancies. The prevalence of major anomalies in our trial (2.3 percent) was similar to[26] or higher than[27,28] that reported in other studies. The detection rate of 35 percent in the ultrasound-screening group was higher than the rate in the control group (10 percent). However, the detection of anomalies by ultrasound screening did not reduce the frequency of adverse perinatal outcome for several reasons. Over half the anomalies in the ultrasound-screening group were detected at or after 24 weeks' gestation (34 of 65, or 52 percent), when legal abortion is not available in most states. The majority of women in whom fetal anomalies were discovered through ultrasound screening before 24 weeks of gestation chose to continue their pregnancies (22 of 31, or 71 percent). Finally, abnormal maternal serum alpha-fetoprotein concentrations and other indications for ultrasonography led to the detection and subsequent abortion of some fetuses with anomalies in the control group. As a consequence, the abortion rate in the ultrasound-screening group was not significantly greater than the rate in the control group (0.15 percent [12 abortions] vs. 0.12 percent [9 abortions]), and it was approximately one fifth of that in the ultrasound-screening group in the Helsinki Ultrasound Trial (0.8 percent). Even if all women carrying fetuses with anomalies detected before 24 weeks in our study had terminated their pregnancies, only nine cases with an adverse outcome would have been prevented in the ultrasound-screening group and three in the control group. The hypothetical rate of adverse perinatal outcome if all fetuses in which major anomalies were detected were aborted would have been 4.9 percent (374 of 7685) in the ultrasound-screening group and 4.9 percent (370 of 7596) in the control group.

The routine use of screening ultrasonography in this study added, on average, 1.6 scans per pregnancy. Screening more than 4 million pregnant women[29,30] annually in the United States at $200 per scan would increase costs by more than $1 billion. Confining the estimate of increased cost to 40 percent of all pregnancies on the basis of eligibility for this study would still result in an increase of over $500 million.

In conclusion, this practice-based trial demonstrates that among low-risk pregnant women ultrasound screening does not improve perinatal outcome. Potential benefits such as satisfying patients' desires for assurance that there are no fetal anomalies[31] must be weighed against the unnecessary anxiety entailed in the examinations and the risks of overtreatment due to false positive diagnoses.[14,32] The adoption of routine ultrasound screening in the United States would add considerably to the cost of care in pregnancy, with no improvement in perinatal outcome.

## Appendix

The following institutions and persons participated in the RADIUS trial. The principal investigators are indicated by asterisks.

Clinical Centers — *University of Missouri School of Medicine, Columbia:* B. Ewigman,* M. LeFevre, S. Cornelison, L. Boyer, D. Horman, and M. Plattner; *Washington University School of Medicine, St. Louis:* J.P. Crane,* D. Kane, R. Winborn, B. Crawford, and L. Boyd; *Brigham and Women's Hospital, Harvard Medical School, Boston:* F.D. Frigoletto,* D.W. Cramer, and B.L. Harlow. Coordinating Center — *The George Washington University Biostatistics Center, Rockville, Md.:* R.P. Bain,* J.K. Evans, T. Turlington, and P.K. Burrows. Project Office — *National Institute of Child Health and Human Development, Bethesda, Md.:* D. McNellis (project officer), S. Yaffe, and C. Catz. Data Monitoring Committee — E.J. Quilligan (chairman), F. Hadlock, J.C. Hobbins, and G. Williams.

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