

AD _____

MIPR NO. 95MM5546

TITLE: The Relationship of Bacterial Contamination and Interleukin-6
in Amniotic Fluid in Preterm Labor and Delivery

PRINCIPAL INVESTIGATOR(S): CPT Rodger K. Martin

CONTRACTING ORGANIZATION: Madigan Army Medical Center
Tacoma, Washington 98431-5000

REPORT DATE: January 1996

TYPE OF REPORT: Final

PREPARED FOR: U.S. Army Medical Research and Materiel Command
Fort Detrick, Frederick, Maryland 21702-5012

DISTRIBUTION STATEMENT: Approved for public release; distribution
unlimited.

The views, opinions and/or findings contained in this report are those
of the author(s) and should not be construed as an official Department
of the Army position, policy or decision unless so designated by other
documentation.

19971223 067

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE January 1996	3. REPORT TYPE AND DATES COVERED Final (1 Dec 94 - 30 Sep 95)	
4. TITLE AND SUBTITLE The Relationship of Bacterial Contamination and Interleukin-6 in Amniotic Fluid in Preterm Labor and Delivery		5. FUNDING NUMBERS 95MM5546	
6. AUTHOR(S) CPT Rodger K. Martin			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Madigan Army Medical Center Tacoma, WA 98431-5000		8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Army Medical Research and Materiel Command Fort Detrick, MD 21702-5012		10. SPONSORING/MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES			
12a. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited		12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) Amniotic fluid (AF) was collected from 54 women with preterm labor at the Tripler and Madigan Army Medical Centers from 19 Dec 94-30 Sep 95. The AF was evaluated by standard culturing methods for aerobic and anaerobic bacteria as well as Mycoplasma. At the time of amniocentesis, 5 mL of AF was aspirated and frozen for detection of bacteria and Mycoplasma by the polymerase chain reaction (PCR) and for interleukin-6 studies. Approximately 55% of the patient AF samples were positive for bacteria by the PCR, whereas the culture data detected bacteria in approximately 9% of the samples. Interleukin-6 was found to be elevated above 600 pg/mL in nine samples. Patients whose amniotic fluid IL-6 levels exceeded 600 pg/mL delivered preterm. The sensitivity of the PCR assay and the prognostic value of IL-6 as markers of preterm labor and delivery are discussed. <div style="text-align: right;">DTIC QUALITY INSPECTED 2</div>			
14. SUBJECT TERMS Defense Women's Health Research Program, Preterm labor, chorio-amnionitis, polymerase chain reaction, bacterial DNA isolation, chemiluminescence, cultures, and interleukin-6.		15. NUMBER OF PAGES 32	
		16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT Unlimited

FOREWORD

Opinions, interpretations, conclusions and recommendations are those of the author and are not necessarily endorsed by the US Army.

Where copyrighted material is quoted, permission has been obtained to use such material.

Where material from documents designated for limited distribution is quoted, permission has been obtained to use the material.

RKM Citations of commercial organizations and trade names in this report do not constitute an official Department of Army endorsement or approval of the products or services of these organizations.

In conducting research using animals, the investigator(s) adhered to the "Guide for the Care and Use of Laboratory Animals," prepared by the Committee on Care and Use of Laboratory Animals of the Institute of Laboratory Resources, National Research Council (NIH Publication No. 86-23, Revised 1985).

RKM For the protection of human subjects, the investigator(s) adhered to policies of applicable Federal Law 45 CFR 46.

In conducting research utilizing recombinant DNA technology, the investigator(s) adhered to current guidelines promulgated by the National Institutes of Health.

In the conduct of research utilizing recombinant DNA, the investigator(s) adhered to the NIH Guidelines for Research Involving Recombinant DNA Molecules.

In the conduct of research involving hazardous organisms, the investigator(s) adhered to the CDC-NIH Guide for Biosafety in Microbiological and Biomedical Laboratories.

Rodger K. Martin 11 Jan 96
PI Signature Date

Table of Contents

	<u>Page</u>
I. Introduction	
A. Background	2
B. Status	3
II. Materials & Methods	
A. Patient Enrollment Criteria	4
B. Collection of Amniotic Fluid & Bacterial DNA Isolation	4
C. Polymerase Chain Reaction	4
1. Eubacterial PCR	
2. <i>Mycoplasma</i> PCR	
D. Southern Blotting & Chemiluminescence	5
E. Interleukin-6 ELISA	6
III. Results	
A. Patient Enrollment & Clinical Data	7
1. Tripler Army Medical Center	
2. Madigan Army Medical Center	
B. Polymerase Chain Reaction Data	8
1. Eubacterial PCR	
2. <i>Mycoplasma</i> PCR Data	
C. Interleukin-6 ELISA Data	9
IV. Conclusions	11
V. References	13
VI. Figures and Tables	16

Final Report: "The Relationship of Bacterial Contamination and Interleukin-6 in Amniotic Fluid in Preterm Labor and Delivery"

INTRODUCTION

BACKGROUND:

Idiopathic preterm labor is the approximate cause of one-third of all preterm births (1). Preterm birth is the largest contributor to neonatal, perinatal, and infant mortality in the United States (2). Preterm birth also is a major cause of infant morbidity such as developmental delay, cerebral palsy, and chronic lung disease (3). Several published reports have identified the gravid active duty soldier as at high risk for preterm labor and delivery (4-6). In the multicenter study by Adams, the rate of preterm delivery of white enlisted women was 10.5%. This is higher than the national average rate for preterm birth of 8.5% (7). This same study noted that black enlisted women have a 31% higher risk than white enlisted women for preterm delivery; black enlisted pregnancies had a preterm birth rate of 13.5%. It is important to note that whereas this is higher than the rate in white enlisted pregnancies, it is still lower than the national average for black women of 18.3% (7). These high rates of preterm delivery occur despite free access to prenatal care, a general healthy population, and a low use of recreational drugs (8,9). To date, no data is published concerning the impact of preterm labor and delivery on duty days lost. However, the primary treatment of preterm labor is bedrest; therefore, it can be expected that a significant number of duty days are lost due to this pregnancy complication. Therefore, any regime that would investigate the cause of preterm labor and delivery would be of great benefit not only to the gravid soldier and their families but also for their unit.

Intra-amniotic infection is thought to play a key role in preterm labor. Slightly greater than 9% percent of women with preterm labor and intact membranes will have amniotic fluid cultures positive for bacteria or *Mycoplasma* species (1,10,11). A proposed mechanism in which bacterial infection leads to premature delivery involves activation of cell-mediated immunity. This immune activation process stimulates production of cytokines. This in turn results in prostaglandin production that leads to uterine contractions (12). One of the cytokines that is stimulated in this cascade event is interleukin-6 (IL-6). Several studies have shown that elevated amniotic fluid IL-6 levels from pregnancies complicated by preterm labor are at high risk for preterm delivery (12-17). Positive amniotic fluid cultures also correlate well with elevated IL-6 levels. However, over 50% of pregnancies that have elevated IL-6 levels have negative amniotic fluid cultures (12). It is unknown if this is due to the poor sensitivity of the culture methods to detect bacteria or if there is another etiology for the stimulation of cytokine production.

Since bacterial infection of the amniotic fluid has been suggested as a cause of preterm labor, several studies have employed antibiotics as part of the treatment for preterm labor. The results of these trials in prolonging pregnancy have been mixed and no clear cut benefit has been proven for the use of antibiotics in preterm labor (18). This may be due to the inability to select the patient population that would best benefit from antibiotic therapy, i.e. those with intra-amniotic infection. It is possible that better results could be obtained by using a very sensitive technique such as the polymerase chain reaction (PCR) to detect the presence of bacteria in the amniotic fluid and treat those patients with antibiotics. Cases in which the IL-6 levels are elevated

Final Report: "The Relationship of Bacterial Contamination and Interleukin-6 in Amniotic Fluid in Preterm Labor and Delivery"

but no bacterial DNA is present may represent a non-infective immune process which would require the development of new treatment strategies, such as immunosuppression.

STATUS:

In this study, we had originally proposed enrolling a minimum of 150 pregnant women from Tripler (TAMC) and Madigan (MAMC) Army Medical Centers. However, due to the late arrival of funds (mid-December 1994), an overestimate of the patient population, and the end of the fiscal year (only nine months for the study), we enrolled 64 women. Of these 64 women, ten were excluded from data analysis due to the induction of delivery due to preeclampsia, the presence of twins, or upon clinical reevaluation, failure to meet inclusion criteria. Amniotic fluid samples (n = 54) were collected from these pregnancies complicated by preterm labor and were obtained by consent in clinically indicated situations that required analysis to rule out chorioamnionitis. At the time of amniocentesis the fluid was gram-stained and cultured for aerobic and anaerobic bacteria as well as *Mycoplasma*. Amniotic fluid was evaluated for the presence of bacteria and *Mycoplasma* utilizing the polymerase chain reaction (PCR) to amplify a ribosomal consensus sequence of DNA. The presence of such sequences in amniotic fluid was considered as evidence of bacterial contamination. Interleukin-6 (IL-6) levels were obtained as well and were correlated with clinical outcomes and the PCR. After delivery, placentas were sent to pathology for observation of polymorphonuclear cells in formalin-fixed, paraffin-embedded chorion or amnion. The presence of polymorphonuclear cells was evidence for chorioamnionitis.

Final Report: "The Relationship of Bacterial Contamination and Interleukin-6 in Amniotic Fluid in Preterm Labor and Delivery"

MATERIALS & METHODS

PATIENT ENROLLMENT CRITERIA:

The study population consisted of women 18 years or older admitted with the diagnosis of preterm labor (regular uterine contractions with a change in cervical dilation between 20-37 weeks) or advance cervical dilation that required amniocentesis to rule out intrauterine infection. Patients with intact membranes and those with premature rupture of the membranes were included. Prior treatment with antibiotics was not an exclusionary factor.

COLLECTION OF AMNIOTIC FLUID & BACTERIAL DNA ISOLATION:

At the time of amniocentesis, the amniotic fluid was collected aseptically and an aliquot removed for clinical analysis. Clinical analyses included the aerobic and anaerobic bacterial cultures, glucose determinations, and gram stains. *Mycoplasma* culturing for TAMC and MAMC was done at MetPath Laboratories in Teterboro, New Jersey.

Additional fluid was collected by aspiration and transferred to a sterile container for PCR and IL-6 studies. This fluid was briefly spun at 1,000 x g, split into two equal fractions, and frozen. The supernatant phase was designated specifically for the IL-6 ELISA in order to minimize the contribution from intracellular IL-6 from leukocytes upon freezing. Samples collected at the TAMC were processed and shipped frozen on dry ice to the Department of Clinical Investigation (DCI) at MAMC for further analyses for IL-6 and PCR studies. Samples from MAMC were generally processed within 24 hours after amniocentesis at the DCI.

The bacterial DNA was isolated from clinical samples by the method of Goldenberger et al. using SDS and proteinase K (19). Of seven bacterial DNA isolation methods evaluated, it was determined to be the best and most effective for gram (+) and gram (-) organisms. Essentially, the amniotic fluid was frozen overnight at -20°C, quickly thawed at 37°C, and subjected to centrifugation at 12,000 x g for 10 minutes at 4°C. The fluid above the pellet was carefully aspirated and discarded. The pellet was resuspended with 0.2 mL of the digestion buffer (50 mM Tris-HCl, 1 mM EDTA, and 0.5% SDS) with 200 µg/mL of proteinase K and placed in a shaking incubator at 55°C for three hours with vigorous agitation (240 RPMs).

After the proteinase K digestion, the enzyme was heat inactivated at 95°C for 10 minutes, the sample cooled to 4°C, and centrifuged at 12,000 x g for 10 minutes at 4°C. The supernatant was transferred to another sterile tube and stored at -20°C until needed. Approximately 10 µL of the supernatant was sufficient for a 100 µL PCR.

POLYMERASE CHAIN REACTION:

PCR was performed according to standard methodology with one modification (20,21). Tween-20 (Sigma) was included in the final PCR at a concentration of 2% (19). This was reported to prevent inhibition of *AmpliTag* polymerase® by minute concentrations of residual SDS from crude DNA extractions. In addition, digoxigenin-11-dUTP (Boehringer Mannheim, Inc.) was directly incorporated into the PCR product to

Final Report: "The Relationship of Bacterial Contamination and Interleukin-6 in Amniotic Fluid in Preterm Labor and Delivery"

facilitate detection by chemiluminescence and to minimize false negative PCR results (22).

EUBACTERIAL PCR

Consensus eubacterial primers to the 16S rRNA were synthesized commercially (Gibco BRL). The sequences were as follows:

16S rRNA Eubacterial Primers (23)

Upstream Primer: 5'-AGA GTT TGA TCC TGG CTC AG-3'

Downstream Primer: 5'-CCG TCA ATT CCT TTG AGT TT-3'

The cycling parameters were 94°C for 30 seconds, 56°C for 30 seconds, and 72°C for 45 seconds for 30 cycles in a Perkin-Elmer 9600 Thermocycler. The resulting PCR product was 900 bp in length.

MYCOPLASMA PCR

Primers for *Mycoplasma* were genus-specific and were synthesized on an oligo-DNA synthesizer, Gene Assembler Special (Pharmacia LKB). Primer sequences were as follows:

16S rRNA Genus-Specific Primers (24)

Upstream Primer: 5'-ACT CCT ACG GGA GGC AGC AGT A-3'

Downstream Primer: 5'-TGC ACC ATC TGT CAC TCT GTT AAC CTC-3'

The cycling parameters were 94°C for 30 seconds, 60°C for 30 seconds, 72°C for 60 seconds for 30 cycles. The resulting PCR product was 717 bp in length.

Amniotic fluid samples that were PCR positive for *Mycoplasma* were assigned to the PCR positive group and further evaluated with species-specific DNA primers for *Mycoplasma genitalium* and *Ureaplasma urealyticum*. Primer sequences were as follows:

***Mycoplasma genitalium* ATT Primers (25,26)**

Upstream Primer: 5'-TGT CTA TGA CCA GTA TGT AC-3'

Downstream Primer: 5'-CTG CTT TGG TCA AGA CAT CA-3'

***Ureaplasma urealyticum* Urease Primers (27)**

Upstream Primer: 5'-CCA GGA AAA CTA GTA CCA GGA GC-3'

Downstream Primer: 5'-CTC CTA ATC TAA CGC TAT CAC C-3'

The thermocycling parameters were as described for the *Mycoplasma* consensus primers. The resulting PCR products for *Mycoplasma genitalium* and *Ureaplasma urealyticum* were 300 bp and 460 bp, respectively.

SOUTHERN BLOTTING & CHEMILUMINESCENCE:

The PCR products were size-fractionated by electrophoresis on 2% agarose gels with 0.5 µg/mL ethidium bromide in 1X TBE (0.089 M Tris-borate, 0.089 M boric acid, and 0.002 M EDTA) buffer (28). After photography of the gel by UV irradiation on a Foto Eclipse (Fotodyne), the DNA was transferred to nylon membranes (Managraph, Micron Separations, Inc.) by the method of Southern (29). Upon completion of the transfer, the membrane was briefly immersed in 2X SSC (0.3 M sodium chloride and 0.03 M sodium citrate), and the nucleic acids crosslinked by UV irradiation at 120,000 µJ (Stratalinker, Stratagene). The

Final Report: "The Relationship of Bacterial Contamination and Interleukin-6 in Amniotic Fluid in Preterm Labor and Delivery"

membranes were processed for chemiluminescence as described (22) and in accordance with the manufacturer's recommendations (Boehringer Mannheim, Inc.). Typical luminograph exposures with XAR-5 film (Kodak) were one, five, and thirty minutes.

INTERLEUKIN-6 ASSAYS

Frozen amniotic fluid was assayed quantitatively for interleukin-6 (IL-6) levels with the Human ELISA IL-6 kit (Endogen, Inc.) in accordance with the manufacturer's recommendations. Amniotic fluid samples that were difficult to quantitate due to concentration were diluted ten-fold with the kit standard diluent. Even with a 1:10 dilution patient, T052's IL-6 level was significantly greater than the upper confidence limits of the assay. Values were reported as pg/mL.

Final Report: "The Relationship of Bacterial Contamination and Interleukin-6 in Amniotic Fluid in Preterm Labor and Delivery"

RESULTS

PATIENT ENROLLMENT & CLINICAL DATA:

A total of 54 patients were finally included in the study. Table I summarizes the demographic data. The clinical profile of the study population is described (Table II). Approximately 67% of the patients (n = 36) delivered preterm. The mean gestational ages at the time of amniocentesis and at the time of delivery were 32.5 weeks and 35.6 weeks, respectively. Table III lists the organisms identified in the amniotic fluid cultures. The overall culture positive rate was 9.2% (n = 5). A summary of the patient population at each institution follows.

Tripler Army Medical Center

A total of 55 amniocenteses were performed and all patients delivered at TAMC. Subsequently, nine were excluded from further analysis due to twinning (n = 7), induction of delivery due to preeclampsia (n = 1), or delivery less than 20 weeks (n = 1). Enrollment of patients began in January for an average of six patients per month.

Fifty percent of the TAMC patients enrolled delivered preterm with 43% of the newborn weights less than 2,500 grams. This was consistent with previous studies of patients that required amniocentesis to rule out infection (1). Of the amniotic fluid cultures, five were positive for bacteria and/or *Mycoplasma* (2 aerobic, 1 anaerobic, and 2 *Mycoplasma*) (Table III). Patient T005 was culture positive for a *Lactobacillus* spp. and a *Neisseria* spp., patient T019 was positive for *Ureaplasma urealyticum* (T-strain), patient T032 was positive for a coagulase negative *Staphylococcus*, T049 was positive for *Propionibacterium acnes*, and patient T052 was positive for *Ureaplasma urealyticum* (T-strain) and a *Fusobacterium* spp. The cultures for patients T032 and T019 were considered skin flora contamination. Nine patients have been diagnosed with clinical chorioamnionitis and nine pathological diagnoses of chorioamnionitis have been noted on examination of placentas.

Madigan Army Medical Center

A total of eleven amniocenteses were performed and eleven patients delivered at MAMC. One patient was subsequently found not to meet the inclusion criteria and was excluded from data analysis. A second was excluded due to twins.

Fifty percent of the patients enrolled delivered preterm with 20% of the newborn weights less than 2,500 grams. The average birth weight was 2,910 grams. Of the nine amniotic fluid cultures, none were positive for bacteria (aerobic, anaerobic, or *Mycoplasma*). One patient was diagnosed with clinical chorioamnionitis with the same pathological results given. No other patients were diagnosed with clinical chorioamnionitis. Only two other placentas were sent for pathological evaluation and one of these was found to have evidence of acute chorioamnionitis despite no evidence clinically. Administrative errors resulted in the failure to send other placentas for pathological examination.

Final Report: "The Relationship of Bacterial Contamination and Interleukin-6 in Amniotic Fluid in Preterm Labor and Delivery"

No complications from the amniocentesis procedures at TAMC and MAMC were noted.

POLYMERASE CHAIN REACTION DATA:

EUBACTERIAL PCR DATA

The optimization of the bacterial PCR studies included ascertaining the most optimal Mg^{2+} concentrations (Figure 1). Briefly, *Escherichia coli* DNA was amplified with the 16S rRNA consensus primer set at 0.5 mM increments of $MgCl_2$ from 1.5 mM-4.0 mM. The most optimal Mg^{2+} concentration was found to be 2 mM, whereas Mg^{2+} levels in excess of 3 mM resulted in either reduced or complete inhibition of signal on ethidium bromide-stained agarose gels. Although there was an absence of the 900 bp PCR product at 3.5 mM of $MgCl_2$ on the agarose gel, it was detectable on the luminograph by chemiluminescence.

Upon completion of standardization of the PCR conditions, the 16S rRNA consensus primer sets were evaluated against a number of bacterial organisms (Figure 2). Bacterial DNA was isolated from *Enterobacter aerogenes*, *Escherichia coli*, *Bacillus subtilis*, *Staphylococcus aureus*, *Streptococcus lactis Serratia marcescens*, and Group B *Streptococcus* (GBS) (gifts of Dr. Robert S. Stewart, Jr., Stephen F. Austin State University, Nacogdoches, TX). The results were uniform and consistent with earlier observations. All bacterial organisms evaluated by the PCR resulted in a 900 bp product. Although no PCR product was observed in the GBS lane, it was readily apparent on the luminograph (data not shown). No cross-reactive PCR products were observed with human genomic lymphocytic DNA on the agarose gel or luminograph.

Amniotic fluid from pregnancies greater than 22 weeks is primarily composed of fetal urine. Amorphous salts in urine were reported as potent PCR inhibitors that required additional measures to counteract. Furthermore, the bacterial DNA recovery method generates a crude extract that could contain potential inhibitors of the PCR. In order to address these concerns, control, non-preterm amniotic fluid (>22 weeks gestation) from the MAMC Department of Pathology was obtained. It was spiked with different concentrations of either GBS or *E. coli*. The samples were processed as described in the methods section. Nineteen microliters of the lysate was added to the PCR with 1 ng of lambda DNA. The results of the subsequent PCR are presented in Figure 3. In all samples, the lambda DNA was amplified and a 500 bp product was generated as seen by ethidium bromide-staining on agarose gels.

The sensitivity of the reaction also was evaluated (Figure 4). Amniotic fluid was spiked with either GBS [gram (+)] or *E. coli* [gram (-)] at dilutions of 10^7 - 10^2 organisms/mL. The PCR products were obtained from both organisms at all concentrations. This was consistent with other observations that the sensitivity of the PCR may approach one to ten microorganisms per biological fluid sample (30,31). Interestingly, PCR products were observed in the unspiked amniotic fluid control lane. The non-preterm control amniotic fluid was an excess clinical specimen obtained from the Department of Pathology. The history of the fluid was unknown so the potential exists that it was contaminated with bacteria prior to the initiation of our studies. This would explain the faint presence of the 900 bp band in the AF lane. We had previously

Final Report: "The Relationship of Bacterial Contamination and Interleukin-6 in Amniotic Fluid in Preterm Labor and Delivery"

demonstrated that the primer sets were not cross-reactive with human DNA (Figure 2).

The utility of these primers for the PCR diagnosis of bacterial infections in amniotic fluid is demonstrated in Figure 5. Amniotic fluid from TAMC patients T005, T006, and T007 were processed as described and subjected to 30 cycles of the PCR. The ethidium bromide stained agarose gel is presented. Patients T005 and T006 are clearly PCR positive whereas patient T007 is PCR negative. The luminograph data is in agreement with these findings (data not shown). The bacterial culture data for patients T005 and T007 were positive and negative, respectively. This is in agreement with the PCR data. However, T006 was bacterial culture negative but PCR positive.

Of the 54 amniotic fluid samples, approximately 56% (n = 30) were positive for bacteria by the PCR. No demographic or clinical differences were observed between the bacterial PCR positive and negative patients (Table IV). The PCR positive group had a shorter time from amniocentesis to delivery (TFATD) interval (μ difference = 12.6 days, p = 0.02) and lower newborn weights (μ difference = 420 grams, p = 0.02). Whereas gestational age tended to be less in the PCR group than a week, this was not statistically significant (p = 0.48). The only death occurred in the PCR positive group. The infant was born at 24.4 weeks gestation, and the cause of death was attributed to extreme prematurity.

MYCOPLASMA PCR DATA

The processed amniotic fluid samples were evaluated with the consensus 16S rRNA *Mycoplasma* primers. Whereas none of the MAMC patients were culture or PCR positive for *Mycoplasma*, two TAMC patients were culture and PCR positive. Interestingly, only one of the culture positive patients, T052, was observed to be PCR positive (Figure 6). Patient T019 was found to be culture positive for *Ureaplasma urealyticum*; however, she was *Mycoplasma* negative by the PCR. Due to a clerical shipping error, no culture data for T006 was available, but she was determined to be PCR positive.

Patients T052 and T006 were assigned to the PCR *Mycoplasma* positive group. Additional studies with the DNA primers for *Mycoplasma genitalium* and *Ureaplasma urealyticum* were negative for patient T006 (Figure 7). Whereas patient T052 was negative for *Mycoplasma genitalium*, she was PCR positive for *Ureaplasma urealyticum* which was in agreement with the *Mycoplasma* culture data.

INTERLEUKIN-6 ELISA

IL-6 concentrations greater than 600 pg/mL were considered to be elevated and evidence of a positive result. Applying this threshold, 17% of the samples were positive and all of the positive patients (n = 9) delivered preterm. A summary of the pregnancy and newborn outcomes for the IL-6 groups is presented (Table VI). The positive IL-6 group delivered on average 5.2 weeks earlier and weighed 1,071 grams less than term deliveries (p<0.0001). The length of the newborn stay was greater in the IL-6 positive group with the positive group staying on average 20.6 more days (p<0.0001). Table VII lists the elevated IL-6 patients along with their clinical outcomes and PCR data (bacteria and *Mycoplasma*). Of the nine elevated IL-6 amniotic fluid samples, six (66%) were positive for bacteria by the PCR. One PCR patient with elevated IL-

Final Report: "The Relationship of Bacterial Contamination and Interleukin-6 in Amniotic Fluid in Preterm Labor and Delivery"

6 was also PCR positive for *Mycoplasma*. Three of the elevated IL-6 patient samples were negative for *Mycoplasma* and bacteria by culture and PCR. Due to a lack of compliance with the protocol, insufficient numbers of placentas were collected to perform an adequate analysis of histologic evidence of chorioamnionitis.

Final Report: "The Relationship of Bacterial Contamination and Interleukin-6 in Amniotic Fluid in Preterm Labor and Delivery"

CONCLUSIONS

In order to perform a prospective investigation concerning the role of infection in preterm delivery a study population with a high incidence of preterm delivery was required. With a preterm delivery rate of 67% in our study population, our target population was appropriate. The incidence of positive amniotic fluid cultures is consistent with other published reports in this pregnant population (1).

One of the objectives of this study was to determine the feasibility of using the PCR to detect evidence of a prior or present infection in amniotic fluid. The utility of this approach for diagnosis of intra-uterine infections has been previously illustrated for *Toxoplasma gondii* (32,33) and *Treponema pallidum* (30,34).

Although great precautions were taken to eliminate bacterial contamination from skin flora and other sites, we were concerned that all samples may be positive due to the sensitivity of the technique. The fact that 40% of the samples returned with no evidence of bacterial infection proves that this technique can be employed and extraneous bacteria avoided.

Another objective was to determine the incidence of bacterial contamination in amniotic fluid detected using the PCR technique. As suspected, the prevalence of the PCR evidence of bacterial contamination in amniotic fluid was much greater than the bacterial culture data. The finding of 55% of pregnancies presenting with preterm labor having evidence of bacteria by the PCR strongly suggests an association between preterm labor and infection. Furthermore, pregnancies with evidence of bacterial contamination by the PCR had a shorter time from amniocentesis to delivery interval and had lower birth weights. Although gestational length was shorter in the PCR positive group by a week, this was not statistically significant. We suspect that many of the PCR positive samples were secondary to skin contamination. Although bacterial speciation is possible using the PCR and DNA hybridizations, it was beyond the scope of this investigation due to the time and funding constraints. It is likely that the use of typing would help determine which positive samples were due to skin contamination and which were true pathogens in the amniotic fluid. In addition, further investigation is needed to determine the incidence of positive PCR samples in a low risk population such as term, uncomplicated deliveries.

IL-6 proved to be a very sensitive and prognostic marker for pregnancies that were destined to deliver preterm. All of the elevated IL-6 samples delivered preterm. The high IL-6 groups delivered earlier, weighed less, and had longer newborn stays. This is consistent with the findings of several other investigations (17).

Our last objective was to determine the incidence of bacterial contamination in amniotic fluid samples with elevated IL-6 concentrations. Previous studies using culture techniques noted that about 50% of these samples were culture positive (13). Our objective was to determine if a more sensitive technique, such as PCR would find a higher incidence of bacterial presence in this population since IL-6 is thought to be elevated in response to infection. Of the nine samples that were elevated 66% were positive for bacteria.

Final Report: "The Relationship of Bacterial Contamination and Interleukin-6 in Amniotic Fluid in Preterm Labor and Delivery"

Of interest are the three amniotic fluid samples that were culture and PCR negative but had elevated IL-6 levels. Two possible causes exist to explain a 33% negative predictive value (although more may exist). Infection limited to the decidual fetal membrane interface could stimulate the release of cytokines from inflammatory cells, which cross into the amniotic fluid. It is conceivable that IL-6 is being stimulated by another factor, such as a noninfective immune process.

Clinically, those patients with elevated IL-6 and evidence of bacterial infection may benefit from aggressive treatment with tocolysis. On the other hand, there may be a role for those patients with no evidence of bacterial infection to receive immunosuppressive therapy. Additional studies to resolve these issues await further investigation.

Final Report: "The Relationship of Bacterial Contamination and Interleukin-6 in Amniotic Fluid in Preterm Labor and Delivery"

REFERENCES

1. Romero R, Sirtori M, Oyarzun E, et al. Infection and labor V: Prevalence, microbiology, and clinical significance of intraamniotic infection in women with preterm labor and intact membranes. Am J Obstet Gynecol 1989; 161:817-824.
2. McCormick MC. The contribution of low birth weight to infant mortality and childhood morbidity. N Engl J Med 1985; 312:82-90.
3. Fuchs AR, Fuch F, Stubblefield P. Preterm Birth: Causes, Prevention, and Management. (2nd ed.) New York: McGraw-Hill, 1993:541.
4. Adams MM, Read J, Rawlings JS, Harless FB, Sarno AP, Rhodes PH. Preterm delivery among black and white enlisted women in the United States Army. Obstet Gynecol 1993; 81(1):65-71.
5. Fox ME, Harris RE, Brekken A. The active duty military pregnancy: A new high-risk category. Am J Obstet Gynecol 1977; 129(6):705-707.
6. Magann EF, Nolan T. Pregnancy outcome in an active-duty population. Obstet Gynecol 1991; 78(3):391-393.
7. Trends in fertility and infant and maternal health-United States 1975-1988. MMWR 1991; 40:381.
8. Brunader Rea, J.A. B, Kugler JP. Prevalence of cocaine and marijuana use among pregnant women in a military health care setting. J Am Board Fam Pract 1991; 4:395-398.
9. Polzin WJ, Kopelman JN, Brady K, J.AR. Screening for illicit drug use in a military obstetric population. Obstet Gynecol 1991; 78:600-601.
10. Skoll MA, Morette M, Sibai B. The incidence of positive amniotic fluid cultures in patients in preterm labor with intact membranes. Am J Obstet Gynecol 814; 161:813-816.
11. Hillier SL, Krohn MA, Kiviat N, Watts DH, Eschenbach DA. Microbiologic causes and neonatal outcomes associated with chorioamnion infection. Am J Obstet Gynecol 1991; 165:955-960.
12. Hillier S, Witkin SS, Krohn MA, Watts DH, Kiviat NB, Eschenbach D. The relationship of amniotic fluid cytokines and preterm delivery, amniotic fluid infection, histologic chorioamnionitis, and chorioamnion infection. Obstet Gynecol 1993; 81(6):941-948.
13. Romero R, Avila C, Santhanam U, Sehgal P. Amniotic fluid interleukin-6 in preterm labor. J Clin Invest 1989;85:1392-4.
14. Menon R, Swan KF, Lyden TW, Rote NS, Fortunato SJ. Expression of inflammatory cytokines (interleukin-1 β and interleukin-6) in amniochorionic membranes. Am J Obstet Gynecol 1995; 172: 493-500.

Final Report: "The Relationship of Bacterial Contamination and Interleukin-6 in Amniotic Fluid in Preterm Labor and Delivery"

15. Coultrip LL, Lien JM, Gomez R, Kapernick P, Khoury A, Grossman JH. The value of amniotic fluid interleukin-6 determination in patients with preterm labor and intact membranes in the detection of microbial invasion of the amniotic cavity. Am J Obstet Gynecol 1994; 171: 901-911.
16. Romero R, Yoon BH, Mazor M, Gomez R, Diamond MP, Kenney JS, Ramirez M, Fidel PL, Sorokin Y, Cotton D, Sehgal P. The diagnostic and prognostic value of amniotic fluid white blood cell count, glucose, interleukin-6, and Gram stain in patients with preterm labor and intact membranes. Am J Obstet Gynecol 1993; 169: 805-816.
17. Greig PC, Ernest JM, Teot L, Erikson M, Talley R. Amniotic fluid interleukin-6 levels correlate with histologic chorioamnionitis and amniotic fluid cultures in patients in premature labor with intact membranes. Am J Obstet Gynecol 1993; 169: 1035-1044.
18. Gibbs R, Romero R, Hillier S, Eschenbach D, Sweet R. A review of premature birth and subclinical infection. Am J Obstet Gynecol 1992;166:1515-1528.
19. Goldenberger D, Perschil I, Ritzler M, Altwegg M. A simple "universal" DNA extraction procedure using SDS and proteinase K is compatible with direct PCR amplification. PCR Meth Appl 1995; 4(6):368-370.
20. Saiki RK. Amplification of genomic DNA. in PCR protocols: a guide to methods and applications. Ed. Innis, MA, Gelfand DH, Sninsky JJ, White TJ. Academic Press, Inc. San Diego, 1990.
21. Saiki RK, Scharf S, Faloona F, Mullis KB, Horn GT, Erlich HA, Arnheim N. Enzymatic amplification of β -globin genomic sequences and restriction site analysis for diagnosis of sickle cell anemia. Science 1985; 230: 1350-1354.
22. Martin RK, Archer KT, Tuttle RM. Detection of *ptc* from archival formalin-fixed, paraffin-embedded tissues: comparison of radiolabeled DNA hybridization and direct incorporation of digoxigenin-11-dUTP into RT-PCR products. Diag Mol Pathol 1994; 3(4): 233-239.
23. Meir A, Persing DH, Finken M, Böttger EC. Elimination of contaminating DNA within polymerase chain reaction reagents: implications for a general approach to detection of uncultured pathogens. J Clin Micro 1993; 31(3):646-652.
24. van Kuppeveld FJM, van der Logt JTM, Angulo AF, van Zoest MJ, Quint WGV, Niesters HGM, Galama JMD, Melchers WJG. Genus- and species-specific identification of *Mycoplasma* by 16S rRNA amplification. Applied Environ Micro 1992; 58(8): 2606-2615.
25. Palmer HM, Gilroy CB, Claydon EJ, Taylor-Robinson D. Detection of *Mycoplasma genitalium* in the genitourinary tract of women by the polymerase chain reaction. Intl J STD & AIDS 1991; 2(4): 261-263.

Final Report: "The Relationship of Bacterial Contamination and Interleukin-6 in Amniotic Fluid in Preterm Labor and Delivery"

26. Palmer HM, Gilroy CB, Furr PM, Taylor-Robinson D. Development and evaluation of the polymerase chain reaction to detect *Mycoplasma genitalium*. FEMS Microbiol Lett 1991; 77: 199-204.
27. Willoughby JJ, Russell WC, Thirkell D, Burdon MG. Isolation and detection of urease genes in *Ureaplasma urealyticum*. Infection & Immunity 1991; 59(7): 2463-2469
28. Sambrook J, Fritsch EF, Maniatis T. Molecular cloning: a laboratory manual, 2d ed. Cold Spring Harbor Laboratory Press, Plainview, 1989.
29. Southern EM. Detection of specific sequences among DNA fragments separated by gel electrophoresis. J Mol Biol 1975; 98: 503-517.
30. Burstain JM, Grimprel E, Lukehart SA, Norgard MV, Radolf JD. Sensitive detection of *Treponema pallidum* by using the polymerase chain reaction. J Clin Micro 1991; 29(1): 62-69.
31. Burg JL, Grover CM, Pouletty P, Boothroyd JC. Direct and sensitive detection of a pathogenic protozoan, *Toxoplasma gondii*, by polymerase chain reaction. J Clin Micro 1989; 27(8): 1787-1792.
32. Hohlfeld P, Daffos F, Costa JM, Thulliez P, Forestier F, Vidaud M. Prenatal diagnosis of congenital toxoplasmosis with a polymerase-chain-reaction test on amniotic fluid. New Engl J Med 1994; 331(11): 695-699.
33. Grover CM, Thulliez P, Remington JS, Boothroyd JC. Rapid prenatal diagnosis of congenital *Toxoplasma* Infection by using polymerase chain reaction and amniotic fluid. J Clin Micro 1990; 28(10): 2297-2301.
34. Grimprel E, Sanchez PJ, Wendel GD, Burstain JM, McCracken GH, Jr, Radolf JD, Norgard MV. Use of polymerase chain reaction and rabbit infectivity testing to detect *Treponema pallidum* in amniotic fluid, fetal and neonatal sera, and cerebrospinal fluid. J Clin Micro 1991; 29(8): 1711-1718.

Final Report: "The Relationship of Bacterial Contamination and Interleukin-6 in Amniotic Fluid in Preterm Labor and Delivery"

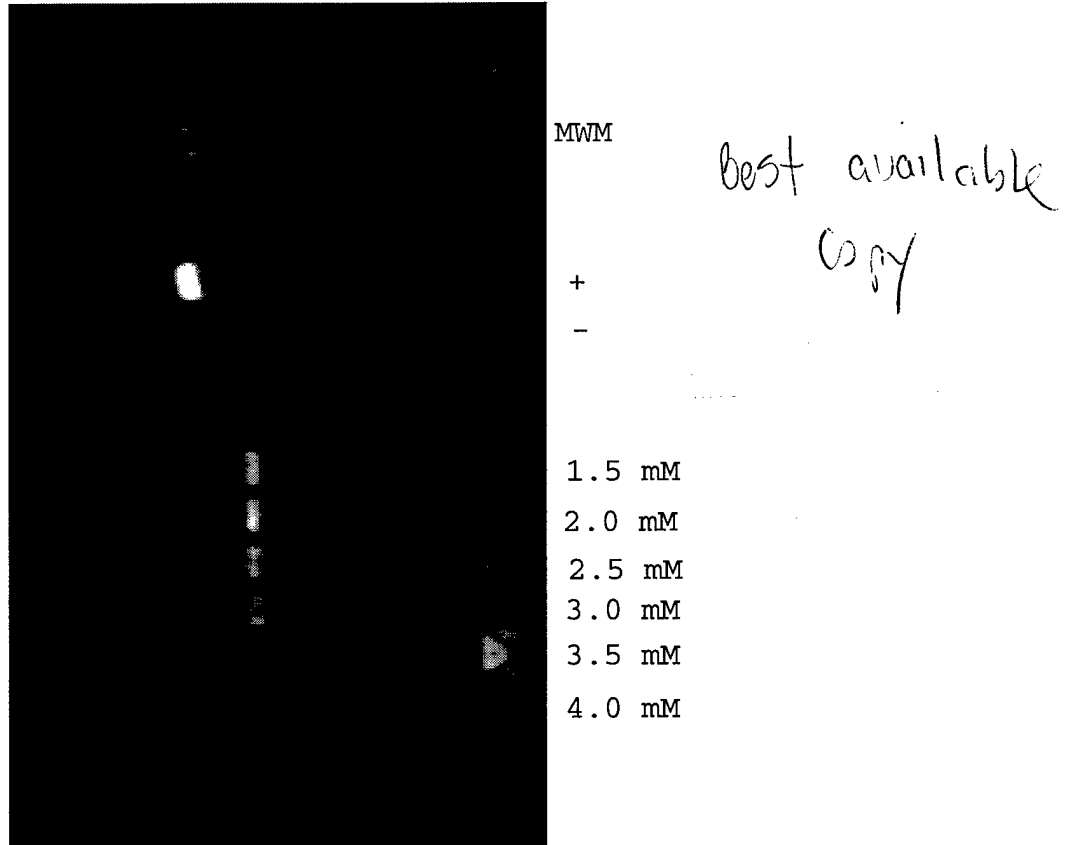


Figure 1

Figure 1. Titration of $MgCl_2$ for the 16S rRNA eubacterial primers. The PCR was performed as described with *Escherichia coli* DNA. MWM is the digoxigenin-labeled molecular weight marker VIII (Boehringer Mannheim, Inc.), (+) is the lambda DNA control PCR positive (500 bp), and (-) is the lambda control PCR negative.

Final Report: "The Relationship of Bacterial Contamination and Interleukin-6 in Amniotic Fluid in Preterm Labor and Delivery"

Best
Available
Copy

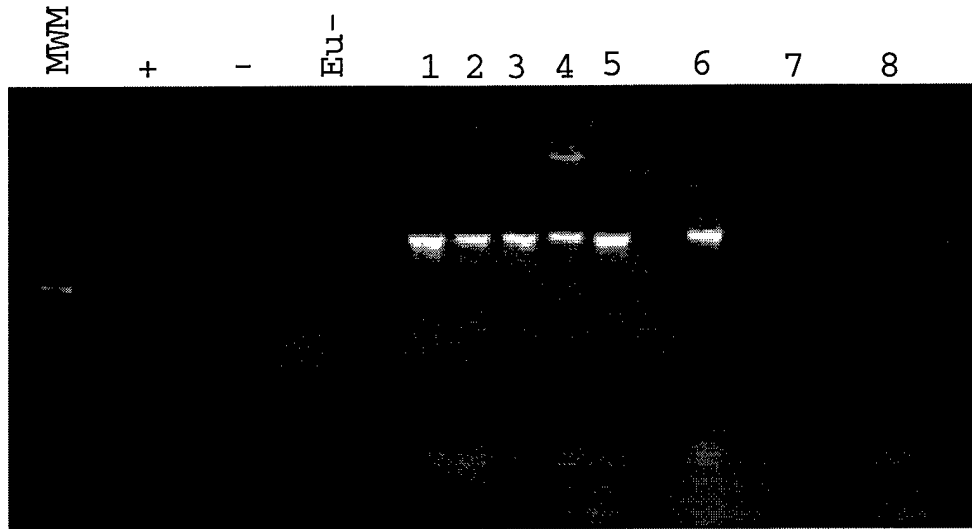


Figure 2

Figure 2. Evaluation of eubacterial 16S rRNA consensus primers against cultured bacterial pathogens. MWM, digoxigenin-labeled molecular weight marker VIII (Boehringer Mannheim, Inc.); (+), lambda DNA control PCR positive (500 bp); (-), lambda control PCR negative; Eu(-), eubacterial control PCR negative; 1, *Enterobacter aerogenes*; 2, *Escherichia coli*; 3, *Bacillus subtilis*; 4, *Staphylococcus aureus*; 5, *Streptococcus lactis*; 6, *Serratia marcescens*; 7, human genomic DNA; and 8, 10^5 Group B *Streptococcus* bacteria.

Final Report: "The Relationship of Bacterial Contamination and Interleukin-6 in Amniotic Fluid in Preterm Labor and Delivery"

best
available
copy

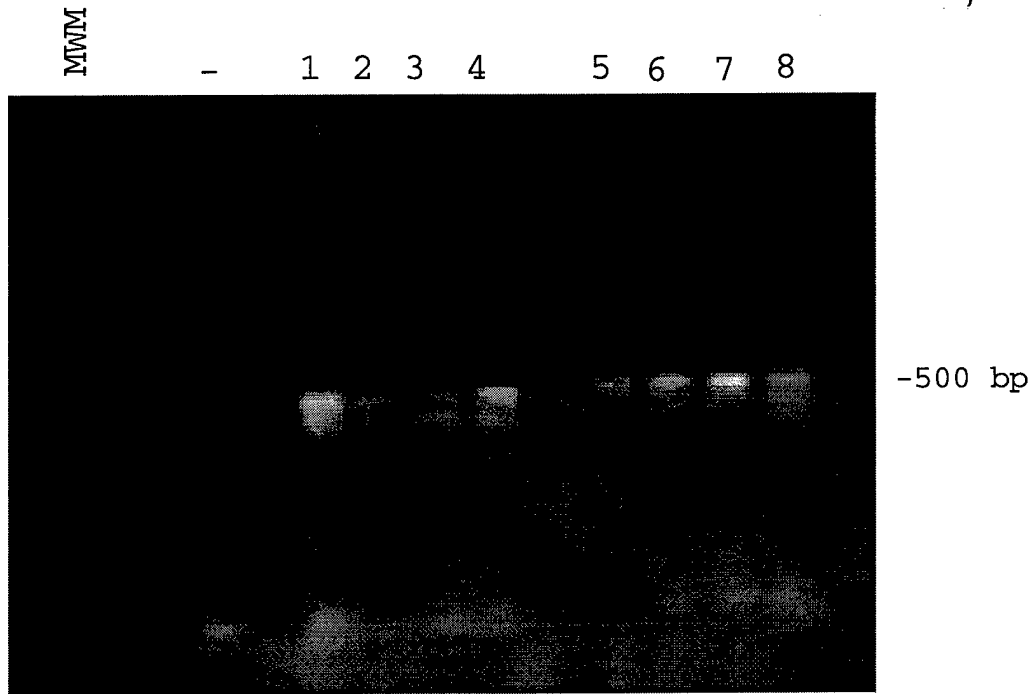


Figure 3

Figure 3. PCR of lambda DNA from amniotic fluid spiked with Group B *Streptococcus* (GBS) and *E. coli*. One mL of control amniotic fluid was spiked with various concentrations of bacteria. Lambda DNA (1 ng) was added to 19 μ L of the lysate and subjected to PCR. Lanes: MWM, digoxigenin-labeled molecular weight marker VIII (Boehringer Mannheim); (-), lambda control negative; 1, 10^8 GBS; 2, 10^6 GBS; 3, 10^4 GBS; 4, 10^2 GBS; 5, 10^8 *E. coli*; 6, 10^6 *E. coli*; 7, 10^4 *E. coli*; and 8, 10^2 *E. coli*.

Final Report: "The Relationship of Bacterial Contamination and Interleukin-6 in Amniotic Fluid in Preterm Labor and Delivery"

Best available copy

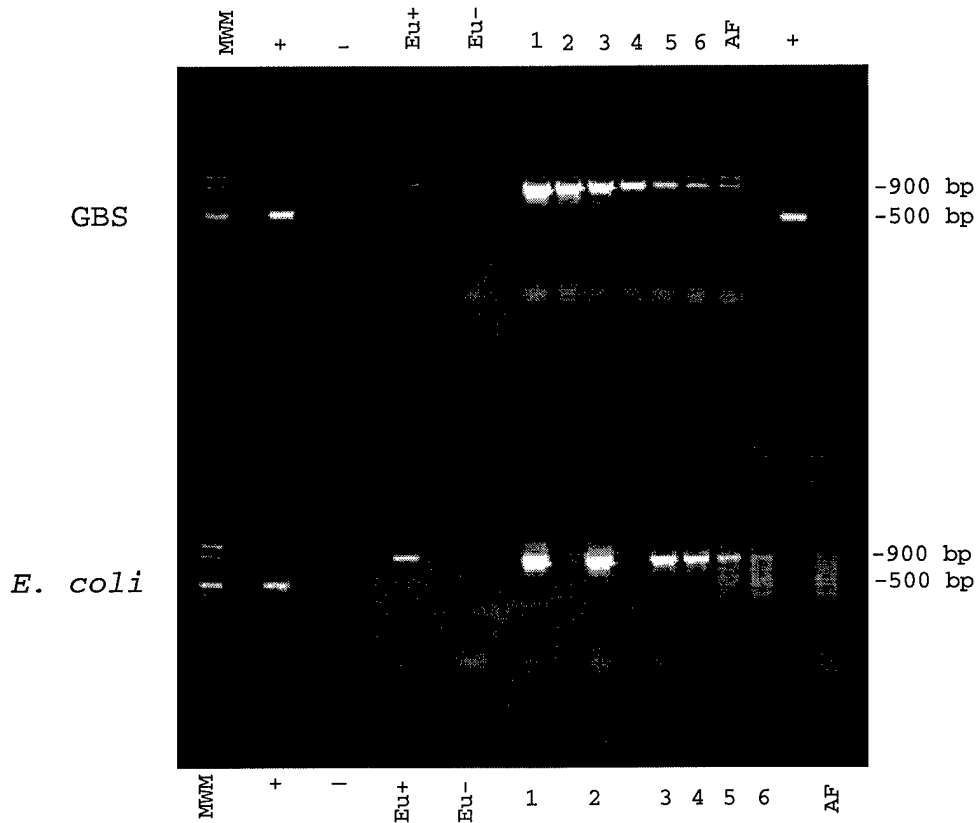


Figure 4

Figure 4. Sensitivity of eubacterial 16S rRNA primers. One mL of control amniotic fluid was spiked with Group B *Streptococcus* and *E. coli* at various concentrations. Bacterial DNA was recovered and the PCR was as described in the Materials & Methods. Lanes: MWM, digoxigenin-labeled molecular weight marker VIII (Boehringer Mannheim, Inc.); (+), lambda DNA control PCR positive, 500 bp; (-), lambda control PCR negative; Eu(+), *Streptococcus lactis* control PCR positive, 900 bp; Eu(-), eubacterial control PCR negative; 1, 10^7 bacteria; 2, 10^6 bacteria; 3, 10^5 bacteria; 4, 10^4 bacteria; 5, 10^3 bacteria; 6, 10^2 bacteria; and AF, unspiked amniotic fluid.

Final Report: "The Relationship of Bacterial Contamination and Interleukin-6 in Amniotic Fluid in Preterm Labor and Delivery"

Best
available
copy

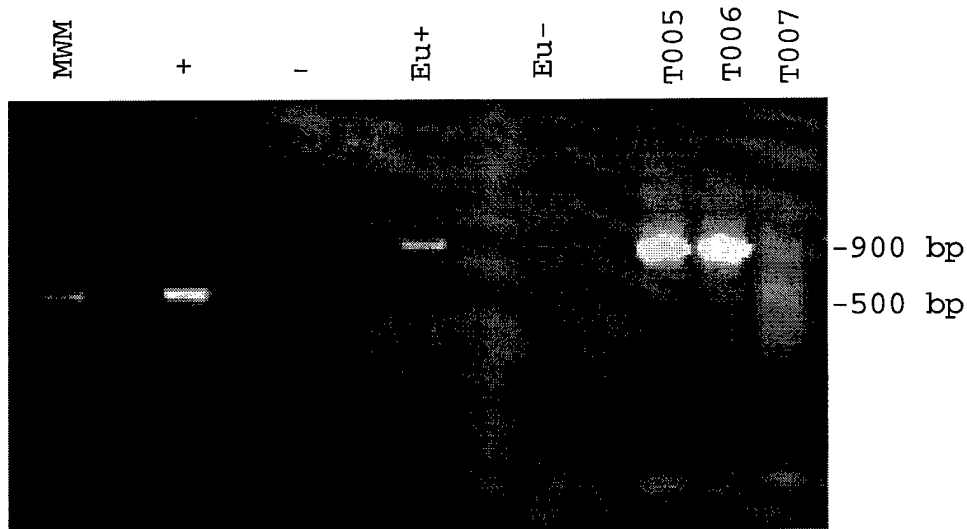


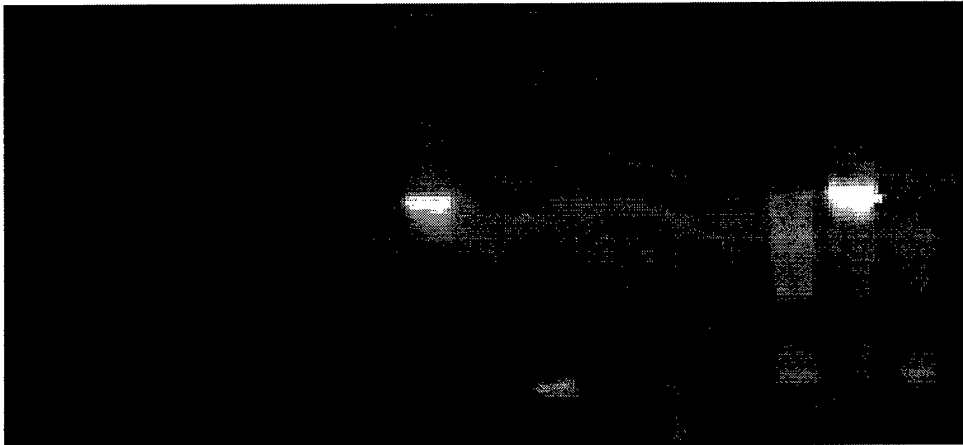
Figure 5

Figure 5. Eubacterial PCR of patient amniotic fluid samples. Lanes: MWM, digoxigenin-labeled molecular weight marker VIII (Boehringer Mannheim, Inc.); (+), lambda DNA control PCR positive, 500 bp; (-), lambda control PCR negative; Eu(+), *Streptococcus lactis* positive control, 900 bp; EU(-), eubacterial control PCR negative; and T005-T007, patients' amniotic fluid samples. Patients' T005 and T006 are PCR positive for bacteria.

Final Report: "The Relationship of Bacterial Contamination and Interleukin-6 in Amniotic Fluid in Preterm Labor and Delivery"

			(+)	(+)	(-)			
MWM	(+)	(-)	MYCO	MYCO	MYCO	T051	T052	T053

Best available copy



717 bp

Figure 6. *Mycoplasma* PCR of patient amniotic fluid samples with *Mycoplasma concensus* 16S rRNA primers. Lanes: MWM, digoxigenin-labeled molecular weight marker VIII (Boehringer Mannheim, Inc.); (+), lambda DNA control PCR positive, 500 bp; (-), lambda control PCR negative; Myco (+), *Mycoplasma* control PCR positive; Myco (-), *Mycoplasma* control PCR negative; and T051-053 patient amniotic fluid patient samples. Patient T052 is PCR positive.

Final Report: "The Relationship of Bacterial Contamination and Interleukin-6 in Amniotic Fluid in Preterm Labor and Delivery"

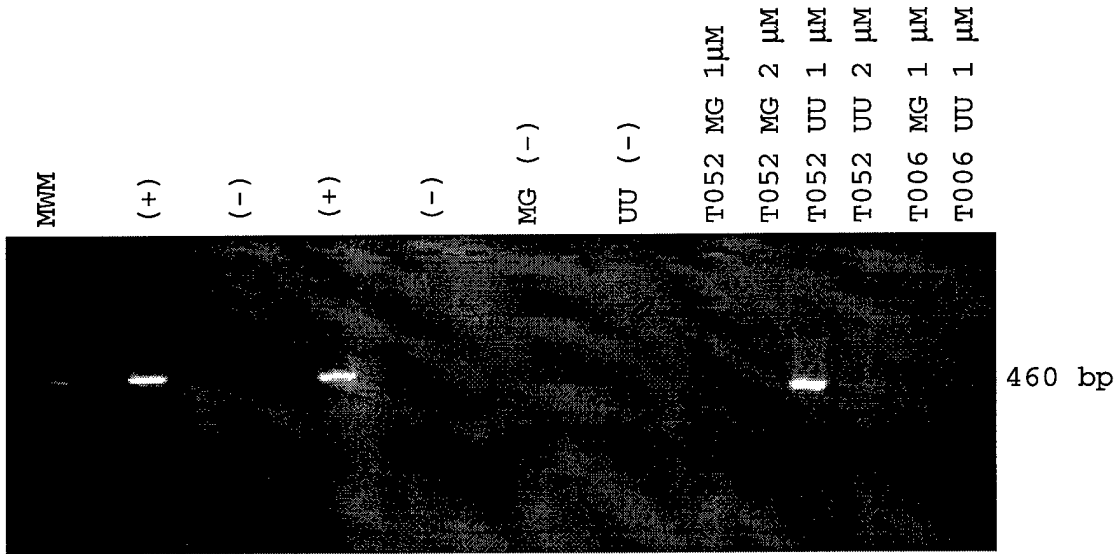


Figure 7. *Mycoplasma* PCR positive patient amniotic fluid samples (T052 and T005) evaluated with species specific primers. Lanes: MWM, digoxigenin-labeled molecular weight marker VIII (Boehringer Mannheim, Inc.); (+), lambda DNA control PCR positive, 500 bp; (-), lambda control PCR negative; MG (-), *Mycoplasma genitalium* control PCR negative; UU (-), *Ureaplasma urealyticum* control PCR negative; and T052-006 patient amniotic fluid samples with *Mycoplasma genitalium* and *Ureaplasma urealyticum* primers at 1 and 2 µM concentrations. Patient T052 is clearly PCR positive for *Ureaplasma urealyticum* at 1 µM of primers.

Best available copy

Table I Patient Demographics

• Mean Maternal Age	25.3 years
• Nulliparous Patients	27 (50%)
• Race	
White	28 (52%)
Black	12 (22%)
Other	14 (26%)

Table II

Clinical Characteristics

• Number of Patients	54
• Preterm Deliveries (< 37 Weeks)	36 (67%)
• Mean Age at Delivery	35.6 wks (3.1)*
• Mean Age at Amniocentesis	32.5 wks (3.1)*
• Mean Newborn Weight	2,792 g (670)*
• Mean Newborn Hosp. Stay	7.3 days (1.2)*
• Mean Cervical Dilation	2.0 cm (1.2)*

*= standard deviation

Table III Amniotic Fluid Positive Cultures

<u>Patient No.</u>	<u>Organism</u>	<u>EGA</u>	<u>Complications</u>
T005	<i>Lactobacillus</i> spp. <i>Neisseria</i> spp.	33 wk	Congenital Pneumonia
T019	<i>Urea urealyticum</i>	34.1 wk	None
T032	Coagulase-negative <i>Staphylococcus</i>	35.9 wk	None
T049	<i>Propionibacterium</i> <i>acnes</i>	36.6 wk	None
T052	<i>Fusiform</i> spp.	27.6 wk	Suspect Sepsis

EGA = estimated gestational age at amniocentesis

Table IV
Demographics & Clinical Data by PCR Status

	<u>(+)</u> (n = 30)	<u>(-)</u> (n = 24)	<u>p-Value</u>	<u>CI</u>
Maternal Age	26.0	24.3	0.24	-1.2, 4.6
Race			0.97	
- Black	7 (13%)	5 (9.2%)		
- White	17 (31.5%)	11 (20.4%)		
- Other	8 (14.8%)	6 (11.1%)		
EGA[@]	32.8 wks	32.2 wks	0.49	-1.1, 2.3
Cervical Dilation	1.8 cm	2.3 cm	0.20	-1.2, 0.03
PROM*	3	2	0.97	

EGA = estimated gestational age at amniocentesis

PROM = premature rupture of membranes

CI = confidence interval

Table V PCR & Clinical Outcomes

<u>Outcome</u>	<u>PCR (+)</u> (n=30)	<u>PCR(-)</u> (n=24)	<u>P-Value</u>	<u>CI</u>
TFATD	16.1 days	28.7 days	0.02	2.0-23.2
Gestational Age at Delivery	35.1 wks	36.2 wks	0.08	-1.2-4.6
Newborn Weight	2,621 g	3,041	0.02	59-781
Newborn Stay	8.2 days	5.9 days	0.49	-4.2-8.9
Newborn Sepsis	3	1	0.48	
Demise	1	0	0.40	

TFATD = time from amniocentesis to delivery

Table VI IL-6 & Clinical Outcomes

<u>Outcome</u>	<u>Elevated IL-6</u> (n = 9)	<u>Normal IL-6</u> (n = 43)	<u>p-Value</u>	<u>CI</u>
TFATD	10.4 days	23.4 days	0.07	-1.3-27.3
Gestational Age at Delivery	31.2 wks	36.4 wks	0.0001	3.5-6.9
Newborn Weight	1,899 g	2,970 g	0.0001	669-1,474
Newborn Stay	25.1 days	4.5 days	0.0001	13.4-28.0
Newborn Sepsis	1	3	0.56	
Demise	1	0	0.17	

TFATD = time from amniocentesis to delivery

Table VII
Patient Samples with Elevated IL-6

<u>Patient</u> <u>(number)</u>	<u>IL-6</u> <u>(pg/mL)</u>	<u>PCR</u> <u>(bact)</u>	<u>PCR</u> <u>(myco)</u>	<u>EGA</u> <u>(wks)</u>	<u>WT</u> <u>(g)</u>	<u>TFATD</u> <u>(days)</u>
M001	1,236	neg	neg	32.3	2,038	0
T006	4,670	pos	pos	29.6	1,315	18
T009	1,140	pos	neg	34.3	2,455	51
T024	6,660	pos	neg	29.6	1,703	0
T034	2,045	pos	neg	24.4	750	17
T050	5,450	pos	neg	33.1	2,335	0
T051	604	neg	neg	34.1	2,545	4
T052	>4,000	pos	neg	27.6	951	1
T055	2,572	neg	neg	35.6	2,996	1

EGA = estimated gestational age

WT = weight

TFATD = time from amniocentesis to delivery