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INFECTION IN THE NEWBORN INFANT

The Importance of Prematurity and Obstetric Complications.

PHILIP J. HOWARD, M.D.*

THE OBJECT OF THIS paper is to emphasize the importance of prematurity in increasing the hazard of infection, to summarize the large place of infection in causing illness and death in the newborn group, and to show the relation of certain complications of pregnancy to mortality. Premature rupture of the amniotic membranes is, in many cases, also related to infantile infection. Suggestions are given for the recognition of septic states, and illustrations of infection in sample cases.

Perinatal mortality has progressively declined with the advent of improved nutrition, earlier recognition of disease states such as toxemia, and better obstetrical technique. At present, a perinatal mortality rate of approximately 30 per 1000 deliveries is attained by hospitals, by many states, and by some countries. This total figure of 30 is composed of stillbirths and hebdomadal infant deaths in about equal parts. This mortality figure is directly affected by the incidence and degree of prematurity in the population sample being studied, and must be considered. Prematurity varies in incidence from 4.9 percent to 13 percent (Table I). Its known causes are social, economic, and nutritional, and among its suspected causes are endocrine diseases.

Table I
Incidence of Prematurity¹

Identity of Group	Total Births	Premature Infants (Under 2500 gms.)
Ford Hospital	1,213	8.9%
Detroit-1962	44,021 (live)	7.0
Boston Lying-In	30,273	7.8
University Minnesota	845	5.7
University Oregon	917	10.0
N. Y. Med. Col.	976	13.0
Rotunda, Dublin	4,881	4.9

The premature infant has a physiologic predisposition toward infection because of ineffective lung expansion, anemia, hypo gamma-globulinemia, and other factors.

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Extra precautions are regularly used in premature care by incubation, isolation and controlled oxygenation. Thus a continued attempt is made to protect them from infection.

Infections are directly responsible for a definite fraction of neonatal and perinatal deaths. The detailed studies of the pathology of these groups carried on by Potter,² by Nesbitt,³ and by Bound,⁴ are extremely valuable because these causes, in minor forms, cause the morbidity in nursery groups, in many samples of which proper treatment leads to a good result. Potter's report showed the results of 8905 autopsies in the newborn, and she reported 1197 or 13.4 percent due to infection. The following tables II and III show the reports of Nesbitt³ and Bound.⁴

Table II

Relative Importance of Causes of Fetal and Neonatal Deaths — Infants 1000 grams and Over.³

Disease	Fetal	Neonatal	Total
Anoxia-visible petechial hemorrhage	25%	9%	34%
No Cause Found	23	9	32
Birth Injury	2	8	10
Malformation	4	5	9
Abnormal Pulmonary Ventilation	0	7	7
Infection	1	4.5	5.5
Erythroblastosis	.6	1.1	1.7
Other	.7	.1	.8
Total	56.3	43.7	100.

Table III

Classification of Perinatal Mortality. Causes of Death in 337 Consecutive autopsies.⁴

Causes	Stillbirths	Premature	Term	Total	Percent
Antepartum with maceration	61	—	—	61	18.0%
Intrapartum Asphyxia	44	5	6	55	16.3%
Malformed	24	11	17	52	15.5%
Birth Trauma	8	14	15	37	11.0%
R.D.S.	—	30	6	36	10.7%
Antepartum Asphyxia	36	—	—	36	10.7%
Pneumonia	—	8	11	19	5.6%
Erythroblastosis	8	3	4	15	4.4%
Intraventricular Hemorrhage	—	10	1	11	3.3%
Miscellaneous	4	1	3	8	2.4%
Previabile	—	7	—	7	2.1%
Total				337	100. %

These analyses of causes show that infection plays an important part in mortality. It is often not clearly evident whether abnormal pulmonary ventilation and respiratory disease syndrome are types of infection. It is known, however, that any interference with alveolar exchange promotes local congestion and infection. These studies show

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at least 5.6% and possibly as high as 16.3% of perinatal deaths in which infection plays a role as the primary cause of damage, or as a secondary invader. Infection is a tangible reality subject to study, culture, isolation and hopefully successful treatment.

Table IV
Mortality Rate According to Diagnosis in High-Risk Pregnancies.⁵

Diagnosis	Incidence/ 1000 Total Births	Stillbirths %	Mortality Live Births %	Totals %
Eclampsia	0.8	28.0	12.0	40.0
Hydramnios	4.7	17.2	22.1	39.3
Premature separation	12.6	21.2	12.7	33.9
Prolapsed cord	4.8	19.7	6.1	25.8
Pre-eclampsia (Grade 2)	6.2	14.7	6.8	21.5
Placenta previa	5.7	7.5	13.8	21.3
Breech (single)	36.5	9.2	8.5	17.7
Diabetes	6.0	6.0	9.2	15.2
Twin birth	22.7	4.3	6.3	10.6
Phlebitis	5.7	4.5	2.3	6.8
Pyelonephritis	6.3	3.1	3.6	6.7
Hypertension and proteinuria	13.9	5.4	0.7	6.1
Pre-eclampsia (Grade 1)	34.8	4.2	1.5	5.7
Pyelitis	32.7	2.1	2.1	4.2
All hospitalized patients.	30,765	1.6	1.5	3.1

Table V
Individual Contribution to Total Hospital Perinatal Mortality⁵

Cause of Death	Incidence/ 1000 Total Births*	Still- births/ 1000 Total Births	Live-born Deaths/ 1000 Total Births	Perinatal Mortality/ 1000 Total Births
Breech (Single)	36.5	3.4	3.1	6.5
Premature separation	12.6	2.7	1.6	4.3
Twin birth	22.7	0.8	1.4	2.2
Pre-eclampsia (Grade 1)	34.8	1.5	0.5	2.0
Hydramnios	4.7	0.8	1.0	1.8
Pyelitis	32.7	0.7	0.7	1.4
Pre-eclampsia (Grade 2)	6.2	0.9	0.4	1.3
Placenta previa	5.7	0.4	0.8	1.2
Prolapsed cord	4.8	0.9	0.3	1.2
Diabetes	6.0	0.4	0.6	1.0
Hypertension and proteinuria	13.9	0.7	0.1	0.8
Pyelonephritis	6.3	0.2	0.2	0.4
Phlebitis	5.7	0.3	0.1	0.4
Eclampsia	0.8	0.2	0.1	0.3
Total hospital perinatal mortality		16.1	14.9	31.0

*30,765 total births

There are certain complications of pregnancy associated not only with death of the infant but also with disease states such as anoxia and brain damage. The cause of death in one infant will be the cause of slight or moderate trouble in another. This has been clearly stated by Clifford⁵ and realized by all dealing with newborn problems. Tables IV and V list complications of pregnancy with their individual risk to the infant. Eclampsia is shown to be the most dangerous complications being associated with 40 percent perinatal mortality or 400 deaths per 1000 eclamptic deliveries. Other complications are listed in descending order of risk to pyelitis carrying a risk of 4.2 percent. The first item in Table V shows breech presentation to be the complication which produces the most perinatal deaths in the total infant population. Breech delivery is not only dangerous, but common and accounts for 6.5 deaths of the total 31 perinatal deaths per 1000 deliveries. Other complications are listed in descending order of total importance in producing perinatal mortality, eclampsia being the last because it is so rare.

The infants of these complex pregnancies then are the most threatened, and among them are many with minor anoxia, slight trauma, and especially beginning infection. These conditions must be recognized and treated early to obtain the best results.

The place of premature rupture of the amniotic membranes is simply that of an added complication. In the extensive computer analysis of 30,765 deliveries detailed in Tables IV and V, this complication was not separately studied. It is, however, at times an important help in alerting the physician to possible infection. During one year May 1963 to May 1964 this complication was studied at the Henry Ford Hospital. Among 1213 deliveries there were 46 with premature amniotic membrane rupture of 20 hours or more before delivery. Seven known infections were observed, and 18 infants were suspected of infection and treated. The seven infected infants had either positive culture or X-Ray evidence of pneumonia. Details of this group are shown on Table VI.

Infection must be suspected in the newborn infant on very slight signs, such as anoxia, cyanosis, irregular breathing, weak cry and poor sucking reflex. Jaundice or increased bilirubin if unexplained by erythroblastosis or obstruction suggests infection. Unusual exposure to infection by early rupture of membranes, prolonged labor or maternal prepartum fever, always suggest germ or virus invasion of the fetus. Four conditions, respiratory distress syndrome, birth trauma, pneumonia, and intraventricular hemorrhage cause two-thirds of infant deaths, and are often indistinguishable at birth on clinical grounds. These conditions should have culture studies, constant observation, and in most cases prophylactic treatment for three days only unless the diagnosis is definite.

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Table VI

Seven Infants born after Prolonged Rupture Time who showed infection or pneumonia. Maternal complications, and infant treatment shown.

Case	Sex	Birth Weight (gms)	Rupt. Time*	Obstetric Complications	Infant Condition and Rx
1	M	2700	59 hrs	Age 20. Sickle cell anemia. Grav. II Para O. Failed medical induction Caesarian. Unmarried. Psychotic Hbg 8.7 gms	Weak Cultures-Throat Staph Albus; cord, corynebacteria Achro 60 mg. d. x 3 days
2	M	2690	34 hrs	Age 27. Grav. V Para III. Miscarriage 1. Amniotic Fl. culture; E. coli and peptococcus. T. 102 F. Chlor. 2. gm d Pen. 625 mg d. Labor induced.	Weakness Pen. 150 mg. d x 3d Strep 60 mg. d. x 3d Cultures and X-Ray neg.
3	F	1710	5 days	Age 34. Grav. IV Para II. One Tubal Preg. Pen & Strep Id.	Weakness. Throat Cult. Staph Albus Pen 500 mg. d. x 4d. Strep 60 mg. d. x 4d.
4	F	3500	24 hrs	Age 31. Labor 55 hrs. Grav. II. Obese. Edema, Para O. Wgt 197 lbs. Pen 625. mg I. V. Strep 500 mg I. M.	Weakness. Bl Culture E. Coli and enterococci Pen 350 mg. d. x 3d Strep 60 mg. d. x 3d
5	M	4380	26 hrs	Age 38. Grav. V Para II. Obese Wgt 177. Labor 8 hrs. Serology positive. Abortions II B. P. increased	Weakness. Throat culture Coliform. Bl cult corynbact. Pen 350 mg. d. x 3d Strep 120 mg. d. x 3d
6	M	1230	66 hrs	Age 30 Caesarian section	Pneumonia by X-Ray Pen 125 mg. d. x 3d Strep 60 mg. d. x 3d
7	F	3120	5 days	Age 40. Grav. XI Para V. Hypertension Induced	Weakness. Cord Bl Coliform. Pen 375 mg. d. x 3d Strep 100 mg. d. x 3d

Pen — Penicillin. 62.5 mg. equals 100,000 units.

Strep — Streptomycin.

*Rupt Time equals hours before delivery of rupture of amniotic membranes.

The following case reports of newborn infants illustrate some of the situations associated with infection.

CASE 1. Baby M. V. was born Jan. 11, 1960 and lived 14 days. Her birth weight was 1300 gms (2 lbs. 13 oz). She was the second of twins. The mother was 35 years old. This was her second pregnancy and it was terminated by Caesarian section for placenta previa. The infant was a normal premature with an Apgar score of 8 given regular care of gavage feedings, oxygen and temperature control. She gained daily from the 9th day on and the 13th day showed spells of apnoea, an increased respiratory rate to 70 per minute, a cardiac rate of 180 per minute. There were also abdominal distension, and bowel patterning. Rapid increase in weakness in the next



Figure 1
Brain damage following early meningitis. a. Front view. b. Side view. Case 2.

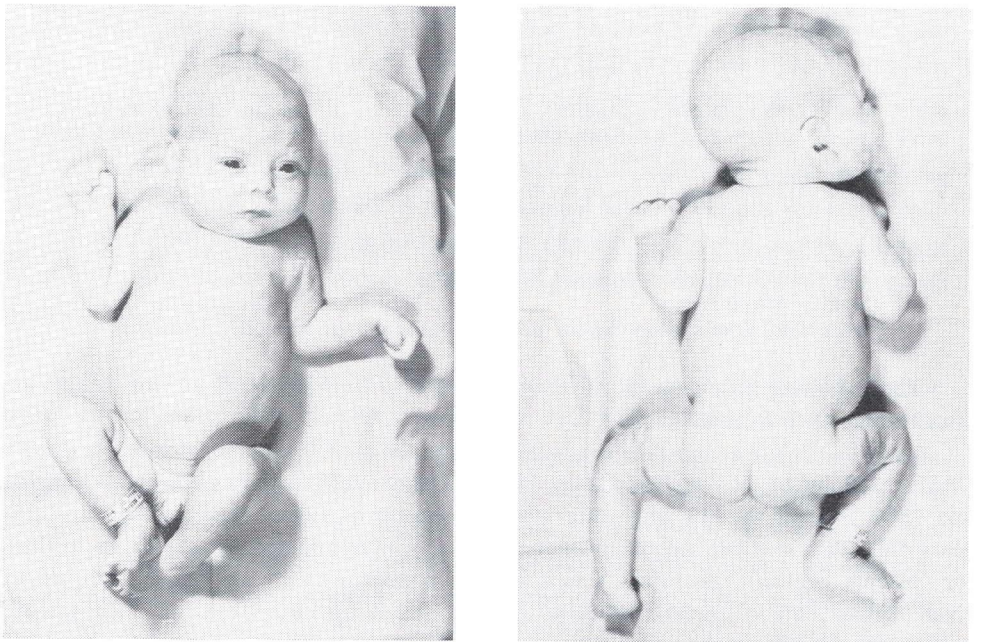


Figure 2
Pseudomonas sepsis, abscesses, and pneumonia associated with congenital lamellar ichthyosis. a. Front view. b. Back view. Case 6.

few hours and death followed. Clinical diagnosis was intestinal obstruction and heart failure. The autopsy showed *E. coli* meningitis.

Early blood and spinal fluid cultures followed by chlormycetin treatment are at present thought best in *E. coli* sepsis or meningitis.

CASE 2. Baby G. DiV. was born Aug. 16, 1964, and survived. His birth weight was 2724 gms (6 lbs) and he was born after a 12 hour labor, and was the mother's third child. He was discharged home the third day of life in apparently good condition. The fourth day of life, the parents undertook an auto trip to St. Louis. During the trip the infant became febrile with temperature of 106°, and also was non-responsive. They sought treatment in Indianapolis where an injection of penicillian was given. On arrival in St. Louis, infant was placed in the C.G.M. Hospital and remained there 9 days. The findings were temperature 102.6F, respiratory rate 80 per minute, pulse 140 per minute, a mottled skin, minimum movement, facial weakness, dry right cornea, skull sutures separated from dehydration, and decreased muscle tone. The clinical diagnosis was sepsis with meningitis, or brain abnormality secondary to birth injury, convulsive disorder secondary to this plus possible hypoglycemia or hypocalcemia. Subdural taps were negative as well as spinal fluid cultures. The treatment was rehydration and antibiotics. On returning to Detroit at the age of 2 weeks, the infant had bulging fontanelles, separated sutures, and poor nutrition. Subdural hematomas were found and drained. The subsequent history has been one of surgical treatment and Pudenz valve insertion. Final diagnosis possible sepsis, possible meningitis, brain injury, hydrocephalus, permanent brain damage. (Fig. 1).

Exposure of newborn infants should be avoided. If travel becomes imperative, the infant should be returned to the hospital for temporary care.

CASE 3. Baby D. L. was born Nov. 23, 1964 and her birth weight was 3240 gms. (7 lbs. 1 oz). The mother was 21 years of age and this was her first pregnancy. The amniotic membranes ruptured 2 days before delivery and an induction was attempted with intravenous pituitrin. A Caesarian section was then done. The infant appeared normal, having an Apgar score of 10. The fourth day baby became jaundiced and failed to gain. Mother and infant both were Group A Rh positive. The bilirubin rose to 21.2 mg percent, and an exchange transfusion was given. The blood culture showed staphylococcus albus coagulase negative and alpha streptococci moderately sensitive to penicillin. Treatment was achromycin 100 mg per day for 6 days and penicillin 500 mg per day for 6 days. Infant showed immediate recovery.

CASE 4. Baby R. K. was born Jan. 6, 1960 and died of infection the third day. The birth weight was 3000 gms (6 lbs). The mother was 22 years of age, was gravida 2, had one living child, and had diabetes. The labor lasted 12 hours 37 minutes, was at the 32nd week of gestation, was a breech presentation rotated to occiput anterior, and delivered with mid forceps. Infant seemed normal and had an apgar score of 9. However, by 6 hours of age had become cyanotic and weak. Oxygen was given constantly. Icterus developed and by second day reached 16.5 mg percent. The mother was blood group A, Rh positive, the infant was group B, Rh positive. Cyanosis increased and resuscitation was needed. The Bilirubin reached 23.8 mg percent and exchange transfusion was tried. After exchanging 400 cc. infant expired. The blood culture showed staphylococcus coagulase negative, and streptococcus. The post mortem showed atelectasis, and liver defect.

Diabetic offspring are especially subject to the many possible complications. This infant was too weak to survive respiratory distress, erythroblastosis, sepsis and exchange transfusion. The exchange was undertaken here with full knowledge of the many complications.

CASE 5. Baby Dal. was born Sept. 15, 1960. Her birth weight was 4260 gms (9 lbs 6 oz). The mother was gravida 4, and had previous Caesarian section for placenta previa, so section was repeated. The infant at once showed respiratory distress, with respiratory rate of 125 per minute. There developed the second day a lung infiltrate. The trachea and bronchi were suctioned by bronchoscopy and respiratory rate dropped to 85 per minute. Jaundice developed the 3rd day, bilirubin rose to 8.1 mg and blood cultures showed staphylococcus. Treatment was carried on with achromycin 400 mg daily for 3 days, chloromycetin 160 mg daily for 3 days, and erythromycetin 160 mg daily for 3 days. X-Rays of the lungs the 4th day showed nodules, consolidation, and hyperlucency. The X-Ray cleared by the 13th day and infant steadily improved and was discharged. The staphylococcus was very sensitive to erythromycin.

This was considered a staphylococcus septicaemia and pneumonia which responded to treatment.

CASE 6. Baby K. K. was born at term July 10, 1964 and lived three and a half months. She was the second baby, pregnancy and delivery were normal. The first infant died of congenital skin disease and septicaemia. Present infant showed epidermolysis and respiratory difficulty at birth, followed by pseudomonas sepsis, pneumonia, convulsions, progressive skin disease, and failure to grow. Antibiotics, transfusion of whole blood, and of packed cells, bronchoscopy and careful nursing all failed and infant steadily failed and expired. The hemoglobin was 10 gms or above most of the time. The gamma globulin was 0.36 gms percent. Final diagnosis was Bronchopneumonia, local abscesses, sepsis due to pseudomonas and congenital ichthyosis lamellar type. The newborn is markedly deficient in bactericidins to gram negative enteric bacilli.⁶ Commercial gamma globulin is low in antibodies to gram negative organisms. In spite of whole blood and plasma, colistin and other support, this infant became progressively worse. (Fig. 2).

CASE 7. Baby B. A. was born prematurely April 21, 1963. His birth weight was 1255 gms. (2 lbs. 12 oz) and he lived 36 hours. The mother, 37 years of age, was gravida 4, and had lost one former premature weighing 4 lbs. 13 oz. The rupture time was 18 hrs. 46 min. Labor time 4 hrs. 48 minutes. The presentation was vertex, and she was said to be in 24th week. The baby was weak and had an Apgar score of 5. The respiratory rate was 40, but increased to 70, retraction of chest was minimal but increased, cyanosis became more marked, and baby became progressively weaker and expired. Clinical diagnosis was respiratory disease syndrome, meaning hyaline membrane disease. X-Ray of chest showed extensive reticular formation of both lungs, nodular densities, probable lung hemorrhage, and slight air bronchogram. Autopsy showed congenital heart disease, atelectasis, and pulmonary hemorrhage. This baby illustrates difficulty of diagnosis in this group. (Fig. 3).

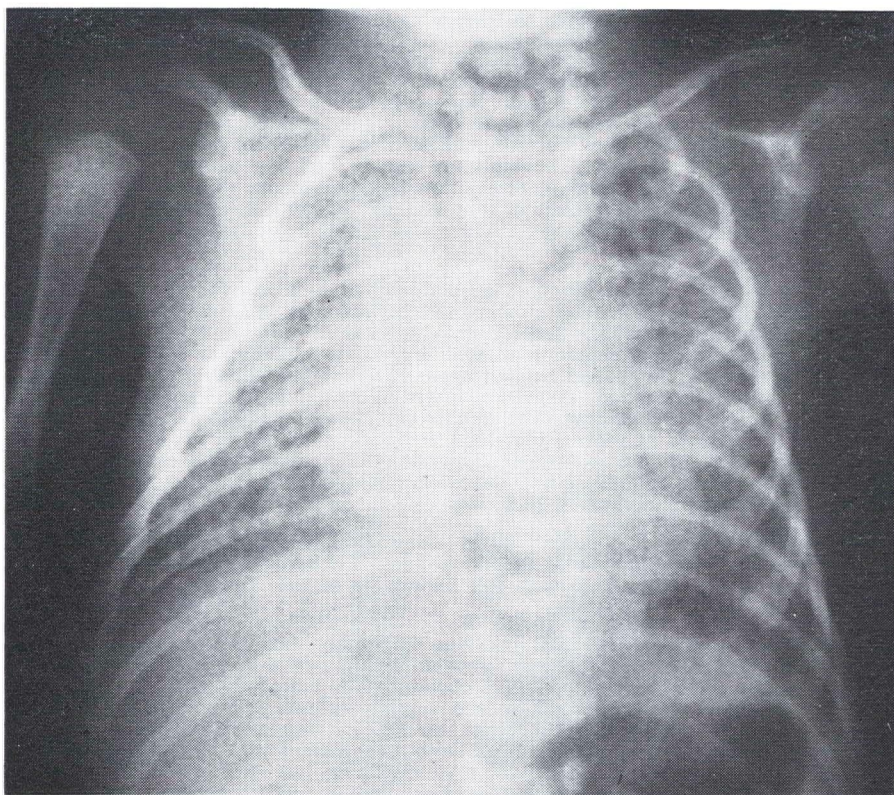


Figure 3

Respiratory distress syndrome and pulmonary hemorrhage. Autopsy showed also, congenital heart disease and atelectasis. Illustrates difficulty in diagnosis. Case 7.

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CASE 8. Baby E. D. was born prematurely weighing 2000 gms (4 lbs. 9 oz) and lived 55 hrs and 17 min. She was the second living child of mother, gravida V, who was a diabetic. A Caesarian section was done at the 36th week. The infant's Apgar score was 9 and by the 4th hour she showed mild retraction and cyanosis. These signs increased along with respiratory rate and grunting respiration. Treatment consisted of mist, oxygen, achromycin 100 mg daily for 2 days, solu-cortef i.m. 20 mg twice daily for 2 days, but infant became progressively weaker and expired. X-Ray showed bilateral, peribronchial infiltration and air bronchogram. The autopsy showed 70% of all alveoli affected with hyaline alveolar membrane. This demonstrates the rapid general development of hyaline membrane in some infants. (Fig. 4).

CASE 9. Baby K. W. was born prematurely weighing 1230 gms (2 lbs 11 oz). The mother, 30 years old, was gravida IX, had history of three miscarriages, and six living children. Amniotic membranes ruptured 3 days before delivery. Pituitrin induction was unsuccessful and Caesarian section was needed. The infant had slight retraction but an Apgar score of 9. At 6 hours of age, slight retraction, cyanosis and increased respiratory rate were present. Treatment consisted of oxygen, mist, temperature control, penicillin 125 mg day for 3 days, streptomycin 60 mg per day for 3 days. X-Ray of chest showed "hyaline membrane disease". The nose and throat cultures were negative. Infant gained steadily from 5th day and went home weighing 5½ lbs. (Fig. 5).

CASE 10. Baby T. H. was born at term September 30, 1964, weighing 3700 gms. (8 lbs. 2 oz). The mother, 20 years old, was primiparous, the amniotic membranes ruptured 36 hours before delivery. Induction was attempted with pituitrin intravenously, but as this was unsuccessful, a Caesarean was done. The infant was in fair condition and given an Apgar score of 8. There was moderate respiratory difficulty for a few hours. Nose and throat cultures and gastric content cultures were negative, but blood culture was positive for peptostreptococcus, a fastidious organism that prefers anaerobiosis initially for growth. Treatment

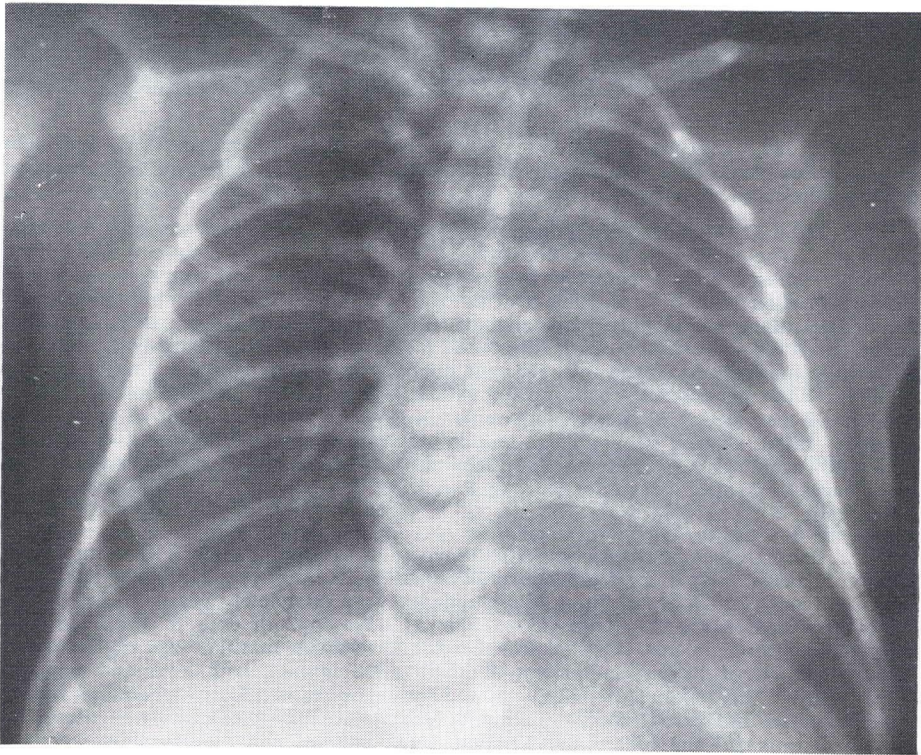


Figure 4

Hyaline membrane disease. Case 8.

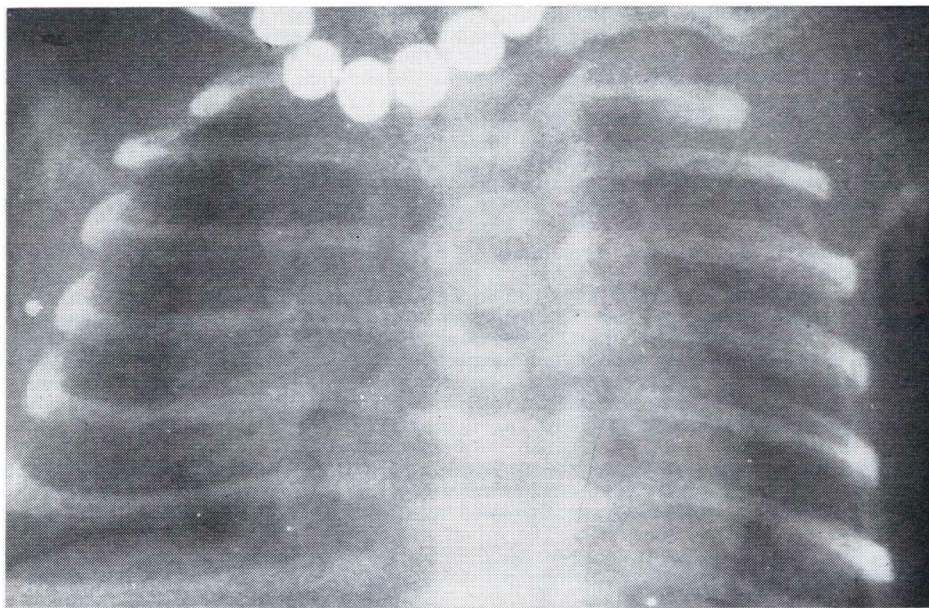


Figure 5

Respiratory distress syndrome in premature infant weighing 1230 gms. Progressive complete recovery. Case 9.

was penicillin 187.5 mg per day for 3 days, and streptomycin 75 mg per day for 3 days. Infant recovered well. This child illustrates the necessity of blood culture on all infants with respiratory difficulty.

CASE 11. Baby D. W. was born prematurely, September 17th, 1964 weighing 2410 gms. (5 lbs. 5 oz). The mother, 37 years old, was gravida V with 3 living children. The amniotic membranes ruptured 3 days before delivery, labor was induced with intravenous pituitrin, and delivery aided with forceps. The mother was given penicillin and streptomycin antepartum. The infant was slightly weak and cyanotic but given an Apgar of 8, and treated with penicillin 125 mg per day for 4 days, and streptomycin 50 mg daily for 11 days. A slight systolic murmur developed into a patent ductus murmur and jaundice developed with a bilirubin of 23.9 mg percent, requiring an exchange transfusion. Respiration was a little irregular, and the 9th day of life seemed worse. X-Rays of lungs now showed a progressing pneumonia. Infant kept on streptomycin, and chlormycetin started 50 mg per day for 2 days, and then 30 mg per day for 3 days. The lungs cleared and infant recovered completely and was discharged. Typical course of late gram-neg bacillus infection. Blood cultures were negative. (Fig. 6).

CASE 12. Baby D. was born weighing 1820 gms. (4 lbs.) Dec. 27, 1962. The mother, age 38, was gravida VI, with four living children, and she had formerly worked in a Tuberculosis Sanatorium. Her chest X-Rays during this pregnancy were completely negative. Infant's only home contact with mother was Jan. 15 to Jan. 22, 19th to 26th days of life. Infant was born with good strength and activity, and seemed normal the first 19 days of life, gaining 13 ounces. At age of 26 days infant was returned to the hospital with fever and respiratory difficulty and X-Ray taken Jan. 22nd showed extensive tuberculosis, tuberculin test was positive Jan. 31st and gastric washings showed tubercle bacilli. Treatment was started with streptomycin isoniazid and para amino salicylic acid. Steroids and tube feedings were used. At 8 months of age infant weighed 11 lbs. Mother's uterus was curetted and tubercle bacilli demonstrated. Twenty-one days of infection are necessary to develop a positive tuberculin test. Such an exposure as this infant had is quite rare.⁸

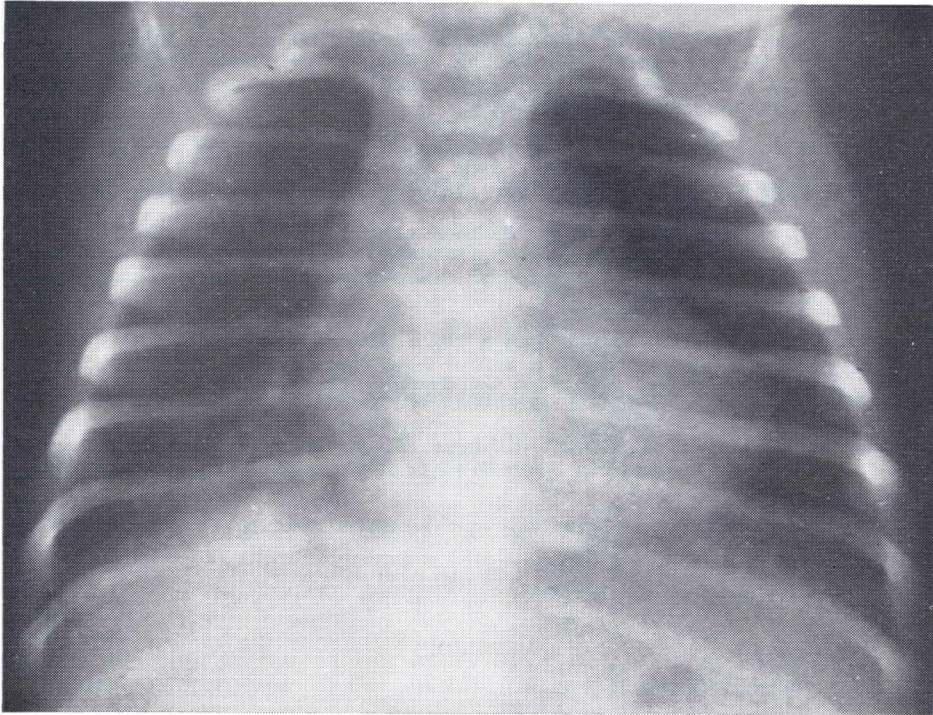


Figure 6

Delayed pneumonia showing 9th day of life probably due to gram-negative organism invasion. Case 11.

SUMMARY

Prematurity increases the risk of infection during the neonatal period. Extensive autopsy studies of perinatal deaths suggest that 5.6 percent to 16.3 percent of them are caused or complicated by infection. Severe pregnancies disturbed by conditions such as eclampsia or breech presentation show an increased perinatal mortality and morbidity. Prominent among the causes of disease in the newborn are infections secondary to prematurity, atelectasis, and anoxia. Premature rupture of the amniotic membranes opens a channel for direct infection of the infant lung and intestinal tract. The recognition of infection in the newborn infant depends largely on minute physical signs found in situations of high risk.

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