Surgical and Orthopedic Aspects of Infections in Newly Born and Young Infants

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This paper reviews the experience in the past 25 years at the Children's Hospital of Pittsburgh with infections requiring surgical and orthopedic consultation in infants under 3 months of age. These include septicemia and its complications, such as peritonitis, osteomyelitis and septic arthritis. Also included are empyema, relatively minor conditions, such as furunculosis and neonatal breast abscesses, and infected congenital anomalies.

Surgical Aspects

Trends in Infecting Organisms

The relative frequency of various organisms recovered from superficial abscesses over the years is shown in Table I. These data document the clinical impression that with the introduction of penicillin, the pneumococcus practically disappeared as a cause of abscesses; a gradual reduction of streptococci infections occurred; and the staphylococcus emerged as the most common organism responsible for peripheral abscesses.

Minor Infections

Furunculosis and pyoderma have assumed importance with the increased incidence of staphylococcal infections in nurseries.

Breast abscesses are peculiar to infants 2 to 3 weeks of age, in whom they owe their origin to estrogenic hypertrophy of the breast. Incision and drainage is often necessary and should not be delayed when a 3- to 4-day course of antibiotic therapy fails to cause recovery.

Paronychia, subungual abscess, and infected ingrown toenail are common, often slow to improve, and may be a source of septicemia. Infants who persist in pulling the feet up and down, while resting on the stomach, will irritate the toes and cause ingrowing. Often the nail itself is slow to grow. Surgical excision, either a wedge or complete removal of the toenail, should not be done. The lateral mounds of granulation tissue can be removed by silver-nitrate cauterization and kept below the level of the nail by pressure with cotton and adhesive tape. Most important, the family must be cautioned against impatience. Actual abscesses must be drained.

Pneumonitis and Empyema

Pneumonitis and empyema in young infants have been occurring with increasing frequency in the past several years. Staphylococci pneumonia with empyema in infants is not a new disease; even the nature of the disease has not altered. Since 1955, Staphylococcus aureus, coagulase positive, has become the most common responsible organism in the empyema complicating bacterial pneumonia in young infants.

The high incidence of empyema in the

Table I

Organisms Cultured from Superficial Abscesses
(As Per Cent of Cases)

<table>
<thead>
<tr>
<th>Organisms</th>
<th>1944</th>
<th>1951</th>
<th>1950</th>
<th>1957</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staphylococcus</td>
<td>48</td>
<td>43</td>
<td>60</td>
<td>66.5</td>
</tr>
<tr>
<td>Streptococcus</td>
<td>30</td>
<td>24</td>
<td>14</td>
<td>6.4</td>
</tr>
<tr>
<td>Mixed streptococci and staphylococci</td>
<td>0</td>
<td>21</td>
<td>12</td>
<td>8.6</td>
</tr>
<tr>
<td>Coifton</td>
<td>20</td>
<td>2.5</td>
<td>14</td>
<td>18.5</td>
</tr>
<tr>
<td>Pneumococcus</td>
<td>7</td>
<td>9.5</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

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TABLE II
Occurrence of Empyema in Infants 3 Months of Age and Under During the Years 1934–1957, Inclusive

<table>
<thead>
<tr>
<th>Years</th>
<th>No.</th>
<th>Died</th>
</tr>
</thead>
<tbody>
<tr>
<td>1934–1944</td>
<td>26</td>
<td>7</td>
</tr>
<tr>
<td>1945–1950</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>1951–1955</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>1956–1957</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>47</td>
<td>9</td>
</tr>
</tbody>
</table>

The thick exudate and common occurrence of pneumatoceles make this condition unique and dangerous. Pneumatoceles occur in half of the cases; in three-fourths of hospitalized infants gross displacement of the mediastinal contents, either from massive effusion or pneumatoceles, is present.

Thoracentesis is a necessary part of the management of these cases. It establishes the diagnosis and, when the fluid is thin, can hasten cure by removing the major portion of it. Occasionally there may be so little fluid and the pneumatoceles so large that thoracentesis is inadvisable. In such cases, diagnosis must rest on the roentgenographic appearance of pneumatoceles and the recovery of the staphylococcus from the nose and throat, umbilicus or blood. When thoracentesis is done in the presence of pneumatoceles, a closed thoracotomy tray should be available because rupture of the pneumatocele and tension pneumothorax can occur. Systemic antibiotic therapy will usually bring about control of the infection and clinical improvement. Intramuscular chloramphenicol and oral erythromycin have been specific. Ristocetin given intravenously has been disappointing. Experience with kanamycin has been limited but it has not been impressively better than chloramphenicol. Intrapleural installation of antibiotics is not a usual part of the treatment. The subsequent treatment of an established empyema varies with the clinical course of the disease.

Pneumatoceles in the presence of acute empyema can rupture spontaneously and cause tension pyopneumothorax and respiratory embarrassment. This acute surgical emergency required prompt insertion of an intercostal catheter and institution of under-water drainage in six cases. Suction applied to the under-water drainage bottle may cause persistence of bronchopleural fistulae and should be avoided.

The intrapleural administration of enzyme preparations has been used in two instances without obvious benefit; in one instance such treatment led to reopening of a bronchopleural fistula.

Case I: D.H., a 3-month-old male infant, was admitted in acute respiratory distress with a temperature of 103°F and a respiratory rate of over 180/min. He had been treated for a cough and possible pneumonia for a period of 2 weeks, but respiratory embarrassment was noted only a few hours before admission. There was right hydropneumothorax with a shift of the mediastinal contents to the left clinically. This was confirmed by roentgenographic examination.

Thoracentesis yielded 50 ml of thick pus and some air. Emergency closed intercostal catheter drainage of the right pleural space was
done. A roentgenogram of the chest then confirmed the clinical finding of re-expansion of the right lung. Chloramphenicol and penicillin were administered. Recovery was rapid. The leukocyte count decreased from 46,800 to 10,000/mm³, and the infant was discharged on the seventeenth hospital day.

Any infant with pneumothorax, even in the absence of shift of the mediastinal contents or increased intrathoracic tension, should have drainage by an intercostal catheter. Massive tension empyema, in the absence of pneumothorax, requires closed drainage by intercostal catheter. In most instances, sufficient displacement of the mediastinal contents is not present and the use of a catheter has not been necessary. Introduction of a catheter can rupture pneumatoceles, promoting a bronchopleural fistula.

Progressive growth of pneumatoceles may occur after signs of infection have disappeared. Displacement of mediastinal contents, with resultant respiratory embarrassment, requires mechanical correction. The introduction of intercostal catheters with closed under-water drainage into the largest pneumatoceles alters the pneumodynamics, and relieves respiratory distress. Pneumatoceles in an asymptomatic infant can remain for many weeks and resolve slowly. Infants with pneumatoceles should remain in the hospital until the pneumatoceles begin to shrink or remain stationary. During this period of observation, a thoracentesis set should be available at the patient’s bedside to combat the sudden respiratory distress which may occur with rupture of a pneumatocele.

**CASE II:** S.F., a 3-month-old male, was admitted to another hospital with clinical evidence of pneumonia of the left lung. After 16 days of hospitalization and treatment with chloramphenicol and oxygen, the temperature and the leukocyte count had returned to normal. The roentgenogram of the chest was normal except for two pneumatoceles, 1 cm in diameter, in the left lower lobe.

Four days later respiratory distress and clinical signs of displacement of the mediastinal structures prompted an emergency roentgenogram of the chest. This confirmed the clinical findings and emergency insertion of an intercostal catheter into the thorax was done. Collapse of the pneumatoceles and recovery was dramatic, and the infant was discharged after a total of 16 days hospitalization. The roentgenogram of the chest was normal at that time.

Caution is urged in recommending major surgical procedure in these infants. As regards recovery, there is not necessarily a correlation between the extent of changes in the roentgenogram and the condition of the patient. Treatment according to the roentgenogram is to be avoided. Clearing of abnormal shadows may occur gradually over a prolonged period. Decortication is rarely if ever necessary and usually follows undue concern about the roentgenogram.

Major thoracotomy was performed in two infants: Complete atelectasis and total empyema with destruction of the right lung in a 2-month-old infant required pneumonectomy; sudden rupture of an asymptomatic pneumatocele simulated a congenital lung cyst in a 2-month-old infant, in whom exploratory thoracotomy disclosed the gross findings of staphylococcal pneumonia with pneumatoceles.

**Infected Cystic Anomalies**

Congenital cystic anomalies commonly become infected and produce unusual clinical problems. An infected sacrococcygeal cyst in a 3-month-old infant produced the classic deformity of an expanding sacrococcygeal teratoma. A further example is a 1-month-old male infant with bilateral retroperitoneal masses which proved to be infected renal duplications. Surgical drainage will control such infections. In some, later surgical excision of the cyst is necessary for cure.

**Septicemia and Its Complications**

The surgeon is consulted in regard to infants with septicemia for surgical and orthopedic opinion and treatment of superficial abscesses, peritonitis, empyema, osteomyel-
litis and septic arthritis. Septicemia may precede or follow localized infection; indeed the localization of the infection often dominates the clinical course to such an extent that the generalized nature of the infection may be overlooked.

**Peritonitis**

Although peritonitis commonly accompanies a septicemia, its actual incidence is difficult to estimate. Five infants with primary peritonitis seen recently had positive blood cultures with the responsible organism also found in cultures of the umbilicus. The umbilicus is the usual portal of entry, its innocent appearance notwithstanding.

The clinical picture of peritonitis varies from that of the infant with mild ileus and slight abdominal distention to that of the critically ill infant with sudden abdominal distention due to large accumulations of intraperitoneal pus and severe ileus. The sudden distention may suggest perforation of a hollow viscus. Bilious vomiting, fever and leukocytosis are regular features. The occurrence of diarrhea may confuse the diagnosis.

The best management of peritonitis depends on accurate and rapid diagnosis. This necessitates roentgenographic examination and abdominal paracentesis. The roentgenogram may show signs of free intraperitoneal fluid, loss of the peritoneal fat line and absence of free intraperitoneal air; the latter excludes perforation of the bowel. Paracentesis yields varying amounts of fluid, usually yielding gram-positive cocci on smear and culture. Gram-negative bacilli in the fluid are associated with alimentary tract pathology; their presence is indication for surgical exploration.

Treatment of the infant with primary peritonitis consists of continuous gastric suction, transfusion for anemia, oxygen to reduce distention, appropriate antibiotics to combat infection, and intravenous administration of fluids to maintain hydration and electrolyte balance. Operative treatment of primary peritonitis is limited to the drainage of localized intraperitoneal abscesses.

The ultimate prognosis of infants with peritonitis, omphalitis and septicemia is uncertain, even though initial recovery is rapid and apparently uneventful. Congestive splenomegaly and hypersplenism were observed in 12 patients, 5 months to 12 years following the initial recovery from septicemia with peritonitis.

**Case III:** M.D. was admitted to the hospital at 17 days of age because of vomiting since birth, with green emesis, diarrhea and fever for 24 hours. He was listless, dehydrated and acutely ill. The abdomen was distended and there was edema over the lower abdominal wall. The temperature was 102.6°F; pulse, 140; and the respiratory rate, 28.

The hemoglobin was 16 gm/100 ml; leukocyte count, 21,900/mm³ with 82% neutrophils and 16% lymphocytes. Plain films of the abdomen revealed signs of free intraperitoneal fluid without evidence of intestinal obstruction.

Abdominal paracentesis recovered 0.5 ml of thin fluid which on direct smear showed gram-positive cocci. Staphylococcus aureus, coagulase positive and sensitive to all antibiotics tested in vitro, was cultured from the peritoneal fluid, the umbilicus and the blood. Fluids, penicillin, streptomycin, polymyxin and gammaglobulin were administered intravenously. Continuous gastric suction was begun.

Recovery was rapid but on the fourth hospital day the infant began to vomit and a mass was palpated in the midline of the upper abdomen. Six days later the mass was drained surgically. The organism recovered from this abscess was penicillin-resistant, but sensitive to tetracycline and chloramphenicol and so these were administered.

A second abscess in the abdomen was drained on the fifteenth hospital day. Roentgenographic signs of osteomyelitis were noted in many bones in a routine skeletal survey on the thirteenth hospital day. Recovery after the drainage was uneventful and the infant was discharged after 33 days of hospitalization. Two years later the infant was completely well.

**Orthopedic Aspects**

After reviewing the records of a series of infants below the age of 3 months who had experienced bacterial infection of the joints or long bones, we concluded: 1) The complications of septicemia are preventable; 2)
From 1940 to 1957, 31 infants under 3 months of age who had bacterial infections of the bones and joints were seen at the Children's Hospital of Pittsburgh. Half of these were first diagnosed from the eleventh to the thirteenth day of life, and six were diagnosed in the first 10 days of life. The streptococcus was the responsible organism. There were three deaths in 1941 and 1942 in infants treated with sulfathiazole and Dakin's solution and tube drainage, and one death in 1953 in an infant with a septic hip treated with aspiration only, with a mortality rate of 7%.

Nine infants had septic hips; five of these showed signs of dislocation on the first no-entgenogram, four were not initially dislocated and did not dislocate under treatment. Of interest to pediatricians is the very definite implication of femoral vein puncture as an etiologic factor in the localization of deformity in these infants. They had entered severely ill with septicemia. All of these dislocated hips involving the femur; at the proximal end in 16. Eleven cases had involvement of the hip; eight of these were already dislocated when the patient was first seen. There were two deaths and 44% of the patients were left with a major deformity of a crippling nature. The disability appeared directly proportional to the delay in instituting treatment. It was quite usual for these infants to have a temperature below 100°F and a leukocyte count that was not particularly elevated for this age group at the onset of the disease.

**Earlier Experience**

Homans, in 1912, reported from the Children's Hospital in Boston a series of 94 cases of osteomyelitis of the long bones encountered over an 8-year period. In this group the mortality was 7% and the incidence of crippling deformity was 19% (Table IV).

Green and Shannon reported from the same hospital, in 1936, a series of 95 cases below the age of 2 years. The mortality rate was 22%.

Blanche, in 1950 from Los Angeles, reported 35 infants less than 9½ months of age with osteomyelitis, observed during a 16-year period. Staphylococcus was the usual responsible organism. There were 20 cases involving the femur; at the proximal end in 16. Eleven cases had involvement of the hip; eight of these were already dislocated when the patient was first seen. There were two deaths and 44% of the patients were left with a major deformity of a crippling nature. The disability appeared directly proportional to the delay in instituting treatment. It was quite usual for these infants to have a temperature below 100°F and a leukocyte count that was not particularly elevated for this age group at the onset of the disease.

**Recent Experience**

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Nine infants had septic hips; five of these showed signs of dislocation on the first roentgenogram, four were not initially dislocated and did not dislocate under treatment. Of interest to pediatricians is the very definite implication of femoral vein puncture as an etiologic factor in the localization of infection in the hip joint of four of these infants. They had entered severely ill with septicemia. All of these dislocated hips following sepsis remained dislocated and the victims have major crippling deformities requiring or undergoing extensive reconstruction.

Lest one be inclined to believe that chemotherapy has eliminated the recurrence of bone infection which had an onset in infancy, it is well to remember that recurrences were rare in 1936 before chemotherapy. Recurrences are rare in infants because of the tendency of infections to

**TABLE IV**

Infections of Bones and Joints

<table>
<thead>
<tr>
<th>Series</th>
<th>Mortality</th>
<th>Crippling Deformity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1904–1912—under 1 yr. Children's Hospital, Boston.</td>
<td>7%</td>
<td>10%</td>
</tr>
<tr>
<td>1915–1936—under 2 yr. Children's Hospital, Boston.</td>
<td>22%</td>
<td>11%</td>
</tr>
<tr>
<td>1934–1950—under 10 mo. Children's Hospital, Los Angeles.</td>
<td>0%</td>
<td>44%</td>
</tr>
<tr>
<td>1940–1957—under 3 mo. Children's Hospital, Pittsburgh.</td>
<td>7%</td>
<td>20%</td>
</tr>
</tbody>
</table>
spontaneously decompress through the relatively spongy vascular bone and the thin cortex.

Major crippling deformity developed in 10% of patients in all age groups in 1912, in 20% of those under 2 years in 1936, in 44% of those under 9 months in 1950, and in 29% of those under 3 months of age in 1958. In the cases with crippling deformity in the last two series, it was noted on the first roentgenogram that the damage was done at the time the diagnosis was first made; none developed after treatment was instituted. These figures suggest that earlier diagnosis is the key to the prevention of complications leading to a crippled child; there is no justification to feel secure merely because the child is given chemotherapy.

The clinical diagnosis is facilitated by remembering that these infants can be quite ill or harbor bone and joint infections without showing a marked systemic reaction. Swelling of the extremity appears earlier in infancy and may be quite diffuse. Failure to move the extremity, even to the point of apparent flaccid paralysis, is the most common presenting complaint. The most valuable sign that allows recognition

FIG. 1A. Early osteomyelitis can be distinguished by deep, soft-tissue swelling centering about a metaphysis before bone changes appear. This is quite evident about the proximal tibia on the left as compared to the right.
of the septic hip is a flexion contracture; this is true allowing for the normal 15 to 20 degrees flexion deformity that may normally be present in the first few months of life. The usual flexion contracture at the hip with sepsis is at least 60 to 70 degrees.

**Relation of the Roentgenogram to Clinical Manifestations**

Unfortunately there has grown up in clinical medicine a concept that osteomyelitis cannot be diagnosed from the roentgenogram until 11 days following the onset. This is not true and is based on a failure to accurately evaluate the soft tissue changes occurring in osteomyelitis. By the time there are clinical symptoms, osteomyelitis is accompanied by a swelling in the deep soft tissues. This is readily recognized and usually is seen at the metaphyseal area where the osteomyelitis originates (Fig. 1). This can be distinguished from the superficial swelling of a primary cellulitis of the soft tissue. The deep swelling has poorly defined edges and involves the so-called muscle shadow, of water density, rather than the subcutaneous tissues. The swelling obliterates fat lines that are normally seen running through the muscle tissue.

A septic hip is recognized by swelling of the shadows about the joint and widening of the joint, recognized at its inferior medial aspect. It is helpful to have the same view of the opposite side in order to make these changes more obvious.

**Treatment**

In order to avoid dislocation of the hip due to sepsis, it is necessary to institute surgical drainage of the tense, pus-filled hip joint as soon as the diagnosis is certain. A preliminary needle aspiration is done.

It is a tenet of our orthopedic service to drain subperiosteal abscesses where they are clearly evident, when fluctuation is apparent, and where there is any possibility of involvement of the epiphyseal line. We do not drain early cellulitis in infancy. When a bone lesion is drained, drill holes are made through the cortex without elevat-

![Fig. 1B. The later roentgenogram reveals bone changes in the same tibia.](image-url)
ing the periosteum to insure adequate decompression of the medullary cavity.

The use of drainage of the joint and abscess appears to prevent the development of a crippling deformity, providing the damage has not already been done.

REFERENCES

METHODS FOR RESEARCH IN HUMAN GROWTH, Stanley M. Garn, Ph.D., and Zvi Shamir, M.D., M.P.H. Springfield, Illinois, Charles C Thomas, Publisher, 1958, 128 pp., $4.75.

In his admirable Foreword to this book, Professor Ashley Weech describes how he would reply, somewhat nettled, to those remarking that growth investigators had first to chart normal seas before paediatricians could spot the abnormal. His laudable reply was that doctors must describe what must be considered abnormal. He goes on to say what a pleasure it is in this volume to find a joining of minds. Indeed there has been.

The authors state, in an excellent introduction, that each chapter could be expanded into a separate monograph but that the book is expressly modest. It is noteworthy that in spite of truly voluminous data collected and published on growth and development in the past, rarely has method been described, critically, educationally, or in detail. Is this book, then, a "do it yourself"? Not entirely: it describes under various headings well-tried and new methods of investigation widely acceptable in the large field of growth and development. Prospective investigators may then know what they are about to get into. This often comes as rather a shock; but it is as well to go into this state in the planning stage rather than later. The book is valuable, therefore, for this kind of reader.

There are 21 chapters ranging wide from "Skin" to "Measurement of Strength and Muscle Function"; from "Sexual Maturation" to "Statistical Analysis of Growth Data." It may be considered that the book becomes a little unbalanced by the fact that this last chapter takes up one fifth of the volume. This is a legitimate criticism. On the other hand, this chapter, in a wholly admirable way, serves to introduce all prospective investigators into child health problems as a whole, to the necessity of planning a study well ahead of putting it into practice, and to be acquainted with biometric principles before entering the water—this element being notorious for its drowning properties. Although it is a large chapter, so is its application.

The publication is up to the publisher's high standard and most up-to-date in content. The bibliography is drawn widely and internationally. Certainly the book will be read by many with profit outside the United States, for it must be remembered that most research into growth and development has emanated from North America in the past, and other countries will be stimulated by descriptions of methods such as these.

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