Analysis of the treatment of basilar skull fractures with and without antibiotics

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The efficacy of chemoprophylaxis in the treatment of basilar skull fractures was studied in 129 patients over a 2-year period; antibiotics were found ineffective in preventing central nervous system infections, and in some cases may have proved harmful. It is suggested that a more rational approach to the treatment of basilar skull fractures includes close observation of the patient for early signs of meningitis, and if these should develop, treatment with antibiotics appropriate to the organism involved.

KEY WORDS • basilar skull fracture • prophylactic antibiotics • meningitis

The treatment of basilar skull fractures has involved two basic controversies, namely, whether explorations should be performed to close the dura, and whether prophylactic antibiotics should be used. In an attempt to answer the latter question, we studied a series of 129 patients treated with and without chemoprophylaxis.

Materials and Methods

We reviewed a series of 129 consecutive patients with 136 basilar skull fractures treated at Denver General Hospital over a 2-year period. Only those patients who survived 10 or more days were included in the series. During the first year, 54 patients with 57 basilar skull fractures were treated with various antibiotics. They were placed on ampicillin or cephalothin 1 gm/6 hr intravenously for the first 3 days, or until 2 days had elapsed after cessation of obvious cerebrospinal fluid (CSF) leak; for the remainder of their hospitalization they were treated with intramuscular or oral antibiotics depending on their clinical status. Of the 54 patients in this group (Group 1), 41 were treated with ampicillin, nine with cephalothin, and the remaining four with other antibiotics or various combinations. This group was studied retrospectively with regard to type and rate of complication.

During the second year, a prospective study was performed on 75 patients with a total of 79 basilar skull fractures. Fifty of these were admitted for a 10-day period of observation but were not treated with antibiotics (Group 2). If fever, stiff neck, or deterioration of neurological status ensued, a lumbar puncture was performed. Another 15 patients with basilar skull fractures were admitted and would have been included in the untreated group; however they had to be placed on antibiotics for reasons other than basilar skull fracture prophylaxis and therefore were excluded from the untreated group in the comparative analysis.
TABLE 1
Incidence of cerebrospinal fluid fistulas in 129 patients*

<table>
<thead>
<tr>
<th>Diagnostic Criteria</th>
<th>Group 1 (treated)</th>
<th>Group 2 (untreated)</th>
</tr>
</thead>
<tbody>
<tr>
<td>rhinorrhea</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>otorrhea</td>
<td>9</td>
<td>16</td>
</tr>
<tr>
<td>hemotympanum</td>
<td>25</td>
<td>34</td>
</tr>
<tr>
<td>lacerated drum with blood in canal</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>x-ray confirmation</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>total</td>
<td>57</td>
<td>79</td>
</tr>
</tbody>
</table>

* Three patients in the treated group and four in the untreated group had evidence of more than one type of basilar fracture. The frequency of the five diagnostic criteria does not differ significantly in the two groups. ($\chi^2 = 1.61; 0.8 < p < 0.9$).

Criteria used for the diagnosis of basilar skull fracture included rhinorrhea, otorrhea, blood behind the tympanic membrane with audiogram evidence of hearing loss, or x-ray confirmation (Table 1). In order to verify that the two main groups analyzed (treated versus untreated) were comparable, a statistical analysis of variables that might have contributed to the overall severity of the illness was made. Table 2 lists those variables and the $\chi^2$ values. With $p = 0.5$ indicating a significant difference, it can be seen that significant differences occurred in four areas. In the untreated group there was a statistically significant greater number of patients who were unconscious for longer than 24 hours, had central nervous system (CNS) operations, and had had major medical illness prior to injury. In the treated group there was a statistically significant greater number of facial fractures. Therefore, in the overall severity of illness the two groups were comparable in most factors analyzed, but possibly the untreated group was at somewhat greater risk overall. Analysis of the mortality in the two groups (treated = 7.2%; untreated = 7.4%) showed no significant difference. The morbidity based on number of days hospitalized for reasons other than basilar skull fracture antibiotic prophylaxis or observation was also comparable.

Follow-up of patients in both groups was from 3 to 24 months. Some authors have reported the late development of meningitis after traumatic CSF fistula; figures have ranged from days to as long as 25 years. It appears that the risk of meningitis is greatest within the first 2 weeks after injury and decreases markedly after 3 months. For this reason our patients were followed for a minimum of 3 months.

Results

In the prospective analysis of the 50 Group 2 patients not treated with antibiotics, there were no CNS infectious complications. The only infection that did develop was an otitis media in a patient with otorrhea 14 days postinjury; this responded well to appropriate antibiotics. Analysis of the CSF including cultures at the time of diagnosis of the otitis revealed no evidence of meningitis. Among the 54 treated patients (Group 1), there were two major CNS infectious complications, namely, meningitis and brain abscess. One of these patients died of this complication and the other suffered serious neurological deficit. No organisms could be identified or cultured in the fatal case of meningitis and brain abscess, and in the survivor the organism isolated was *E. coli*. This organism proved to be resistant to the antibiotics that the patient had been receiving; when antibiotics to which the organism was sensitive were introduced, the meningitis abated. The rate of infection in the two groups is too small for the difference to be statistically significant; however, none of the 50 patients in the untreated group developed a CNS infection.

Of the 15 patients admitted in the second year who were treated with antibiotics for reasons other than basilar skull fracture prophylaxis, eight were placed on antibiotics for clinical infection. In five of these cases this was for various types of pneumonia and in the remaining three for scalp infection, otitis media, and postoperative wound infection. The remaining seven patients in this group were placed on antibiotics for prophylaxis other than for basilar skull fracture, four because of compound depressed skull fractures, and three for oral-facial fractures. Three of these 15 patients developed infections while on antibiotic therapy. One of these patients placed on antibiotics for an open depressed skull fracture developed a fulminating fungal infection and abscess of the brain and died; two of those placed on antibiotics for infection later developed pneumonias that were considered superinfections and complications of antibiotic therapy.
Basilar skull fractures with and without antibiotics

Of the 129 patients in the total series, three of the 69 who were treated with chemoprophylaxis developed a CNS infection. Although the rate of infection did not differ significantly (Fischer's exact test: \( p = 0.50 \)), the data suggest that antibiotics did not prevent the development of CNS infection.

In an attempt to determine possible reasons for the development of CNS infection in those patients receiving chemoprophylaxis, a group of 10 patients with basilar skull fractures was randomized at the completion of the analysis described above so that five received prophylactic antibiotics (ampicillin or cephalothin, 1 gm/6 hr for 10 days), and five did not. Cultures of the posterior nasopharynx were taken on admission and on the fifth and tenth hospital days; they were obtained by calcium alginate swabs in the area of the posterior naso-oropharynx and cultured by routine laboratory methods. The results were interesting. None of the patients developed meningitis; however four of the five placed on prophylactic antibiotics developed a significant change in their posterior nasopharyngeal flora, while the five not treated with antibiotics did not. In the treated group the change was toward more invasive and potentially more pathogenic organisms resistant to the antibiotic regimen the patient was receiving (Table 3).

**Discussion**

Traumatic spinal fluid fistula has been described since the Middle Ages. The first case reported in the English literature was by Charles Miller in 1826. These early observations were crude since the nature and circulation of spinal fluid was not fully appreciated. In 1884, Chiari gave the first anatomical demonstration of a pneumatocele at necropsy and traced the fistula from the nasopharynx through the ethmoid and lacerated dura into the frontal lobe. A major breakthrough occurred in 1926 when Walter Dandy diagnosed and successfully repaired a posttraumatic dural laceration secondary to a basilar skull fracture. The Second World War provided a vast experience in the treatment of these problems. Concomitant with the understanding of the pathophysiology of these lesions was the advent of the antibiotic era. Because of the early reports of the grave and often fatal complication of meningitis with these fistulas, antibiotic chemoprophylaxis was a natural development.

Since that time the treatment and complication rate has changed little. Basilar skull fractures represent only about 2% to 10% of the head injuries admitted to large trauma hospitals, so it is difficult to obtain a large enough series to make valid comparisons of the different modes of treatment. Another major problem is that the nature, mode of presentation, and outcome of the various diseases has changed with the development of newer techniques of diagnosis, surgery, and antibiotic therapy, each of which has its own set of complications.

With regard to repair of the fistula itself, some have urged repair of the dura in all cases but especially those of the frontal sinus with rhinorrhea, regardless of whether the leak stops spontaneously. The more conservative approach recommends operative exploration for repair of the defect if the CSF fistula has not stopped within 7 to 14 days after the time of trauma.

There has been much debate regarding chemoprophylaxis, and the actual risk of

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**Table 2**

<table>
<thead>
<tr>
<th>Illness</th>
<th>Group 1 (treated, ( n = 54 ))</th>
<th>Group 2 (untreated, ( n = 50 ))</th>
<th>( x^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>unconscious &gt; 24 hours</td>
<td>16</td>
<td>20</td>
<td>.828†</td>
</tr>
<tr>
<td>decerebrate</td>
<td>3</td>
<td>5</td>
<td>.235</td>
</tr>
<tr>
<td>focal deficit</td>
<td>6</td>
<td>5</td>
<td>.018</td>
</tr>
<tr>
<td>CNS operation</td>
<td>1</td>
<td>10</td>
<td>7.314†</td>
</tr>
<tr>
<td>other operations</td>
<td>2</td>
<td>2</td>
<td>.189</td>
</tr>
<tr>
<td>linear skull fractures</td>
<td>6</td>
<td>7</td>
<td>.022</td>
</tr>
<tr>
<td>depressed skull fractures</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>compound skull fractures</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>compound depressed skull fractures</td>
<td>1</td>
<td>0</td>
<td>.002</td>
</tr>
<tr>
<td>skull fractures</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>multiple other fractures</td>
<td>5</td>
<td>5</td>
<td>.042</td>
</tr>
<tr>
<td>facial fractures</td>
<td>9</td>
<td>2</td>
<td>3.206†</td>
</tr>
<tr>
<td>each major non-CNS injury</td>
<td>3</td>
<td>2</td>
<td>.008</td>
</tr>
<tr>
<td>major medical illness</td>
<td>12</td>
<td>15</td>
<td>.468†</td>
</tr>
<tr>
<td>prior to injury tracheostomy</td>
<td>8</td>
<td>5</td>
<td>.201</td>
</tr>
<tr>
<td>infection</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CNS</td>
<td>2</td>
<td>0</td>
<td>.440</td>
</tr>
<tr>
<td>other</td>
<td>2</td>
<td>0</td>
<td>.440</td>
</tr>
</tbody>
</table>

† Patients were categorized as to severity of illness 72 hours after admission.

\( x^2 \) values differ significantly at the 0.5 level.
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**TABLE 3**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>No. of Cases</th>
<th>Day 0</th>
<th>Day 5</th>
<th>Day 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>no antibiotics</td>
<td>5</td>
<td>normal</td>
<td>unchanged</td>
<td>unchanged</td>
</tr>
<tr>
<td>cephalothin (1 gm/6 hr for 10 days)</td>
<td>3</td>
<td>normal</td>
<td>Gram-negative</td>
<td>Gram-negative</td>
</tr>
<tr>
<td>ampicillin (1 gm/6 hr for 10 days)</td>
<td>2</td>
<td>normal</td>
<td>Gram-negative</td>
<td>normal but increased</td>
</tr>
</tbody>
</table>

* Normal indicates hemolytic and nonhemolytic streptococcus predominating with occasional pneumococcus and staphylococcus. Gram-negative indicates that the organisms were resistant to the antibiotics that the patient was receiving.

Meningitis with the lesion. The reported incidence of meningitis developing after cerebrospinal fluid fistula varies from 6% to 25% in large retrospective series, whether or not antibiotics were used. In surveys where all patients received antibiotics the reported incidence of meningitis ranged from 2% to 25%. In a recent retrospective analysis, 16% of the patients treated with antibiotics developed meningitis while only 3% of those patients who did not receive chemoprophylaxis developed the complication.

Ours is the first reported prospective study of the risk of developing meningitis in those patients not placed on prophylactic antibiotics; none of our 50 patients not treated with antibiotics developed meningitis. Rhinorrhea is a more common type of CSF leak than otorrhea; it persists longer, and carries a greater risk of meningitis. Our three patients with CNS infection all had rhinorrhea, but were also on chemoprophylaxis. Nine patients with rhinorrhea in our untreated group did not develop meningitis. It appears, therefore, that basilar skull fractures carry a low incidence of meningitis and that withholding prophylactic antibiotics does not lead to meningitis; conversely, three patients placed on chemoprophylaxis developed a serious meningitis.

Antibiotic prophylaxis has come under considerable re-examination in recent years. Prophylactic antibiotics have proved valuable in some conditions when directed at a specific agent such as beta-hemolytic streptococcus in rheumatic fever, and meningococcus in outbreaks of meningocemia.

The second type of prophylaxis is that type directed at secondary bacterial complications and not specific organisms or specific predictable entities. Examples of this include the common cold, measles, respiratory paralysis and polio, and influenza. Studies have shown that antibiotics have no beneficial action in these states and, in fact, may be harmful. In unconscious patients, a higher incidence of pneumonia, dermal lesions, and an unfavorable change in the flora of the respiratory and urinary tracts have been found in those patients placed on antibiotics than in controls. In a study on the bacterial flora and infections in patients with brain injury, it was suggested that although tracheostomies seem to be significant in causing changes in flora, bacterial selection due to antibiotic therapy probably also occurred. Several papers now suggest that there are changing patterns of life-threatening disease in hospitalized patients. The emergence of Gram-negative pneumonias, septicemias, and meningitides as well as fungal diseases are on the increase while formerly more common bacteriological diseases are decreasing. Antibiotics have been implicated in these changing patterns. The manner in which this occurs appears to revolve around interbacterial inhibition in maintaining the balance of normal flora, the inhibition of normal phagocytic responses by antibiotics, and the alteration of the host's immunological defenses by antibiotics.

Our data on 10 randomized basilar skull fracture patients confirms the thesis that chemoprophylaxis shows a trend in these patients toward alteration in the nasopharyngeal flora to potentially more invasive organisms.
Basilar skull fractures with and without antibiotics

**Conclusions**

We believe that prophylactic antibiotics do not favorably alter the incidence or risk of meningitis in basilar skull fractures, and may even be harmful and lead to more serious complications. Our own analysis of 129 patients supports this thesis. Basilar skull fractures are a serious aspect of head trauma, and meningitis is a grave complication to be watched for and treated appropriately, should it develop. However, we contend that careful observation of the patient for early signs of this developing complication and initiation of appropriate treatment at that time will lead to more rational management and ultimate better prognosis than prophylactic antibiotic regimens.

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