대 한 방 사 선 의 학 회 지 1993 ; 29(2) : 312~318
Journal of Korean Radiological Society, March, 1993

# Bacterial Meningitis in Newborn and Infant: Correlation between Organism, CT Findings and Clinical Outcome

**Hye-young Choi, M.D., Young-seo Park, M.D.*, Shi-joon Yoo, M.D., Dae-chul Suh, M.D., Young-kyo Chung, M.D.**

*Department of Diagnostic Radiology, Asan Medical Center, University of Ulsan College of Medicine*

**— Abstract —**

Bacterial meningitis results in significant neurologic dificits despite in spite of much effort in the treatment of the disease. This study was performed to determine the incidence of caustive organisms and to correlate between the organisms and computed tomographic (CT) findings with clinical outcome of bacterial meningitis in newborns and infants.

We analyzed the brain CT and clinical records of 15 infants who had been diagnosed as bactrial meningitis by CSF culture.

We found that the most common organisms were Group B streptococcus in neonates withou no neurologic complications in all but one and Hemophilus influenza in infants whose clinical outomes were poor in all except one. CT findings related with poor prognosis in this study were cerebral edema, basal cisternal obliteration & enhancement, and cerebral infarction on initial CT and ventriculomegaly on follow-up CT.

We concluded that CT diagnosed intracranial complications of bacterial meningitis well and could contributed to better treatment of bacterial meningitis.

**Index Words:** Meningitis 10.202
Brain CT 10.1211

## INTRODUCTION

Acute bacterial menigitis often results in significant neurologic complications regardless of the antibiotics treatment Computed tomographic (CT) finding of tuberculous meningitis is fairly well known but not the findings of bacterial meningitis.

The purpose of this study is to determine the incidence of causative agents of bacterial meningitis and to correlate the causative agents and the CT findings with clinical course in newborns and infants.

## MATERIALS AND METHODS

We reviewed the CT and clinical records of 15 newborns and infants who had been diagnosed as bacterial meningitis between December 1989

* 울산대학교 의과대학 소아과학교실
* *Department of Pediatrics, Asan Medical Center, University of Ulsan College of Medicine*
이 논문은 1991년 12월 10일 접수하여 1993년 1월 18일에 채택되었음.
Received December 10, Accepted January 18, 1993

and July 1991 at the Asan Medical Center.

The diagnosis of bacterial meningitis was based upon the culture of cerebrospinal fluid (CSF) in all 15 cases.

CT scans were performed with GE 9800(General Electric, Milwaukee, WI) or Picker 1200 Expert(Highland Heights, Ohio) before and after intravenous contrast infusion in all 15 cses. Follow-up CT scan were performed in six cases.

We evaluated the incidence of the responsible causative organisms and correlated CT findings and the causative organisms with clinical course. Clinical outcome was categorized according to the modified version of Song's calssification (1) as follws (Table 1): Group I, cured with no resdual neurologic deficit related to bacterial meningitis; Group II, live with neurologic deficit; GroupIII, discharged in hopeless state or expired.

## RESULTS

Causative organisms of bacterial meningitis in our cases were Group B streptococcus in four, Hemophilus influenza in four, Escherichiae coli and Streptococcus pneumoniae in two each and Neisseria meningitidis, Listeria monocytogenes, and Staphylococcus aureus in one each patient.

The most common organism for under one month of age was Group B streptococcus in four cases. The prevalent organisms for above one month of age was Hemophilus influenza in four followed by Streptococcus pneumoniae in two cases (Table 2).

Upon correlation of causative organism with clinical grouping, Group II was found to be reated with Hemophilus influenza in two, Streptococcus pneumoniae and Neisseria meningitidis in one each and Group III with Hemophilus in-

**Table 1.** Grouping of Clinical Outcome

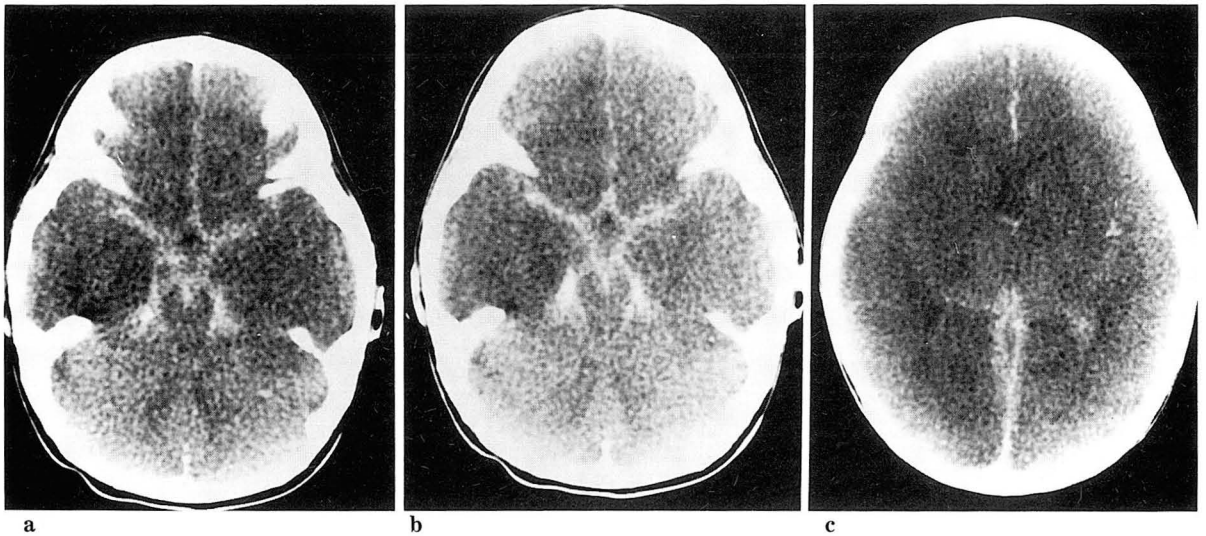
| | |
|---|---|
| Group I | Cured with no neurologic deficit |
| Group II | Cured with neurologic deficit |
| Group III | Discharged in hopeless state or expired |

**Table 2.** Causative Organisms of Bacterial Meningitis in Neonate and Infant

| | Age | | |
|---|---|---|---|
| Organisms | 0-1 M | 2-12 M | Total |
| Group B. streptococcus | 4 | | 4 |
| Hemophilus influenza | | 4 | 4 |
| Escherichiae coli | 1 | 1 | 2 |
| Streptococcus pneumoniae | | 2 | 2 |
| Listeria monocytogenes | 1 | | 1 |
| Neisseria meningitidis | | 1 | 1 |
| Staphylococcus aureus | | 1 | 1 |
| Total | 6 | 9 | 15 |

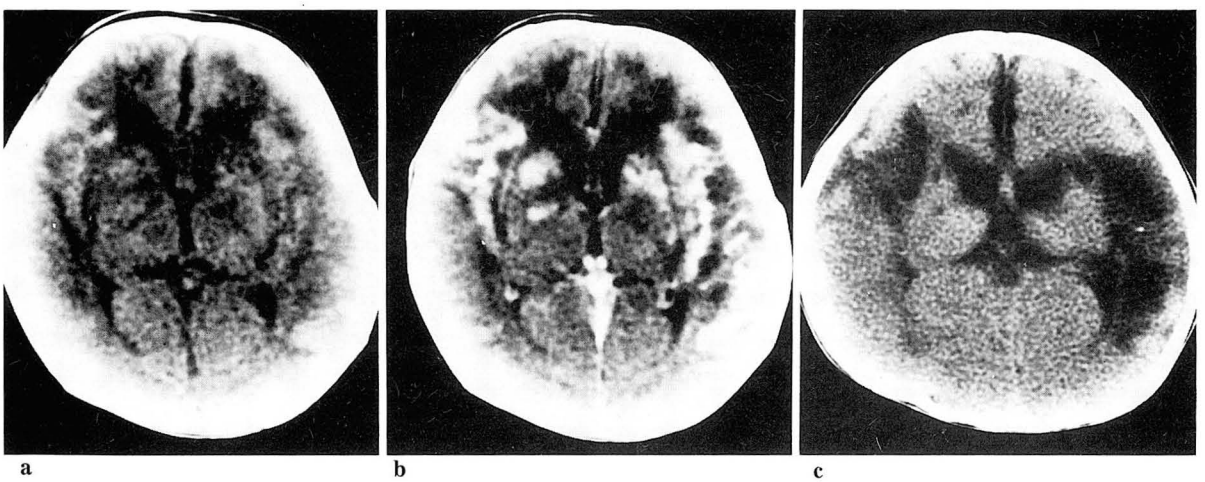
**Table 3.** Correlation between Causative Organisms and Clinical Outcome

| | Clinical outcome | | | |
|---|---|---|---|---|
| Causative organisms | Group I | Group II | Group III | Total |
| Group B. streptococcus | 3 | 1 | | 4 |
| Hemophilus influenza | 1 | 2 | 1 | 4 |
| Escherichiae coli | 2 | | | 2 |
| Streptococcus pneumoniae | | 1 | 1 | 2 |
| Listeria monocytogenes | 1 | | | 1 |
| Neisseria meningitidis | | 1 | | 1 |
| Staphylococcus aureus | 1 | | | 1 |
| Total | 8 | 5 | 2 | 15 |



a b c

**Fig. 1.** A 8 months infant with Hemophilus influenza meningitis (Group III).
a, b, c. Pre- (a) and post-enhancing (b) CT show basal cistiernal obliteration and enhancement with diffuse cerebral edeam (c).



a b c

**Fig. 2.** A 3 days neonate with Group B. Streptococcus meningitis (Group II).
a. Pre-enhanced CT shows inhomogenous high and lower density lesions at bilateral basal ganglia and fronto-temporo-parietal areas with periventricular low density by cerebral infarction.
b. Post-enhanced CT shows gyriform enhancing lesions at both temporoparietal poritons and noular enhancing lesions at both basal ganglia by cerebral infarction.
c. Follow-up pre-enhnaced CT after 5 months shows encephalomalacia in pre-existing infacted portions and small calcified spot in left temporal area with diffuse atrophic change.

fluenza and Streptococcus pneumoniae in one each case (Table 3).

The correlation of the initial CT findings with clinical grouping was listed in Table 4. Te CT findings related with the worst prognosis were diffuse cerebeal edema with basal cistrnal obliteration on pre-enhancing and basal cisternal enhancement on post-enhancing scan in Hemopilus influenza meningitis (Fig. 1). The common and poor prognostic finding in the initial CT was cerbral infarction in three cases which showed Group II clinical course (Fig. 2). Subdural effu-

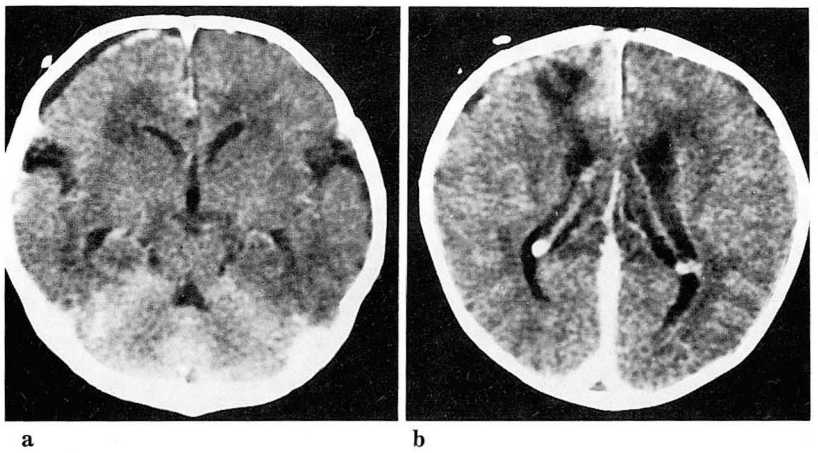


**Fig. 3.** A 17 days neonate with Group B. Streptococcus meningitis (Group I).
a, b. Post-enhancing CT shows subdural effusion (a) and cerebritis at the right frontal area (b).

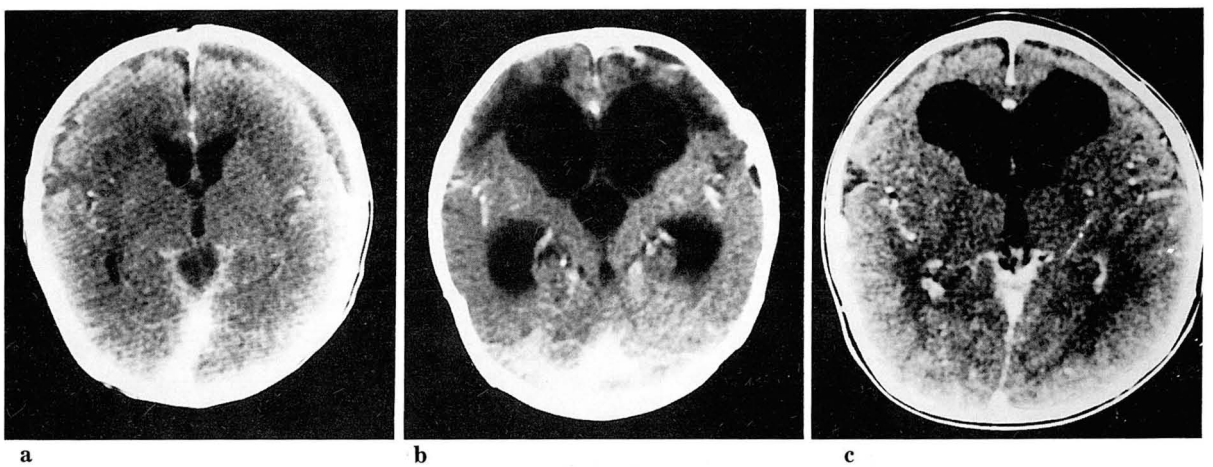
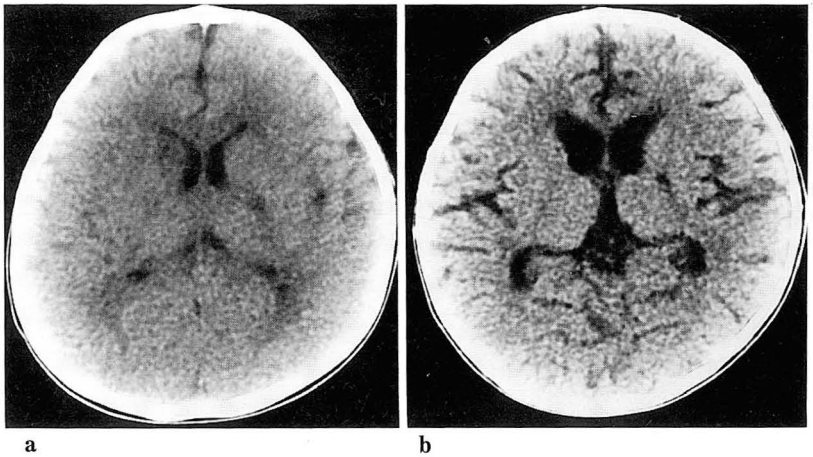


**Fig. 4.** A 2 months infant with Streptococcus pneumoniae meningitis (Group II).
a. Initial CT shows subdural effusion at the left frontal area and cerebral infarction at the left proximal frontal lobe (not shown in this slice).
b. Follow-up CT after 3 weeks reveals marked hydrocephalus with periventricular interstitial edema and focal residual subdural effusion.
c. Follow-up CT after 7 months reveals ventriculomegaly in the third and both lateral ventricles.

sion was seen in four cases: two each patients presented Group I and Group II clinical course (Fig. 3).

On the available follow-up CT in six patients, we identified ventriculomegaly in all six, rain atrophy in five, encephalomalacia, and encephalic cyst in one each patient (Table 5).

Upon correlation of the follow-up CT with clinical course, four of six patients of ventriculomgaly revealed Group II clinical course (Fig. 4). Of four patients with ventriculomegaly, three patents revealed cerebral infarction on the initial CT and one patient had marked ventriculomegaly on the follow-up CT. Brain atrophy was seen in five patients: two in Group I and three in Group II. All of Group II patients with brain atrophy had also cerebral infarction on the initial CT and two patients had also ventriculomegaly on the follow-up CT (Fig. 5). Among the eight cases with abnormal initial CT findings, one case expired with Hemophilus influenza meningitis, four cases revaled neurologic deficits, and three cases improved without neurologic deficits. Another expired case of Strepto-



a b

**Fig. 5.** A 9 months infant with Neisseria meningitidis meningitis (Group II).
a. Initial CT shows small infarction at the left basal ganglia.
b. Follow-up CT after 3 weeks shows diffuse cerebral atrophic change.

**Table 4.** Initial CT Findings vs. Clinical Outcome.

| | Clinical outcome | | | |
|---|---|---|---|---|
| Initial CT findings | Group I | Group II | Group III | Total |
| Normal | 5 | 1 | 1 | 7 |
| Subdural effusion | 2 | 2 | | 4 |
| Cerebral edema | 1 | 1 | 1 | 3 |
| Cerebral infarction | | 3 | | 3 |
| Ventriculitis | | 1 | | 1 |
| Cerebritis | 1 | | | 1 |
| Basal cisternal enhancement | | | 1 | 1 |

**Table 5.** Last Follow-up CT Findings vs. Clinical Outcome

| | Clinical outcome | | | |
|---|---|---|---|---|
| Follow-up CT findings | Group I | Group II | Group III | Total |
| Ventriculomegaly | 2 | 4 | | 6 |
| Brain atrophy | 2 | 3 | | 5 |
| Encephalomalacia | | 2 | | 2 |
| Encephalic cyst | | 1 | | 1 |
| Calcification | | 1 | | 1 |

coccus pneumoniae meningitis revealed no significant abnormal findings on the initial CT.

## DISCUSSION

Group B streptococcus is the most common causative agent of bacterial meningitis in neontes, followed by gram (-) enteric bacilli, Listeria monocytogenes, Hemophilus influenza, Streptocccus pneumoniae, and Neisseria meningitidis (2). Of our six neonates, Group B streptococcus was responsible for four, Escherichiae coli and Listeria monocytogenes for one each patient. Walter et al (2) reported that the incicences of causative orgsanisms of bacterial meningitis in chidren younger than 2 years were 85%, 42%, and 38% for Hemophilus influenza, Neisseria meningitidis, and Streptococcus

pneumoniae respectively. Most of other studies also reported that the common caustive organism of bacterial meningitis in children was Hemophilus influenza with incidence rate from 40% to 70% (3,4,5,6) and followed by Neisseria meningitidis (2,6) or Streptococcus pneumoniae (3,5,7) with 15% to 20% incidence rate. Among 9 patients with over 1 month of age in our series, Hemopilus influenza was the most common causative organism in four patients (44%).

Of the initial CT findings of our study, the poor clinical prognostic findings were cerbral infarction, cerebral edema, and basal cisternal obliteration and enhancement. Synder et al (8) reported that cerebral infarction in bacterial meningitis appears to be a serious, relatively common complications and 27% of his cases demonstrated cerebral infarction on CT. Our study showed cerbral infarction in three cases (20%) who all showed neurologic deficits, such as seizure, delayed development, hearing and visual impairment. Basal cisternal enhancement on post -enhancing C is reported to be the specific finding in tuberculous meningitis. However, one patient with Hemopilus influenza meningitis in this study revealed high density at basal cisterns on both pre-and post-enhancing CT scans. Basal cisternal obliteration on pre-enhancing CT was probably due to high viscosity of accumulated pus in the subarachnoidal spaces. Song et al (1) reported that the basal cisternal enhancement on CT was the most poor prognostic finding. Our case expired shortly after the onset of bacterial meningitis in accordance with the findings of Song et al.

Of the six follow-up CT scans, ventriculomegaly and brain atrophy were the most frequently obsrved findings. Ventriculomegaly was the most common complication of bacterial meningitis but mild ventriculomegaly in acute state of bacterial meningitis usually represents mild pressure hydrocephalus (7). However, significant ventriculomegaly appears to be more often secondar to diffuse brain atrophy without increased intraventricular pressure, developing in later stage of the illness (9,10). Many mechanisms have been postulated to explain ventriculomegaly such as vascultis, bacterial neurotoxins, some toxic components of granulocytes, or an immunologic reaction. Regarless of the mechanisms involved, it is apparent that toxic-atrophic encephalopathy sometimes is the cause of marked ventriculomegaly (7,9,10,11). All of the six cases with the follow-up CT scans sowed ventriculomegaly and four of these six cases represented neurologic deficits.

Jadavji et al (5) reported the mortality rate of bacterial meningitis as 6.4% and the neurologic sequelae as 20%. The mortality rate and neurologic sequelae of this study were 13% and 33%, respectively. The mortality rate was significantly greater in pneumococcal meningitis (15.2%) than with other forms of meningitis and neurologic deficit occurred in 10%-25% of the survivors with more subtle intellectual, hearing, and visual impairment (5,11). Neurologic deficits in our patients incuded seizure and hearing impairment in three cases each, visual impairment and deayed development in one each case. Smith & Landig recognized the relative frequency of phlebitis in the subarachnoid exudate and they felt that phlebitis may be an important mechanism in neurologic deficit (8).

In conclusion, bacterial meningitis in infants resulted in significant neurologic sequelae and mortality and the most common responsible organisms were Group B streptococcus in neonates and Hemophilus influenza in infants. All of Group B streptococcus meningitis except one with Group II outcome revealed no neurologic sequeale, but all but one Hemophilus influenza meningitis represnted poor Group II or III clinical outcomes. The worst prognostic findings were cerebral edema with basal cisternal obliteration

and enhancement of the initial CT. The common poor prognostic findings were cerebral infarction on the initial CT and marked ventriculomegaly on the follow-up CT.

Despite the small number of cases, this study showed the adequate CT display of the complicaions of bacterial meningitis well related with the patient outcome. Thus, CT would contribute to better patient management.

## REFERENCES


1. Song CS, Chang KH, Yeon KM. A study on correlation between CT findings and clinical course of meningitis in children. J. of Korean Radiological society 1984; 20 (3):414-423.
2. Walter F. Schlech III, Joel I. Ward, Jeffrey D. Band. Bacterial meningitis in United States,1978 through 1981. JAMA 1985; 253:1749-1754.
3. Mark W. Kline, Sheldon L. Kaplan. Computed tomography in bacterial meningitis of childood. Pediatr Infect Dis J 1988; 7:855-857.
4. David A. Cabral, Olof Flodmark, Kevin Farrell. Prospective study of computed tomography in acute bacterial meningitis. The journal of Pediatrics 1987; 111:201-205.
5. Jadavji T., Biggar WD, Cold R. Sequelae of acute bacterial meningitis in children treated for seven days. Pediatrics 1986; 78:21-25.
6. Karen M. Kaplan, Frank A. Oski. Anemia with Hemophilus influenza meningitis. Pediarics 1980; 65:1101-1104.
7. Jorgen Stovring, Russell D. Snyder, Albuquerque, NM, Commputed tomography in childhood bactrial meningitis. The Journel of Pediatrics 1980; 96:820-823.
8. Snyder J. Stovring, Cushing AH, Divis LE. Cerebral infarction in childhood bacterial meningtis. Journeal of Neurology, Neurosurgery, and Psychiatry. 1981; 44:581-585.
9. Snyder RD. Ventriculomegaly in childhood bacterial meningitis. Neuropediatrics 1984; 15:136 -18
10. Kim BK, Babcock DS, McAdamx L. Bacterial meningitis in infants: Sonographic findings. Radilogy 1985; 154:645-650.
11. Jose Bodino, Pedro Lylyk, Miguel Del Valle. Computed tomography in purulent meningitis. Am J Dis Child 1982; 136:495-501.



〈국문 요약〉

영유아의 세균성 뇌막염에서의 원인균 및 CT 소견과 임상적 예후와의 관계

울산대학교 의과대학 진단방사선과학교실

최혜영 · 박영서 · 유시준 · 서대철 · 정영교

세균성뇌막염은 영유아에서 호발하며 아직도 신경학적 후유증을 남기거나 사망까지 초래하는 질병으로 임상 증상으로 그 예후를 예측하기 어려울때 전산화단층촬영 소견 별 및 원인균에 따른 임상 예후와의 관계를 추적 분석하는 것이 세균성뇌막염 환아를 치료하는데 도움을 주리라고 사료된다. 이에 저자들은 1989년 12월부터 1991년 7월까지 원인균이 증명되어 세균성뇌막염으로 확진된 15명의 영유아를 대상으로 전산화단층소견과 임상 예후와의 관계 및 원인균과 임상 예후와의 관계를 분석하였다. 원인균 중에서는 신생아 6명중 Group B, Streptococcus에 의한 것이 4명으로 가장 많았는데 이중 1명만 Group II의 예후를 보여 대부분이 좋은 임상적 결과를 나타내었으나 영유아 9명 중에서는 Hemophilus influenza 4명, Streptococcus pneumoniae 2명으로 가장 많았으며 임상적 예후도 1명만 제외하고는 모두 Group II와 III로 나쁜 결과를 보여주었다. 전산화단층촬영에서 Group II와 III의 나쁜 예후를 나타낸 것은 뇌부종, 뇌저지주막하조의 손실 및 조영증강과 뇌경색, 그리고 뇌실증대가 보인 경우로 전산화단층촬영은 세균성뇌막염 환자의 뇌에서 나타날 수 있는 합병증을 진단할 수 있게 하므로 환아의 치료방향을 결정하고 임상적 예후를 예견하는데는 필수적이라고 생각한다.