*Neurol J Southeast Asia 2000; 5 : 61 – 67*

# Nipah encephalitis outbreak in Malaysia, clinical features in patients from Seremban

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*Abstract*

*Background:* An outbreak of viral encephalitis occurred among pig industry workers in Malaysia in September 98 to April 1999. The encephalitis was attributed to a new paramyxovirus, Nipah virus. This is a description of the clinical features of 103 patients treated in the Seremban Hospital with characterization of the prognostic factors. *Methods:* Clinical case records and laboratory investigations were reviewed. The case definition was: patients from the outbreak area, direct contact or in close proximity with pigs, clinical or CSF features of encephalitis. *Results:* The mean age was 38 years, 89% were male, 58% were ethnic Chinese, 78% were pig farm owners or hired workers. The mean incubation period was 10 days. The patients typically presented with non-specific systemic symptoms of fever, headache, myalgia and sore throat. Seizures and focal neurological signs were seen in 16% and 5% respectively. In the more severe cases, this was followed by drowsiness and deteriorating consciousness requiring ventilation in 61%. Autonomic disturbances and myoclonic jerks were common features. The mortality was high at 41%. Systolic hypertension, tachycardia and high fever were associated with poor outcome. On the other hand, 40% recovered fully. As for the other 19%, the residual neurological signs were mostly mild.
*Conclusion:* Nipah virus caused an encephalitis illness with short incubation period and high mortality. The prognosis for the survivors was good.

*Key words:* Nipah virus, encephalitis, clinical features, Seremban, Malaysia

## INTRODUCTION

From December 1998 to May 1999 there was an outbreak of encephalitis among the workers in the pig farm villages in Sikamat, Bukit Pelanduk (including Sungei Nipah and Kampong Jawa), Tanah Merah, Negri Sembilan State, as well as Sepang and Sungei Buloh, Selangor State in Central Peninsular Malaysia involving more than 200 patients. The outbreak was thought to have started in pig farming villages in Ulu Piah, Tambun and Ampang around Ipoh, about 200 km north of Kuala Lumpur, in September 1998.[1,2] The outbreak also spread to involve abattoir workers in Singapore.[3,4] Chua et al in an earlier report of 3 fatal cases with post-mortem findings has shown that the encephalitis was due to a new strain of paramyxovirus closely related to Hendra virus, later named Nipah virus.[5,6] During the epidemic, the patients were seen in two main Medical Centres, the University Malaya Medical Centre and Seremban Hospital.[7-15] Over the five months period from 26th December 1998 to 21st April 1999, 107 patients with encephalitis were admitted to Seremban Hospital. Four patients were transferred to another hospital during the acute illness for further care. This is the report of the 103 patients with Nipah encephalitis treated in this Medical Center.

## METHODS

Patients were defined as having Nipah encephalitis if they came from the outbreak areas, had direct contact or in close proximity with pigs, and who had features of encephalitis clinically and/or abnormal cerebrospinal fluid.

The report is based on the clinical records of the patients. All of the patients were seen by one or more of the study physicians. The incubation period was defined as the interval between the last contact with pig and the onset of clinical symptoms and was deduced from patients who left the area in a subsequent voluntary evacuation.

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The patients were managed in two dedicated wards. They were given general supportive therapy, anticonvulsants and other agents as necessary. The indications for ventilation were: Glasgow coma scale (GCS) score <8, rapidly deteriorating GCS score or inability to protect airway because of seizure. Patients were treated with inotropic agent(s) if they had persistent hypotension despite adequate volume. Ribavirin, a nucleoside analogue antiviral drug was used in 65% of the patients.

For serology, the CSF and serum samples were tested with an IgM-capture enzyme-linked immunoabsorbant assay (ELISA) for antibodies against Hendra virus antigen. The antigens were inactivated by cobalt irradiation.

Univariate analyses were performed to correlate specific clinical features or laboratory findings with the outcome. For contingency tables, chi square tests with Yate's correction when necessary, was used. When the numbers were small the two-tailed Fisher's exact test was used. For unpaired non-parametric variables, Kruskal-Wallis statistics was used. Unpaired parametric variables were tested with analysis of variance. Where multiple comparisons for parametric variables were necessary, we used analysis of variance with Bonferroni's correction. The prognostic factors for outcome were analysed with multivariate logistic regression. All values below 0.05 were considered statistically significant. All values of relative risks (RR) were also expressed in 95% confidence interval.

## RESULTS

### Demographic characteristics

The demographic and epidemiological characteristics are as listed in Table 1. The mean age was 38 $\pm$ 14 years (4-75). As for the 10 patients who have other occupations, there was each a coffee-shop operator, carpenter, oil palm seller, farmer, retired pig farm worker, clerk, housemaid, housewife, a student and a $4\frac{1}{2}$ year old child. All the patients had direct contact or were in close proximity to pigs in the course of their daily life.

### Clinical and laboratory features

The incubation period based on the 49 patients who left the pig farm before the onset of symptom was: 10 $\pm$ 8.7 days (1-32). There were 4 patients who had a fixed period of exposure. These were the patients who went into the area, contracted

**Table 1: Demographic features of patients with Nipah encephalitis**

| Characteristics | | No. of patients (%) (N=103) |
|---|---|---|
| Gender | Male | 91 (88) |
| | Female | 12 (12) |
| Race | Chinese | 60 (58) |
| | Indian | 25 (24) |
| | East Malaysian | 4 (4) |
| | Migrant | 14 (14) |
| | Indonesian | 10 (10) |
| | Nepalese | 4 (4) |
| Occupation | Pig farmers | 41 (40) |
| Hired workers | | 39 (38) |
| Truck drivers | | 8 (8) |
| Culling team members | | 3 (3) |
| Abattoir workers | | 2 (2) |
| Others (see text) | | 10 (10) |

**Table 2: Symptoms at presentation of patients with Nipah encephalitis**

| Symptom | Percentage (N=103) |
|---|---|
| Fever | 97 |
| Headache | 88 |
| Chills or rigors | 51 |
| Myalgia | 47 |
| Dizziness | 39 |
| Vomiting | 36 |
| Flu-like symptoms | 29 |
| Anorexia | 27 |
| Seizure | 27 |
| Sore throat | 21 |
| Diarrhoea | 21 |
| Fatigue, malaise or lethargy | 19 |
| Nausea | 16 |
| Abdominal pain | 8 |
| Arthralgia | 7 |
| Focal neurological symptoms | 5 |
| Dyspnoea | 2 |
| Chest pain | 2 |
| Constipation | 2 |
| Vertigo | 2 |
| Urinary symptoms | 2 |

the disease, and subsequently left the outbreak area. In these patients, the interval from the time they left the area until the onset of symptoms was 2.3 ± 3.2 days (0-7). The interval from the time they moved into the area until the onset of symptoms was 16.5 ± 19.4 days (2-45). The mean incubation period of these 4 patients was 9.4 days.

For most patients, the presenting symptoms mimic benign viral illness with some of them having respiratory and abdominal symptoms (Table 2). The focal neurological symptoms seen in the five patients were: two with diplopia, one each with blindness, ataxia and dysarthria. Table 3 lists the clinical signs. As for the myoclonus, they occurred with the frequency of about 2 Hz. Of the patients who had segmental sweating, some were unilateral, all were in the upper part of the body.

Although the most prominent manifestations originated from the central nervous system, other organs were involved as evident by the abnormal laboratory and radiological findings, as listed in table 4. Chest x-rays were taken just before or immediately after intubation in 42 patients. Eight patients (7.8%) were found to have Syndrome of Inappropriate Antidiuretic Hormone in their recovery phase, with hyponatraemia and natriuresis without renal failure.

Sixty two patients (61%) were ventilated. The interval between the onsets of symptoms to intubation was 5.8 + 4.2 days. The patients were ventilated for a mean period of 6.6 + 5.4 days. The majority of the ventilated patients developed dysautonomia, which were: hypertension (74%), tachycardia (71%), sweating, and hyperglycaemia (58%). Lymphopaenia and thrombocytopaenia occurred at about the same time as ventilation; (onset of symptom to lymphopaenia: 5.8 + 4.8 days, onset of symptom to thrombocytopaenia: 6.0 + 4.3 days). Dysautonomia was noted 2 to 3 days later; and that of raised aspartate transaminase after another 2 days. There was however, substantial overlap between the occurrence of these clinical and laboratory changes.

**Tables 3: Clinical signs of patients with Nipah encephalitis**

| Signs | Percentage (N = 102) |
|---|---|
| Drowsiness | 85 |
| Confusion | 69 |
| Hyporeflexia | 59 |
| Myoclonus | 54 |
| Diaphragmatic muscle | 20 |
| Limbs muscles | 17 |
| Facial muscles | 3 |
| Diaphragmatic and limbs muscles | 7 |
| Limbs and facial muscles | 3 |
| Diaphragmatic and facial muscles | 2 |
| Diaphragmatic, limbs and facial muscles | 2 |
| Tachycardia (heart rate > 120 bpm) | 53 |
| Hypertension | 52 |
| Ptosis | 30 |
| Sweating (profuse or segmental) | 27 |
| Nystagmus | 25 |
| Hypotonia | 25 |
| Dysconjugate eye movement | 16 |
| Babinski's sign | 16 |
| Paralysis | 15 |
| Neck stiffness | 12 |
| Cranial nerve(s) palsy | 9 |
| Cerebellar signs | 3 |

**Table 4: Summary of laboratory and radiological findings of patients with Nipah encephalitis**

| Laboratory features | Percentage (N) | Means ± SD (range) |
|---|---|---|
| Abnormal cerebrospinal fluid * | 83 (54) | Protein: 1.3 ± 1.1(0.32-7.0) g/dl<br>Sugar: 5.5 ± 4.9 (3.6-34.4) mmol/l<br>White cell: 61 ± 101 (0-384)/$mm^3$ |
| Positive sera Hendra IgM serology | 81 (91) | |
| Positive CSF Hendra IgM serology | 58 (31) | |
| Thrombocytopaenia (< 150,000/μl) | 66 (102) | 139000 ± 55100 (41000-331000) /μl |
| Elevated alanine transaminase (> 65 IU/L) | 61 (76)** | 119 ± 120 IU/l |
| Elevated aspartate transaminase (> 37 IU/L) | 60 (76)** | 108 ± 112 IU/l |
| Lymphopaenia (< 1000 lymphocytes/μl) | 60 (102) | 1050 ± 579 (279–3351)/μl |
| Chest x-ray changes | 24 (42) | |
| Left upper lobes alveolar consolidation | 10 (42) | |
| Bilateral upper lobes alveolar consolidation | 2 (42) | |
| Lower lobes alveolar consolidation | 7 (42) | |
| Reticular changes | 5 (42) | |

* Cerebrospinal fluid is defined as abnormal if the white cell count is > 5 /$mm^3$ or protein > 0.45 g/dl
** One patient with concomitant acute alcoholic hepatitis was excluded in analysis.

The Hendra serology was positive in 91 patients, however when compared with the patients with negative serology, there was no difference in clinical features, laboratory results, proportion being ventilated or mortality.

### Outcome

The mortality was 41%. The interval between the onsets of symptom to death was 10 + 6.8 days. The pre-terminal events were autonomic derangements with eventual hypotension unresponsive to triple inotropes (dobutamine, dopamine and high dose adrenaline or noradrenaline infusion). When the surviving patients were last seen 5 months since the outbreak, some 40% recovered fully while 19% had residual neurological deficits which were: cerebellar signs (6.8%), tetraparesis (4.9%), cranial nerve palsies (3.9%), monoparesis (1.0%), peripheral nerve lesions (2.9%) and higher mental function deficits (2.9%). Of the 4 patients with cranial nerve palsies, two had facial nerve palsy, one each had unilateral sensorineural deafness and diplopia. Of the 3 patients with peripheral nerve lesions, one each had ulnar nerve palsy, foot drop, and digital numbness. Of the 3 patients with higher mental deficits, one each had medial temporal syndrome (hyperphagia, inappropriate sexual behaviour), global dysphasia and vegetative state. As for the functional status, one patient was in persistent vegetative state, 2 have marked disabilities and are dependent on caregivers, while 4 have mild disabilities and are independent in their activities of daily living.

Table 5 lists the prognostic factors for mortality. On logistic regression analysis, tachycardia (p=0.025), high fever (p=0.039) and hypertension (p=0.045) were independently associated with poor outcome.

## DISCUSSION

Pig farming in the Bukit Pelanduk area started almost 70 years ago. The industry had largely remained a family business. Often the owners and his family took care of the animals with assistance from a few migrant workers, mainly from Bangladesh, Indonesia and Nepal. Bukit Pelanduk and its neighbouring areas had developed into the biggest pig farm industry centre in South East Asia. There were estimated a million pigs at the time of the outbreak.[7] The pigs were exported to Singapore as well as for home market.

**Table 5: Prognostic factors of Nipah encephalitis**

| Prognostic factors* | Mortality in the presence of prognostic factor percentage (no. of patients/N) | Mortality in the absence of prognostic factor percentage (no. of patients/N) | Relative risks (95% CI) | |
|---|---|---|---|---|
| Tachycardia | 69 (38/55) | 8 (4/48) | 3.3 (2.1 < RR < 4.9) | P< 0.001 |
| Hyperthermia | 79 (23/42) | 14 (9/61) | 5.2 (2.8 < RR < 9.6) | P< 0.001 |
| Diastolic hypertension | 84 (33/47) | 16 (9/56) | 6.0 (3.0 < RR < 12) | P< 0.001 |
| Systolic hypertension | 64 (36/57) | 13 (6/46) | 2.6 (1.8 < RR < 3.7) | P< 0.001 |
| Hyperglycaemia | 77 (31/41) | 17 (10/60) | 4.9 (2.6 < RR < 9.2) | P< 0.001 |
| Sweating | 70 (19/27) | 30 (23/70) | 2.3 (1.5 < RR < 3.5) | P<0.001 |
| Need of inotrope(s) | 84 (31/37) | 17 (11/64) | 4.9 (2.8 < RR < 8.5) | P<0.001 |
| Ventilation | 58 (36/62) | 15 (6/41) | 4.0 (1.8 < RR < 8.6) | P< 0.001 |
| Antiepileptic agent used | 64 (29/45) | 22 (13/58) | 2.9 (1.7 < RR < 4.9) | P< 0.001 |
| Myoclonus | 54 (30/56) | 26 (12/47) | 2.1 (1.2 < RR < 3.6) | P= 0.007 |
| Thrombocytopaenia | 57 (30/53) | 25 (12/50) | 1.9 (1.3 < RR < 2.7) | P= 0.008 |
| Raised aspartate transaminase | 54 (14/25) | 24 (12/51) | 2.4 (1.2 < RR < 4.5) | P= 0.009 |
| Lymphopaenia | 51 (31/61) | 25 (11/42) | 1.5 (1.1 < RR < 2.1) | P= 0.006 |
| Diabetes mellitus | 86 (6/7) | 38 (36/96) | 2.3 (1.5 < RR < 3.4) | P=0.018 |
| Age ≥ 40 years | 55 (27/50) | 29 (15/53) | 1.8 (1.2 < RR < 2.7) | P= 0.017 |

* On the need of inotropic agents and ventilation, see text for definition. Hyperglycaemia is defined as peak random plasma sugar of ≥ 11.1 mmol/l. Tachycardia is defined as peak heart rate ≥ 120 beats per-minute. Hyperthermia is defined as peak temperature ≥ 40°C. Systolic hypertension is defined as peak systolic blood pressure ≥ 160 mmHg. Diastolic hypertension is when the diastolic component of the peak systolic hypertension is ≥ 100 mmHg. Thrombocytopaenia is defined as trough platelet count < 133,000/μl. Elevated aspartate transaminase is peak level ≥ 100 IU/l. Lymphopaenia is trough lymphocytes count ≤ 1000 cells/μl. The average patient is taken of having a relative risk of 1.0 and mortality of 41%.

The patient characteristics of mainly adult Chinese males who worked with live pigs, full time or part-time suggested that it was a zoonotic disease from pigs.[7,8,16,17] Animal studies has showed a moderate to severe instititial pneumonia with immunohistochemical staining showing high concentration of viral antigen in the endothelial cells of blood vessels, as well as in the cellular debris in the lumen of the upper respiratory tract. The disease could thus spread from pig to man through infected secretions by direct body contact or via respiratory droplets at close range.[7,16-18] The disease initially affected 27 pig farmers in Perak at the north with 15 mortality. When the encephalitis occurred in Perak, the government imposed restriction on the transportation of pigs across state border. Some farmers had disregarded this. This may be the cause of the spread of the disease.[18]

The estimated mean incubation period was short at 10 days, and the longest was 32 days. This may be an underestimation as it was based on the time of last exposure. In one of the patients with a fixed period of exposure time, the symptom started two days after entering the area suggesting that the incubation period could be as short as 2 days. Many of the patients also gave the history of the pigs falling ill around Chinese (lunar) New Year on the 16th and 17th of February 1999. The first few patients had the onset of symptoms on the 18th to the 22nd of February 1999, again suggesting a relatively short incubation period.

The patients commonly complained of symptoms that mimic benign viral illness with fever, headache, chills, rigors, and myalgia probably due to the initial viraemia. About a quarter of the patients had sore throat and an equal number had flu-like symptom with cough suggestive of respiratory tract involvement. Pathological studies has shown vasculitic changes in the lung.[5] Some had gastrointestinal symptoms of anorexia, nausea, vomiting, diarrhoea and abdominal pain. These could be due to nervous or direct gastrointestinal involvement.

Many of the patients subsequently developed drowsiness, confusion and focal neurological signs. The conscious state deteriorated rapidly with ventilation required in 61% of the patients. The interval between the onset of symptom to intubation was 5.8 days. The common occurrence of coma, diaphragmatic myoclonus, autonomic changes with tachycardia, hypertension, hyperthermia, profuse and segmental sweating, ptosis and nystagmus suggested prominent involvement of the brainstem, upper spinal cord and hypothalamus. Disseminated microinfarction in the brain secondary to vasculitis-induced thrombosis has been the main pathological finding.[5] The neurological features could be partly due to the widespread microinfarction. There is also evidence of direct neuronal involvement with neuronal inclusion body and positive immunohistochemical staining of neurons.[3,5,6] The myoclonus, particularly the diaphramatic myoclonus which was a characteristic feature of the illness, would be consistent with direct neuronal involvement.[8] The previously demonstrated association between CSF virus isolation and mortality also support direct neuronal invasion being important in the pathogenesis of severe disease.[10] The meningism which was seen in only 12% of the patients was consistent with the CSF examination, which was normal in 17% of the cases. Histologically, meningitis were generally mild.[5]

Paton *et al* [3] reported three of their eleven patients who were abattoirs workers in Singapore presented with atypical pneumonia, one later had evidence of cerebral involvement. Although chest radiograph abnormalities were noted in 24% of our cases, none had primary lung disease. This is similar to the finding from the University Malaya Medical Centre, which is the other major treatment centre for the encephalitis.[8] These indicate that the virus caused a predominantly neurological disease. Pathologically, although organs including the lung, heart and kidney were affected, the brain was the most severely affected organ.[5]

The mortality was high at 41%. The mean duration of illness from onset of symptoms to death was 16 days. Goh *et al*[8] reported that tachycardia and an abnormal doll's-eye reflex were associated with poor outcome, suggesting a severe brainstem involvement in the fatal cases. We found that in addition to this, hypertension and high fever were also associated with mortality. This is also consistent with severe brainstem and hypothalamic involvement in the fatal cases. The association of thrombocytopaenia, raised aspartate transaminase and hyperglycemia with mortality is probably reflective of non-specific changes of the very sick patients.

Although the mortality was high, for the patients who survived, the outlook was good. Most of the 23 patients (19%) with residual neurological deficits were mild. Most were able to independently carry out their activities of daily living. The outcome is better than that of Japanese encephalitis, another encephalitis related to pig farming.[19]

## ACKNOWLEDGEMENT

We thank Dr. Thomas Ksiazek and his team from the Center of Disease Control and Prevention, the Microbiological Department, University of Malaya and the Nipah encephalitis task force laboratory staff for their help in the serological tests, and the doctors and nurses from all over Malaysia who worked in the Special Wards 3A, 3B, the Intensive and Coronary Care Units, Seremban Hospital for their help. We also thank the visiting Neurologists from the Department of Neurology, Hospital Kuala Lumpur, for their opinion and help, and the Ministry of Health, Malaysia, for their generous funding, provision of equipments and coordination effort during the outbreak.

## REFERENCES

1. Centre for Disease Control. Update: Outbreak of Nipah virus – Malaysia and Singapore, 1999. MMWR Morb Mort Wkly Rep 1999;48:265-9.
2. Centers for Disease Control. Outbreak of Hendra-like virus – Malaysia and Singapore, 1998-1999. MMWR Morb Mort Wkly Rep 1999;48:335-7
3. Paton NI, Leo YS, Zaki SR et al. Outbreak of Nipah-virus infection among abattoir workers in Singapore. Lancet 1999;354:1253-56.
4. Lee KE, Umapathi T, Tan CB et al. The neurological manifestations of Nipah encephalitis, a novel paramyxovirus. Ann Neurol 1999;46:428-32.

5. Chua KB, Goh KJ, Wong KT, Kamarulzaman A, Tan PSK, Ksiazek TG, Zaki SR, Paul G, Lam SK, Tan CT. Fatal encephalitis due to Nipah virus among pig farmers in Malaysia. Lancet 1999;354:1256-9.
6. Chua KB, Bellini WJ, Rota PA et al. Nipah virus: A recently emergent deadly paramyxovirus. Science 2000;288:1432-5.
7. Tan KS, Tan CT, Goh KJ. Epidemiology aspects of Nipah virus infection. Neurol J Southeast Asia 1999;4:77-81.
8. Goh KJ, Tan CT, Chew NK et al, Clinical features of Nipah virus infection among pig farmers in Malaysia. N Eng J Med 2000;342:1229-35.
9. Chew, Goh KJ, Tan CT. The mechanism of areflexia in patients with Nipah encephalitis. Neurol J Southeast Asia 2000;5:29-33.
10. Chua KB, Lam SK, Tan CT, Hooi PS, Goh KJ, Chew NK, Tan KS, Kamarulzaman A, Wong KT. High mortality in Nipah encephalitis is associated with presence of virus in cerebrospinal fluid. Ann Neurol 2000;48:802-5
11. Ramasundrum V, Tan CT, Chong HT, Goh KJ, Chew NK, Petharunam V, Thayaparan T, Chua KB, Lam SK, Ksiazek TG. Presence of CSF IgM do not have protective effect in Nipah encephalitis. Neurol J Southeast Asia 1999;4:73-6
12. Ahmad Sarji S, Abdullah BJ, Goh KJ et al. MR Imaging features of Nipah encephalitis. AJR 2000;175:437-42.
13. Chew NK, Goh KJ, Tan CT et al. Electroencephalography in acute Nipah encephalitis. Neurol J Southeast Asia 1999;4:45-51
14. Ramasundrum V, Tan CT, Chua KB, Chong HT, Goh KJ, Chew NK, Tan KS, Thayaparan T, Kunjapan
SR, Petharunam V, Loh YL, Ksiazek TG, Lam SK. Kinetics of IgG and IgM in Nipah virus infection. Neurol J Southeast Asia 2000;5:23-8.
15. Chua KB, Lam SK, Goh KJ, Hooi PS, Ksiazek TG, Kamarulzaman A, Olson J, Tan CT. The presence of Nipah virus in respiratory secretions and urine of patients during an outbreak of Nipah virus encephalitis in Malaysia. J Infect 2001;42:1-4
16. Parashar UD, Lye MS, Ong F et. al. Case control study of risk factors for human infection with a new zoonotic Nipah virus during a 1998-1999 outbreak of severe encephalitis in Malaysia. J Infect Dis 2000;181:1755-9.
17. Chew MHL, Arguin PM, Shay DK et al. Risk factors for Nipah virus infection among abattoir workers in Singapore. J Infet Dis 2000;181:1760-3
18. Mohd Nor MN, Gan CH, Ong BL. Nipah virus of pigs in Peninsular Malaysia. Rev Sci Tech Off Int Epiz 2000;19:160-5
19. Thongcharoen Prasert. Japanese encephalitis virus encephalitis: an overview. Southeast Asian J Trop Med Pub Health 1989;20:559-73