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Current Situation of Japanese Encephalitis in the South of Vietnam, 1976−1992

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Abstract: Cases of "Acute Encephalitis Syndrome (AES)" and deaths were reported annually in all 17 provinces in the South of Vietnam. The highest morbidity of 936 patients was recorded in 1980, while highest mortality of 339 deaths in 1977. The lowest figures of morbidity was 197 cases in 1990 and lowest mortality was 34 deaths in 1985. Sporadic cases were reported throughout the year but small outbreaks with low peaks were seen in February and July annually. Twenty five strains of Japanese encephalitis (JE) virus were isolated during 1978−1992: 8 from patients' blood, 5 from cerebrospinal fluid (CSF), 9 from *Culex quinquefasciatus,* 3 from *Aedes aegypti.* Serologically confirmed JE cases were not many, because most of the human sera sent to us for testing were used for differential diagnosis of pernicious malaria. The anti−JE antibody prevalence among healthy human in 11/17 provinces was found to be extremely high, especially in adults. The antibody positive rate among swine to JE was found to be high: 82% with GMT 65.2 in 189 sera taken at My Tho−Tien Giang province in March 1978 and 77.4% with GMT 49.7 in 261 sera taken in the vicinity of Ho Chi Minh City in September 1992. From the above data, the Southern part of Vietnam is an endemo−epidemic area of JE virus infection.

Key words: Japanese encephalitis, Vietnam

Introduction

In terms of human morbidity and mortality, JE virus is the most important and widespread in the group of flavivirus. Approximately 50,000 sporadic and epidemic cases of JE are reported annually in Asia (Burke and Leake, 1988). In Vietnam, JE virus has been the leading cause of human encephalitis. In 1952 the first JE virus was isolated from an African soldier (Prevot *et al.,* 1954) and in 1953, 98 European and African soldiers affected by JE were reported (Puyuelo and Prévot, 1953).

In the decade of 1960, acute encephalitis epidemics had frightfully increased and had been recognized as a serious public health problem in Vietnam.

In the Southern part, Nguyen Thi Kim Thoa, Beytout D. and Do Van Quy in Pasteur Saigon isolated for the first time 1 JE virus from 50 *Aedes aegypti* in 1963 (Nguyen *et al.*, 1966). Then in 1972−1973, Nguyen Thi Kim Thoa *et al.* isolated 10 JE virus strains from 3 mosquito species in Saigon areas: 5 from *Culex tritaeniorhynchus,* 3 from *Culex quinquefasciatus* and 2 from *Culex gelidus.* Six of them were isolated in urban area and 4 in the suburb, respectively (Nguyen *et al.,* 1974).

In the North in 1964, Do Quang Ha and Doan Xuan Muou in the National Institute of Hygiene and Epidemiology isolated for the first time 4 JE virus strains: 2 from post−mortem human brains, 1 from patients' blood and 1 from wild birds *Garrulax perspicillatus* Gmelin (Do and Doan, 1965). In the following years, they isolated 18 JE virus strains: 7 from post−mortem human brains, 1 from a swine, 10 from mosquitoes (7 strains from *Culex tritaeniorhynchus,* 1 from *Culex gelidus,* 1 from *Aedes albopictus* and 1 from sylvan mosquitoes: *Aedes diemmaccus*) (Do and Pham, 1974; Do *et al.,* 1977; Do and Nguyen, 1977). High JE antibody prevalences in healthy human population, domestic animals and wild birds have been demonstrated (Doan and Do, 1965; Do and Nguyen, 1971).

The aim of our study is to identify the AES aetiology, and to introduce the results of viral isolation from patients' blood diagnosed as non AES and from a species of mosquito that just now is considered as uncommun vector of JE virus.

Materials and Methods

Epidemiological data

These were collected from Pasteur Institute Ho Chi Minh City.

Specimens

Blood and CSF fluid samples were obtained from the Center of Tropical Diseases, the Pediatric Hospital No 1, No 2 and Cho Ray Hospital in Ho Chi Minh City. The blood was taken aseptically, agitated in bottle with glass beads, then centrifuged, the serum was withdrawn for viral isolation. Mosquitoes were captured indoor from 8 to 11: AM. Two technicians carried−out hand catches by using glass tubing and aspirated the mosquito by mouth, for 15 minutes per house. After identification, female mosquitoes were reared in the laboratory until complete digestion of blood (5−6 days), then they were triturated with PBS, pH 7.8, containing 0.4% bovine albumin. After being centrifuged, the mid whitish suspension was pipetted out, filtered through Sartorius GmbH−3.400 membrane (Gottingen, Germany), then used for viral isolation.

Viral isolation

In 1978−1986 stage, samples were inoculated into suckling mice, and during 1987−1992, into the C6/36 cell culture (Igarashi, 1978). For identification of the isolates, the complement fixation test and the neutralization test in adult mice (8gm) were used. Then

from 1987 to 1992 the direct immunofluorescent antibody test (DFA) and the indirect immunofluorescent antibody test (IFA) with dengue specific monoclonal antibodies (MnAb) and the hyperimmune mouse sera of the Nakayama strain were performed (Henchal *et al.*, 1983).

Serological studies

Serum samples for diagnosis were received from the Hospitals in Ho Chi Minh City and the Provincial Centers of Hygiene and Epidemiology. The acute phase serum was taken on the day of admission and the second serum, on 7−10 days later. Blood samples for serological survey were obtained in 11/17 provinces. Blood was taken from the finger tip through a lancet puncture then collected into capillary tubes. All specimens were collected at random in different age groups. Serum specimens were tested by the micro haemagglutination−inhibition (HI) test (Clarke and Casals, 1958) with JE, dengue (DEN) and chikungunya (Chik) antigens. The IgM−capture ELISA (MAC ELISA) has been used since 1987 (Kuno *et al.*, 1987).

Virus strains

Following virus strains were used: DEN−1 (ATCC. VR. 71), Hawaiian, Mochizuki; DEN−2 (New Guinea C. VR. 222); DEN−3 (H87. VR. 216); DEN−4 (ATCC. VR. 217 H241); Chik (IPDA/CS 13); JE (Nakayama).

The biological products

The hyper−immune mouse ascitic fluids (HIMAF) of 4 DEN types were produced at Yale Arbovirus Research Unit (WHO International Reference Center) and the National Institute of Allergy and Infectious Diseases Bethesda Maryland USA. The MnAb DEN−1 Hawaii 15F3−1−15 and D2−1F1−3, DEN−2 New Guinea C 3H5−1−21, DEN−3H87 5D4−11−24 and DEN−4 H 241 1H10−6−7 were produced at CDC Atlanta Georgia USA. The peroxidase conjugated anti−flavivirus human IgG was produced at CDC Atlanta Georgia USA. The anti−flavivirus human IgG−FITC conjugate was produced at CDC Puerto Rico USA and in Pasteur Institute Ho Chi Minh City. The anti−mouse IgG−FITC conjugates were produced by Sigma Chem. Co. St. Louis, MO USA and Pasteur Paris Production. The anti−human IgM (μ−chain specific) goat IgG was produced by Cappel Laboratories Pa USA. The hyper−immune sera of JE and Chik were produced in our laboratory, using white mice weighed 18−20 gm with viral strains mentioned above.

RESULTS

The epidemiological data

Epidemiological data were summarized in Table 1, Figures 1 and 2. Cases of AES were reported annually in all 17 provinces in South Vietnam. The highest morbidity rate/100,000 population was 4.95 in 1980 and the highest mortality rate/100,000 population was 1.91 in 1977. It is noted that the AES cases were recorded all the year round with two

Table 1. Number of reported cases of Acute Encephalitis Syndrome and deaths in South Vietnam during 1976−1992.

Year	Morbidity		Mortality		CFR
	No of cases	Cases/10^5	No of cases	Cases/10^5	%
1976	721	4.17	271	1.63	37.59
1977	873	4.94	339	1.91	38.83
1978	540	2.98	135	0.74	25.00
1979	327	1.76	83	0.50	25.38
1980	936	4.95	257	1.36	27.46
1981	658	3.40	165	0.76	25.08
1982	747	3.77	188	0.94	25.17
1983	556	2.73	117	0.57	21.04
1984	886	4.20	138	0.65	15.58
1985	374	1.76	34	0.16	9.09
1986	700	3.22	145	0.66	20.71
1987	667	3.00	105	0.47	15.74
1988	594	2.61	84	0.37	14.14
1989	387	1.70	46	0.20	11.89
1990	197	0.85	71	0.30	36.04
1991	798	3.36	49	0.20	6.14
1992	823	3.39	83	0.34	10.09

low peaks in February and July (Figure 1). Briefly, in South Vietnam the AES occurred sporadically throughout the region with the highest incidence in the Mekong delta (Figure 2)−a largest area with full agricultural and pig breeding activities.

Virus isolation and identification

From 1978 to 1992, we have isolated 25 strains of JE virus from human and mosquitoes (Table 2). Genomic relationship of JE virus isolated in the North and South of Vietnam has been compared with other strains in Asia. A dendrogram was constructed by calculating the similarity score observed by sequence pair comparison of 18 JE strains (10 isolates in the North, 4 isolates in the South) was reported already (Vu *et al.,* 1993). From this result, there is some difference in genomic sequence among JE strains isolated in different areas in the North (5.26%) in comparison with the Nakayama strain. Surprisingly a homology was observed between HN−60 strain isolated at Dong Anh−Hanoi (1964) and 3 strains isolated in Ho Chi Minh City in 1978 and they had only a slight difference (less than 2.11%) in comparison with the Nakayama strain (Note: the HN−60 strain only has been used in our laboratory from 1989 for a vaccine production assay).

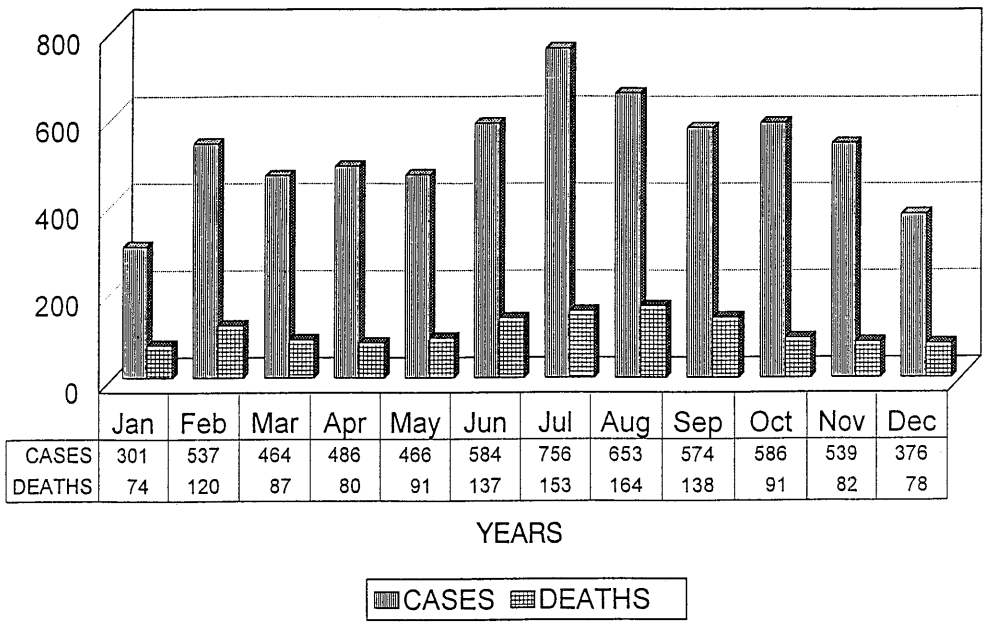

Fig. 1. Encephalitis syndrome, cases and denths in 10 years (1979−1988) in south Vietnam by months

Serological data

Results of the sero−diagnostic of the AES were summarized in Table 3. From this result, the JE positive rate was low because most of the convalescent phase serum samples could not be obtained and many sera were sent to our laboratory for differential diagnose with cerebral malaria. Nevertheless, by analyzing the patient age, we found that children under 15 years of age were more affected by JE virus than adults.

Serosurveys of JE in healthy population in some localities by years and ages were summarized in Tables 4, 5 (cross sectional study) and Table 6 (longitudinal cohort study).

The inapparent infection of JE virus was investigated by looking at seroconversion of children in the cohort study (Tables 7, 8). Latent activities of JE virus were expressed by the seroconversion by year in children. Second serum samples were taken from children who had JE negative sera in the previous year. If the second serum became positive, these children would be considered as inapparently infected.

From Tables 7 and 8, it is noted that the percentage of inapparent infection by year with JE virus was relatively high from 6.4% to the highest rate 38% in 1987.

Serosurveys were also conducted in slaughtered pigs in My Tho−Tien Giang province in 1978 and in the suburb of Ho Chi Minh City in 1992. (Table 9), and high JE antibody prevalence in pigs has been demonstrated.

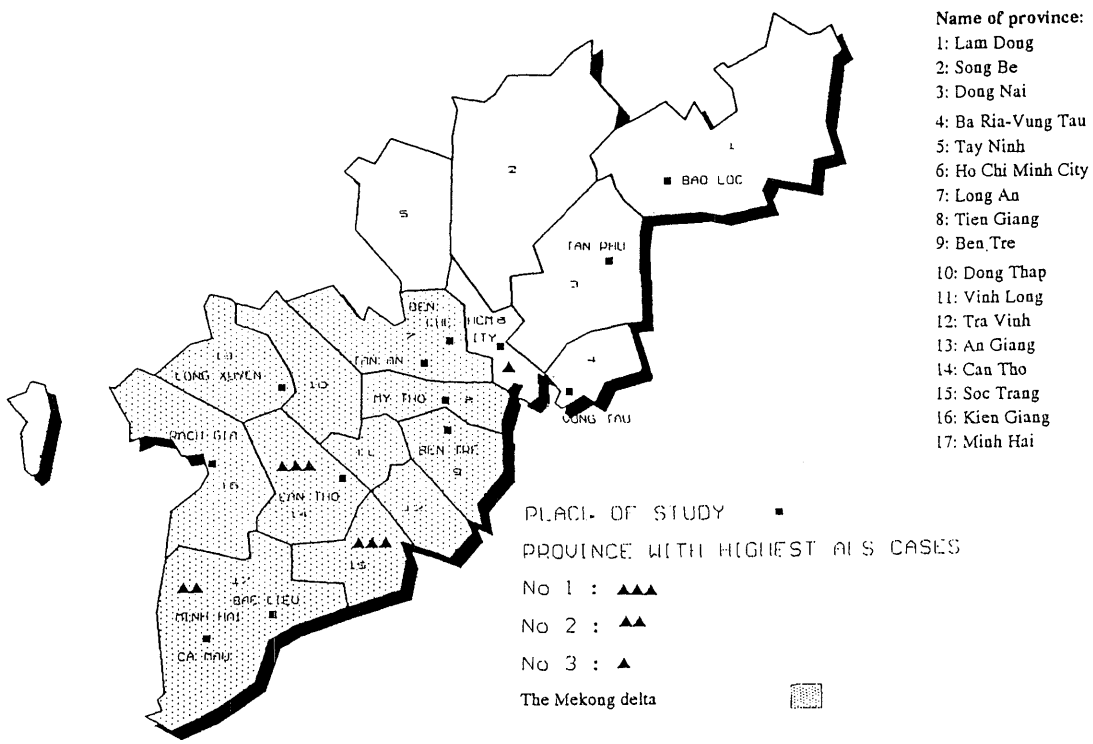

Fig. 2. Sero−epidemiological study of JE, by locality.

Table 2. JE viruses isolated in Ho Chi Minh city and in some provinces during 1978–1992.

Year		JE virus strain	Isolated from
Apr	1978	S–AA–25 (Q.17–D.3, HCM City)	28 *Ae. aegypti*
Sep	1978	S–M–14 (CMT8– D. Tan Binh, HCM City)	Patient's blood, 4 years old
Feb	1979	S–CF–79 (Q.15–D. Binh Thanh, HCM City)	35 *Cx quinquefasciatus*
Oct	1979	S–CF–114 (Q.4–D. Binh Thanh, HCM City)	21 *Cx quinquefasciatus*
Oct	1979	S–CF–115 (Q.15–D. Binh Thanh, HCM City)	25 *Cx quinquefasciatus*
Jan	1980	S–CF–129 (Q.4–D. Binh Thanh, HCM City)	29 *Cx quinquefasciatus*
Mar	1980	S–CF–133 (Q.22–D.3, HCM City)	24 *Cx quinquefasciatus*
Mar	1980	S–CF–137 (Q.22–D.3, HCM City)	07 *Cx quinquefasciatus*
Mar	1980	S–AA–136 (Q.22–D.3, HCM City)	06 *Ae. aegypti*
Jul	1982	LA–CF–227 (D. Ben Thu–Long An province)	37 *Cx quinquefasciatus*
Aug	1987	S–M–99 (Q.15–D.11, HCN City)	Patient's blood, 6 years old
Sep	1987	S–M–377 (Q.1–D.5, HCM City)	Patient's blood, 5 years old
Oct	1987	DT–M–580 (Cao Lanh, Dong Thap province)	Patient's blood, 4 years old
Oct	1987	SB–M–691 (Phu Cuong, Song Be province)	Patient's blood, 11 years old
Jan	1988	S–CF–3/88 (Q.14–D.4, HCM City)	153 *Cx quinquefasciatus*
Aug	1988	S–CF–25/88 (Q.8–D.4, HCM City)	95 *Cx quinquefasciatus*
Oct	1988	S–AA–29/88 (Q.15–D.3, HCM City)	21 *Ae. aegypti*
Aug	1989	S–M–25/89 (Pediatric Hospital No 1)	Patient's blood, 10 years old
Jul	1991	DN–M–230/91 (Center of Hyg. and Epi., Lam Dong Province)	Patient's blood, 40 years old (diagnosed as DF)
Apr	1992	CSF–56/92 (Center of Tropical Diseases)	Patient's CSF, 4 years old
Apr	1992	CSF–66/92 (Med. Anal. Lab., Past. Inst. HCM City)	Patient's CSF, 16 years old
Apr	1992	CSF–67/92 (Med. Anal. Lab., Past. Inst. HCM City)	Patient's CSF, 48 years old
Apr	1992	CSF–69/92 (Center of Tropical Diseases)	Patient's CSF, 7 years old
Jun	1992	CSF–147/92 (Center of Tropical Diseases)	Patient's CSF, 8 years old
Jul	1992	S–M–194/92 (Pediatric Hospital No 1)	Patient's blood, 2 years old

Q: Quarter, D: District.

Table 3. Results of the serodiagnosis of AES cases with JE antigen (HI) by years.

Year	Single sera		Paired sera	
	No.	No. (+) (%+)	No.	No. (+) (%+)
1978	608	137 (22.53)	188	115 (61.17)
1979	406	39 (9.60)	26	7 (26.92)
1980	486	7 (1.44)	26	12 (46.15)
1981	287	2 (0.69)	10	1 (10.00)
1982	187	1 (0.53)	7	3 (42.85)
1983	172	2 (1.16)	21	1 (4.76)
1984	130	11 (8.46)	25	8 (32.00)
1985	23	0 (0.00)	3	0 (0.00)
1986	51	3 (5.88)	5	2 (40.00)
1987	68	1 (1.47)	23	5 (21.74)
1988	184	1 (0.54)	16	0 (0.00)
1989	387 AAG	23 (5.94)	0	0 (0.00)
	86<15Y	5 (5.81)	4<15Y	2 (50.00)
1990	442 AAG	21 (4.75)	53 AAG	4 (7.54)
	107<15Y	7 (6.54)	9<15Y	3 (33.33)
1991	558 AAG	90 (16.13)	84 AAG	17 (20.24)
	182<15Y	45 (24.73)	23<15Y	8 (34.78)
1992	585 AAG	33 (5.64)	73 AAG	10 (13.69)
	247<15Y	25 (10.12)	48<15Y	10 (20.83)

From 1989: MAC ELISA were used. AAG: all age groups. Y: years old.

Table 4. Serological investigation of JE in healthy population in some provinces in South Vietnam by years.

Year	Localities	No of sera tested	HI antibody titer					%Ab (*)	GMT (†)
			20	40	80	160	320		
41	My Tho	168	41	8	1	0	1	30.3	7.3
1979	1st District, HCM city, AAG	826	136	259	91	21		61.3	28.7
	BT District, HCM city, AAG	640	182	176	85	18	2	72.3	31.9
	Vung Tau, AAG	275	101	53	17	2	2	63.6	21.3
	My Tho, AAG	423	138	20	21	3		43.0	13.5
	Bac Lieu, Ca Mau, AAG	330	14	44	36	10	1	31.8	19.8
1981	10th District, HCM city 5–14Y	445	60	10	2	1		16.4	4.3
1985	Long Xuyen, AAG	315	66	83	29	5	2	58.7	24.8
1986	Ben Luc, Tan An, 1–4Y	325	95	13	2			33.8	7.9
	My Tho, AAG	234	35	42	22	15		48.7	27.9
	Can Tho, 1–3Y	154	2	2				2.5	0.7
	Long Xuyen, 1–4Y	241	12	3	2			7.0	2.1
	Rach Gia, 1–4Y	290	19	12	1	1		11.3	3.7
1987	Tan Phu, Dong Nai, AAG	111	24	12	11	2		44.1	19.4
1988	Ca Mau, Minh Hai, 1–6Y	276	57	43	32	15		53.2	28.3
1989	Bao Loc, AAG	502	85	108	32	34		51.5	27.9
	Ben Tre, AAG	232	63	56	19	9		63.3	27.8

AAG: all age groups. Y: years old. (*): % possessing antibody. (†): geometric mean titer.

Table 5. The human immune status by ages and years in some provinces.

Year	Localities and age groups	No of sera tested	HI antibody titer					%Ab (*)	GMT (†)
			20	40	80	160	320		
1978	My Tho								
	1–4	2							
	5–9	66	10				1	16.6	3.0
	10–14	21	3	1				19.0	4.7
	15–19	10	5	2				70.0	18.0
	≥20	69	23	5	1			42.0	10.7
1981	10th District, HCM City								
	5–9	73	144	1	1			21.9	5.4
	10–14	372	46	9	1	1		15.3	4.0
1985	Long Xuyen								
	1–4	183	27	35	10	3	1	41.5	17.6
	5–9	18	2	5	2			50.0	22.2
	10–14	16	5	6	4			93.7	41.2
	15–19	19	8	5	4			89.4	35.7
	≥20	79	24	32	9	2	1	86.0	39.4
1986	My Tho								
	1–4	125	16	22	8	5		40.8	21.1
	5–9	43	7	7	5	4		53.4	33.9
	10–14	25	5	2	2	3		48.0	32.8
	15–19	9	2	1	1	1		55.5	35.5
	≥20	32	5	10	6	2		71.8	40.6
1987	Tan Phu								
	1–4	21	5	1				28.5	6.6
	5–9	59	10	9	9	1		49.1	24.4
	10–14	27	8	2	2	1		48.1	20.7
	15–19	4	1					25.0	5.0
1988	Ca Mau								
	1–4	211	45	32	22	11		52.1	27.0
	5–6	65	12	11	10	4		56.9	32.6
1989	Bao Loc								
	1–4	309	57	54	9			38.8	13.0
	5–9	19	5	2	1	1		47.3	22.1
	10–14	27	6	9	3	2		74.0	38.5
	15–19	26	4	8	4	1		65.3	33.8
	≥20	121	13	35	15	30		76.8	63.3
1989	Ben Tre								
	1–4	50	1	9	2	1		26.0	14.0
	5–9	11	2	1		2		45.4	34.5
	10–14	9	3	1	1	2		77.7	55.5
	15–19	12	2	6	2	1		91.6	50.0
	≥20	150	55	39	14	3		74.0	28.4

(*): % possessing antibody.
(†): geometric mean titer.

Table 6. Longitudinal cohort study on anti−JE HI antibody prevalence.

Localities	No of sera tested	HI antibody titer					%Ab (*)	GMT (†)
		20	40	80	160	320		
Long An (Ben Luc+Tan An)								
Mar 1986: 1−5Y	325	95	13	2			33.8	7.9
Mar 1987: 1−5Y	281	53	18	3	6		28.4	10.6
My Tho								
Apr 1986: 1−4Y	338	11		1			3.5	0.8
Apr 1987: 1−4Y	338	16	2	1			5.6	1.4
Long Xuyen								
Nov 1986: 1−4Y	241	12	3	2			7.0	2.1
Dec 1987: 1−4Y	221	42	25	8	5		36.1	14.8
Rach Gia								
Nov 1986: 1−5Y	290	19	12	1	1		11.3	3.7
Nov 1987: 1−5Y	124	25	22	7	9		50.8	27.2

(*): % possessing antibody.
(†): registered only antibody titer ≤ 160

Table 7. Seroconversions in children, whose first sera were negative in the previous year.

Localities	Mar−May 1979	Dec 1979	
	No of sera (−)	Seroconversion rate	
		No.	%
HCM City (Binh Thanh, 1st District)	96	7/96	7.2
Vung Tau	49	4/49	8.1
My Tho	65	5/65	7.6

Table 8. Inapparent infection of JE in 1987.

Localities	1986	1987					
		Antibody titer (HI test)					% seroconversion
	No of sera (−)	20	40	80	160	320	
Ben Luc−Tan An	125	17	4	1	2		19.2
My Tho	77	5					6.4
Long Xuyen	73	11	11	4	2		38.3
Rach Gia	75	11	7	2	5		33.3

Table 9. Investigation of JE antibody in pigs at My Tho (March 1978) and in Thu Duc, Hoc Mon, Tan Binh−Ho Chi Minh City (Sept. 1992).

Year	Localities	No of sera tested	Antibody HI titer					% positive	% GMT
			20	40	80	160	320		
1978	My Tho	189	11	51	66	24	3	82.0	65.29
1992	HCM suburb	261	65	62	47	22	6	77.4	49.73

Discussion

During 1978−1992, we have isolated 25 strains of JE virus from human and mosquitoes. In spite of some viruses isolated from blood or CSF of AES patients, most of them were recovered from patients' blood diagnosed as DEN fever or fever of unknown origin. This fact has introduced a new concept, because the isolation of JE virus from patients' blood has still been so far universally recognized as very rare in the medical literature. Post−mortem human brain specimen was difficult to obtain here in view of the custom and habit of local people, therefore the cause of death from most of AES cases could not be indisputably proved.

Regarding the age distribution in the above serological study and with our previous publication (Do, 1978), younger children had less contact with JE virus, then time by time they were gradually infected inapparently by this virus and the immunity developed. This is the reason why in Vietnam acute Japanese encephalitis occurred mostly in children and a nearly universal JE exposure by adults was recorded.

It has been already demonstrated that JE virus was transmitted mainly by the *Culicinae* mosquitoes and the principal vector in rural areas was *Culex tritaeniorhynchus* (Nguyen *et al.*, 1974; Do and Pham, 1974; Do *et al.*, 1977). In Table 2, the lack of JE virus strains isolated from the principal JE vector is the result of an integrated programme of Dengue Haemorrhagic Fever study; virus isolation was performed mainly from mosquitoes captured indoor and in daytime. Therefore during 1978−1988, 12 strains of JE virus were isolated from other mosquito species as 9 strains from *Culex quinquefasciatus,* 3 from *Aedes aegypti* (11 JE viruses in Ho Chi Minh City and 1 at Ben Thu−Long An province). In the absence of the amplifying host such as pig in urban areas with the permanent positive results in isolation of JE virus from *Culex quinquefasciatus*−an anthropophilic mosquito and from patients' blood diagnosed as non−AES cases; can we put forward the hypothesis that in the tropical area, out of the classic JE zoonotic cycle in rural areas, a second pattern has appeared and therein man should play the role in the evolving cycle of JE in the nature. Moreover with the result of the genomic relationship study mentioned above, a homology between JE virus isolates in Hanoi and Ho Chi Minh City was recorded. As we suppose above, maybe human plays the role of transportation (by plane) of virus between the two regions, but a convincing explana-

tion is still pending and further studies (viremia in man could be demonstrated) to explicate this phenomenon are needed. It is noted that in 1992, 1 DEN−1 (1F1) strain was isolated from a girl of 12 years of age diagnosed as "Encephalitis Syndrome". So in both ways, we isolated JE virus from patient diagnosed as DEN fever and vice versa (Do *et al.,* 1994).

JE virus is transmitted in a natural cycle between mosquitoes−vertebrates including wild birds and domestic animals. As demonstrated in our previous studies, we isolated the JE virus LD−68 strain from birds *Garrulax perspicillatus* Gmelin (Do and Doan, 1965), and JE antibodies were demonstrated in 8 out of 14 bird species (Doan and Do, 1965). Therefore it is evident that wild birds are natural reservoir of JE in this region (Do and Nguyen, 1977).

With regard to the amplifying hosts of JE virus in South Vietnam, high JE antibody prevalence in pigs has been demonstrated and the same results were also recorded in our previous studies in the North of Vietnam (Do and Nguyen, 1971). These data confirm that pigs are an important amplifying host of JE virus in Vietnam. The role of other domestic vertebrates is less certain (Do, 1978). Therefore, a pig−mosquito−man transmission sequence may be sufficient to account for human infection that occurs throughout the year.

The South of Vietnam, a tropical region with high agricultural activities−large paddy fields with many canals and irrigration, possesses favorable conditions for the JE transmission. Therefore the AES were registered all the year round with low transmission peaks in February and July. These factors are correlated with the vector mosquito abundance and the breeding of vertebrate amplifying hosts, especially pigs. These together with rainfall influence the circulation of JE throughout the region.

With all the above findings, the epidemiological data, the virus isolation from human cases and mosquitoes, the high antibody prevalence in human and swine have demonstrated that the Southern part of Vietnam is an endemo−epidemic area of JE infection.

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