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Human outbreak of St. Louis encephalitis detected in Argentina, 2005

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Abstract

Background: An outbreak of flavivirus encephalitis occurred in 2005 in Córdoba province, Argentina.
Objectives: To characterize the epidemiologic and clinical features of that outbreak and provide the serologic results that identified St. Louis encephalitis virus (SLEV) as the etiologic agent.
Study design: From January to May 2005, patients with symptoms of encephalitis, meningitis, or fever with severe headache were evaluated and an etiologic diagnosis achieved by detection of flavivirus-specific antibody sera and cerebrospinal fluid.
Results: The epidemic curve of 47 cases showed an explosive outbreak starting in January 2005 with one peak in mid-February and a second peak in mid-March; the epidemic ended in May. Cases occurred predominantly among persons 60 years and older. Nine deaths were reported. SLEV antibodies, when detected in 47 patients studied, had a pattern characteristic of a primary SLEV infection.
Conclusions: Even though isolated cases of St. Louis encephalitis have been reported in Argentina, this is the first description of a large SLEV encephalitis outbreak in Argentina.

Keywords: St. Louis encephalitis virus; Encephalitis outbreak; SLEV antibodies; Argentina

1. Introduction

St. Louis encephalitis virus (SLEV) is a mosquito-borne flavivirus and human neuropathogen occurring in the western hemisphere that is maintained in enzootic cycles primarily involving passerine birds and *Culex* mosquitoes (Tsai et al., 1989; Berge, 1975). Humans are considered dead-end hosts of the virus. Less than 1% of SLEV infections are clinically apparent (Tsai et al., 1987). Illness ranges in severity from transient fever and headache to severe meningoencephalitis and death. The severity of clinical illness increases with

Abbreviations: SLEV, St. Louis encephalitis virus; CNS, central nervous system; CSF, cerebrospinal fluid; IgM, immunoglobulin M; MAC-ELISA, IgM-capture enzyme-linked immunosorbent assay; IFA, immunofluorescent assay; IH, hemagglutination inhibition; PRNT, plaque reduction neutralization test; UTMB, University of Texas Medical Branch; YF, yellow fever; DEN-1, DEN-2, DEN-3, dengue 1, 2, 3; ILH, Ilheus; ROC, Rocio; WN, West Nile.

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age, and persons >60 years old have the highest frequency of encephalitis (Calisher, 1994). Although SLEV encephalitis cases in the United States are usually sporadic, focal outbreaks and widespread epidemics occasionally occur (Tsai et al., 1987). Viral isolation from serum or cerebrospinal fluid (CSF) is unusual, since viremia is transient and most patients develop antibodies by the time they manifest neurological disease. Thus, diagnosis usually relies on serological tests done on appropriately timed acute and convalescent samples (Calisher and Poland, 1980). Available serologic screening tests for SLEV infection include IgM-capture enzyme-linked immunosorbent assay (MAC-ELISA), IgM immunofluorescent assay (IFA), and hemagglutination inhibition (HI) tests. However, in the event of a positive result, confirmatory testing for virus-specific diagnosis is required because cross-reactions between related flaviviruses are common. Thus serologic tests for SLEV and other flaviviruses must be evaluated by parallel testing for antibodies against other related flaviviruses. In general, the most specific results are obtained by plaque reduction neutralization tests (PRNT).

Serological evidence (in some cases a prevalence of up to 50%) of SLEV transmission in Argentina has usually been found wherever it has been sought. SLEV is endemic in subtropical provinces, as well as in some temperate regions in Argentina. In the province of Buenos Aires in 1963, 2 clinical cases characterized by fever without signs of central nervous system (CNS) infection were reported and diagnosed by virus isolation and serology. Between 1966 and 1984 two SLEVs were isolated from animals in the province of Córdoba: the strain CbaAn9124 from the urine of a *Calomys* sp. and the strain CbaAn9275 from a brain-spleen pool of a juvenile *Mus musculus*. Six additional strains of SLEV were subsequently recovered from *Culex* sp. mosquitoes in the province of Santa Fe, including strain 78V6507 (Sabattini et al., 1998). Spinsanti et al. (2002) reported a seroprevalence of SLEV antibodies of 13.9% among persons between 0 and 87 years of age living in Córdoba city. The first clinical case of SLEV infection was recorded in Córdoba in the summer of 2002 (Spinsanti et al., 2003) without additional human cases. However, in January 2005, infectious disease specialists in Córdoba city noted a large number of elderly patients admitted for encephalitis. A SLEV encephalitis outbreak was suspected when several sera tested positive for immunoglobulin M (IgM) antibody to SLEV. Two SLEV isolations were subsequently made from mosquitoes collected in Córdoba in February 2005 (Díaz et al., 2006). This report describes the clinical and epidemiologic aspects of the 2005 SLEV encephalitis outbreak in Argentina.

2. Methods

2.1. Human samples and study site

From January to May 2005, 72 patients with CNS disease compatible with SLEV encephalitis were reported in Córdoba Province. Most patients had fever associated with meningeal signs, altered mental status, or both.

Cases of neurologic disease occurred predominantly in Córdoba city, a metropolitan area of 1.3 million inhabitants. Eight cases were from adjacent localities (Colón, Río Segundo and San Javier) located between 30 and 180 km away from Córdoba city. The climate is temperate without a warm winter and with a water deficit in spite of a relatively high precipitation level (750 and 800 mm), due to high evapotranspiration (Jarsún et al., 2003).

2.2. Serologic techniques

We used autochthonous strains SLEV CbaAn9275, 78V6507 (Sabattini, 1969; Mitchell et al., 1985) and prototype Parton strain (Muckenfuss et al., 1933). MAC-ELISA tests using the CbaAn9275 strain of SLEV were performed by adaptation of the protocol described by Kuno et al. (1987). IgM-IFA for SLEV strain 78V6507 was done as described previously (Spinsanti et al., 2001). An anti-human IgG was used to remove rheumatoid factor and IgG from patient samples. Four paired sera and six unpaired serum samples were tested at the University of Texas Medical Branch (UTMB) in Galveston. These samples were tested against 9 different flavivirus antigens, yellow fever (YF), Dengue 1, 2 and 3 (DEN-1, DEN-2, and DEN-3), Ilheus (ILH), Rocio (ROC), West Nile (WN), and SLEV (Parton prototype and CbaAn9275 strains) by HI test, using the Clarke and Casals's method (1958). The sera were also examined for neutralizing antibodies to SLEV strain 78V6507 by a 90% PRNT done in Vero cells (Early et al., 1967). SLEV 78V6507 strain captures homologous antibodies and also those generated by the attenuated CbaAn9275 strain (non-published data). Some of these sera were also examined by PRNT against the ChimeriVax WN strain (Arroyo et al., 2001).

We defined a confirmed case by the presence of specific IgM antibody in the cerebrospinal fluid (CSF) or serum

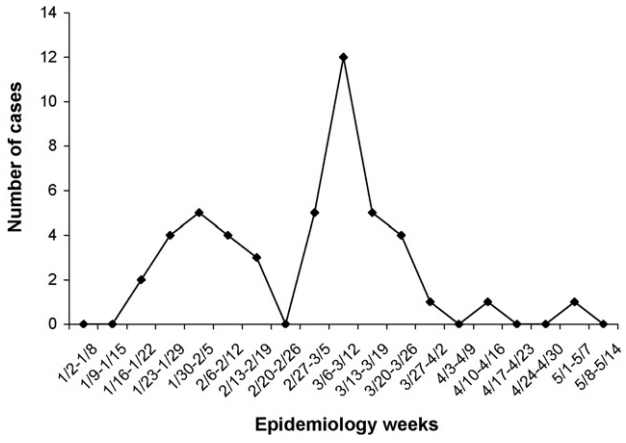

Fig. 1. Reported human SLEV encephalitis cases in Córdoba, January to May 2005, by epidemiologic week.

Table 1
Summary of serologic test results on St. Louis encephalitis cases, Córdoba, 2005

Case	Age (year)/sex	Days[a]	MAC-ELISA[b] (SLEV CbaAn9275)		IFA[c] (SLEV 78V6507)		PRNT[d]		Conclusion
			CSF	Serum	CSF	Serum	SLEV	WN	
01-LM	76/F	16 32	+	+	–	+	160 160		Probable
02-FCH	72/M	13 35	ND	+	ND	+	80 80		Probable
03-NT	50/F	16 36	+	+	–	+	1280 160	<20 <20	Confirmed
04-AB	55/M	13 29	ND	+	ND	+	1280 640	<10 10	Probable
05-MP	73/M	9 20	+	+	–	+	160 80	40 <20	Probable
06-RB	19/M	34 55	ND	+	ND	+	640 160	<20 <20	Confirmed
07-CP	58/M	9 18	+	+	–	+	320 2560	<10 <10	Confirmed
08-FT	75/M expired	21 ND	ND	+	ND	+	10		Probable
09-JP	56/M	11 45	+	+	–	+	320 40	40 <20	Confirmed
10-DR	21/M	26 34	ND	+	ND	+	640 320	<20 <20	Probable
11-RS	68/M expired	8 16	ND	+	ND	+	40 160		Confirmed
12-AA	71 expired	3 17	+	+	–	+	10 320		Confirmed
13-JA	44/M	15 23	ND	+	ND	+	40 160	<20 <20	Confirmed
14-AM	71/F expired	11 53	+	+	–	+	1280 1280	10 10	Probable
15-CP	10/M	9 ND	ND	+	ND	+	160		Probable
16-AA	24/M	10 39	ND	+	ND	+	640 320		Probable
17-DB	63/M	6 27	ND	+	ND	+	640 2560		Confirmed
18-JZ	22/M	5 18	ND	+	ND	+	80 2560	<20 <20	Confirmed
19-JS	74/M	36 57	+	+	–	+	80 80		Probable
20-RA	70/M	5 33	+	+	–	+	80 1280	<20 <20	Confirmed
21-JA	16/M	7 31	ND	+	ND	+	640 640		Probable
22-CS	80/M expired	13 ND	ND	+	ND	+	40		Probable
23-LG	72/F	14 34	+	+	–	+	640 640	<40 <40	Probable
24-AV	15/F	5 37	+	+	–	+	640 1280		Probable
25-GV	58/M	5 22	+	+	–	+	80 1280	<20 <20	Confirmed

Table 1 (*Continued*)

Case	Age (year)/sex	Days[a]	MAC-ELISA[b] (SLEV CbaAn9275)		IFA[c] (SLEV 78V6507)		PRNT[d]		Conclusion
			CSF	Serum	CSF	Serum	SLEV	WN	
26-JG	48/F	20	ND	+	ND	+	160	<20	Probable
		52					80	<20	
27-JA	60/M	7	+	+	–	+	1280	20	Confirmed
		232					320	<20	
28-MQ	61/M	7	+	+	–	+	640	10	Probable
		22					1280	20	
29-AC	71/M	6	+	+	–	+	80	<20	Confirmed
		20					320	<20	
30-EP	7/F	7	ND	+	ND	+	160		Probable
		30					320		
31-RM	87/M	4	+	+	–	+	640	10	Probable
		17					1280	80	
32-EP	69/F	5	+	+	–	+	640	<20	Probable
		37					640	<20	
33-SU	48/M	10	ND	+	ND	+	640	40	Probable
		40					640	20	
34-MO	25/F	s/d	ND	+	ND	ND	ND	10	Probable
	expired								
35-NR	62/F	7	+	+	–	–	160		Confirmed
		259					640		
36-AT	76/M	8	ND	+	ND	+	20		Probable
	expired	39					40		
37-VG	33/F	7	ND	+	ND	–	320		Probable
		237					640		
38-NV	25/F	3	ND	+	ND	–	80	10	Probable
		ND							
39-CA	s/d	s/d	ND	+	ND	–	20		Probable
40-AR	14/M	4	ND	+	ND	–	80	20	Probable
41-PL	18/M	6	ND	+	ND	–	320		Probable
42-ES	45/F	20	ND	+	ND	–	10	<10	Confirmed
		251					80		
43-MC	7/F	ND	+	+	–		80	<10	Probable
		103				+			
44-LA	9/M	s/d	+	ND	ND	ND	ND		Probable
45-LC	58/M	s/d	+	+	ND	ND	ND	<10	Probable
	expired	4							
46-PA	11/M	14	ND	+	ND	+	640	<10	Confirmed
		38					160	<10	
47-EG	52/F	11	ND	+	ND	+	80	10	Probable
		15					80		

[a] Days after onset.

[b] Ig M-capture enzyme-linked immunosorbent assay; SLEV, St. Louis encephalitis virus; CSF, cerebrospinal fluid; ND, not available. Results are expressed as positive-negative.

[c] Ig M-Immunofluorescence assay. Results are expressed as positive-negative.

[d] Plaque reduction neutralization test. Results are expressed as reciprocal antibody titers; WN, West Nile; <10, negative.

plus ≥four-fold increase or decrease in serum neutralizing antibody titers between paired serum samples (obtained at least 1 week apart) for SLEV. A probable case was defined by demonstration of SLEV-IgM antibody in serum or CSF.

2.3. Statistical analysis

We studied the association between age and severity of the disease with Spearman's test. We prepared a structured scale (1, 2, 3 and 4) of disease severity based on state of

Table 2
Hemagglutination inhibiting antibody titers with nine flavivirus antigens on selected St. Louis encephalitis virus (SLEV) seropositive sera, Córdoba, 2005

Case	Days	Antigens (4 units)								
		DEN-1	DEN-2	DEN-3	YF	ILH	ROC	SLEV Parton	SLEV CbaAn9275	WN
04-AB	13	20	20	20	40	40	0	1280	1280	40
	29	0	0	0	20	20	0	160	320	0
014-AM	11	0	10	0	10	10	0	160	320	0
	53	0	10	0	10	20	0	80	160	0
023-LG	14	0	0	0	0	40	0	320	640	20
028-MQ	7	10	20	10	20	20	0	160	320	20
	22	10	20	10	20	40	20	320	640	40
031-RM	4	0	10	0	20	20	0	160	320	20
	17	20	40	20	80	80	40	640	1280	80
038-NV	3	0	10	10	10	10	0	80	80	20
040-AR	4	10	20	10	20	20	0	80	160	40
042-ES	20	0	0	0	0	0	0	40	80	0
043-MC	103	10	40	20	40	40	20	160	320	40
047-EG	11	20	20	20	80	80	40	160	160	80

Days, days after onset; DEN-1, dengue type 1; DEN-2, dengue type 2; DEN-3, dengue type 3; YF, yellow fever; ILH, Ilheus; ROC, Rocio; SLEV, St. Louis Encephalitis virus; WN, West Nile; Results are expressed as reciprocal antibody titers; 0, <1:20.

consciousness: confusion (1), lethargy (2), delirium (3) and coma (4).

3. Results

Anti-SLEV IgM antibodies were detected by IFA in 37 sera and by MAC-ELISA in 46 sera and 21 CSF samples. IgM was not detected by IFA in CSF. Forty-four patients had SLEV-neutralizing antibodies by PRNT with strain 78V6507; and 16 of these individuals demonstrated seroconversion. In addition, sera from 28 patients were examined by PRNT against the ChimeriVax WN strain; eight positive sera had titers $\geq$1:20, but in all cases the corresponding serum titers to SLEV were four-fold or greater (Table 1). Eighteen single serum samples were also tested against ILH and DEN-2 virus by PRNT with negative results (data not shown).

By HI test, 13 (93%) cross-reactive samples had higher titers for SLEV CbaAn9275 antigen. One (7%) specific reaction was detected for SLEV. There were two serological conversions to SLEV (04-AB and 031-RM cases) consistent with a primary flavivirus antibody response to SLEV infection (Table 2).

The epidemic curve of 47 cases showed an explosive outbreak starting in January 2005 with one peak in mid-February and a second peak in mid-March; the epidemic ended in May (Fig. 1).

Symptoms and signs that suggested CNS involvement were headache and sensory depression, temporal–spatial disorientation, tremors, and change in consciousness level. There was a significant association between age and disease severity (Spearman coefficient equal 0.74). The CSF findings ($N = 21$) were typical of viral infection.

Of the 47 probable or confirmed cases of SLEV infection, 45 were hospitalized and 2 were diagnosed in ambulatory settings. Mean age was 47.8 ± 24.6 years old (range 7–87). Most cases were between 10 and 60 years old (52%), which comprises 70% of the total population; 19 patients (40%) were >60 years. Thirty patients (64%) were males. The frequency of encephalitis (including meningoencephalitis) varied from 80% of cases in persons under 20 years to 95% in those over 60 years. Fig. 2 shows the age distribution for the most common clinical syndromes observed with SLEV infection.

Nine patients died (one was 25 years old; eight were older than 50 years). Death was not a direct result of the CSN viral infection, but was a consequence of complications of underlying diseases, prolonged hospitalization, or nosocomial infection.

All patients in this study were interviewed. Forty percent of the patients were either retired or housewives.

4. Discussion

Although SLEV is endemic in Córdoba, the impact of the 2005 SLEV encephalitis outbreak was unprecedented.

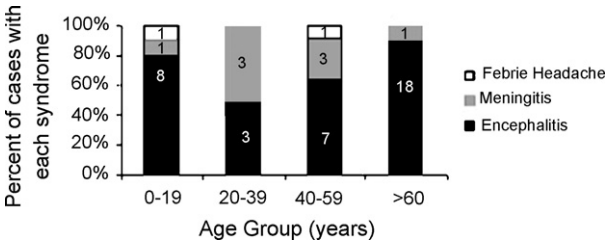

Fig. 2. Frequency of the three clinical syndromes (encephalitis, meningitis, and febrile headache) among probable and confirmed cases of SLEV encephalitis by age group in Córdoba, 2005.

It involved mainly persons over 60 years old from Córdoba city and adjacent localities. Forty-five patients were hospitalized within a 5-month period. In our study a correlation between age and disease severity was observed. Advanced age is associated with a greater severity of disease by several flavivirus (West Nile encephalitis, Japanese encephalitis) (Johnson, 2002; Brinker and Monath, 1980). The reason for the more severe illness in older persons is not known, but impaired integrity of the blood–brain barrier due to cerebrovascular disease has been postulated (Mashimo et al., 2002).

This raises the question of whether advanced age is a risk factor itself or whether coexisting conditions associated with advanced age account for higher risk. Even though death was not included in the correlation of severity of the illness and age, a previous study (Meehan et al., 2000) suggested that advanced age is the most important host factor related to mortality. Thirty-three percent of the patients had one or more coexisting illnesses or medical conditions; the most frequently found were arterial hypertension, diabetes mellitus, alcoholism, and cerebral vascular disease.

The serologic tests for SLEV IgM antibodies were positive in 47 of the 72 patients studied. The IFA-IgM test, which is routinely used in our laboratory for serological screening, could not detect antibodies in CSF. This lack of sensitivity when compared with MAC-ELISA could be due to an IgG competition for IgM binding (Monath et al., 1984). MAC-ELISA detected IgM antibodies in serum and CSF in all the patients. Correlation of the MAC-ELISA results with the PRNT was 100%. This is consistent with prior studies that indicate that MAC-ELISA is the serodiagnostic test of choice for determining recent human infections with arboviruses, and that the PRNT is the "gold standard" for definitive viral diagnosis.

Based on the pre-specified criteria, 16 cases were confirmed and 31 were diagnosed as probable. Failure to confirm cases by the PRNT test frequently stems from obtaining the first serum too late, usually more than 6 days after the onset of symptoms (i.e., more than 10 to 27 days after exposure to the virus) (Calisher and Poland, 1980). Thirty samples were taken too late after the onset of illness due to lack of awareness of this disease by the health personnel.

In Córdoba, the incidence for encephalitis of undetermined etiology increases during the summer months, in conjunction with arboviral and enteroviral activity does. SLEV is probably responsible for some of these undiagnosed clinical cases, mainly those in the elderly.

The vector density has been long emphasized as a critical factor in the transmission of SLEV and other arboviruses. Studies in Kern County, California and elsewhere in North America have revealed positive correlations between viral activity and the availability of water for mosquito breeding and vector population size, especially during epidemic years (Monath, 1980). Thus, in February 2002, the first reported SLEV encephalitis case in Córdoba (Spinsanti et al., 2003) occurred when a peak in *Culex quinquefasciatus* abundance was also recorded. These mosquitoes are recognized as the probable vector of the SLEV in Argentina (Díaz et al., 2003). Two SLEV strains were isolated from *Cx. quinquefasciatus* mosquitoes collected in Córdoba during the current (2005) outbreak (Díaz et al., 2006).

The high percentage of cases in housewives and retired people may reflect a higher exposure to infected mosquitoes in the peridomestic environment. This hypothesis is consistent with observations made during 1964 in Danville, Kentucky, where unemployed and non-labor-force groups were found to be at higher risk than employed persons (Mack et al., 1967).

The full magnitude of this outbreak could not be evaluated, because only hospitalized patients were included, and most SLEV infections are sub-clinical (Tsai et al., 1987). Other limitations were that the clinical and demographic data were abstracted from medical records that varied greatly in their completeness and legibility. General ignorance about this disease among health workers resulted in lost cases, inadequate sampling, and patients discharged without appropriate interview. Even though isolated cases have been reported in Argentina (Spinsanti et al., 2003) and Brazil (Rocco et al., 2005), outbreaks of such magnitude attributed to SLEV in Central and South America have not been reported. This is in marked contrast to North America, where outbreaks have occurred repeatedly, in places not so distant from tropical America (Texas and Florida) (Spence, 1980).

The occurrence of this outbreak of SLEV encephalitis has alerted the authorities to intensify the surveillance of neurological syndromes of non-confirmed viral etiology.

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References

Arroyo J, Miller CA, Catalan J, Monath TP. Yellow fever vector live-virus vaccines: West Nile virus vaccine development. Trends Mol Med 2001;7:350–4.

Berge TO, editor. International catalogue of arboviruses including certain other viruses of vertebrates. U.S. Department of Health, Education, and Welfare Publication No. (CDC) 75-8301; 1975. p. 668–9.

Brinker KR, Monath TP. The acute disease. In: Monath TP, editor. St. Louis Encephalitis. Washington, DC: American Public Health Association; 1980. p. 503–34.

Calisher CH, Poland JD. Laboratory diagnosis. In: Monath TP, editor. St. Louis Encephalitis. Washington, DC: American Public Health Association; 1980. p. 571–601.

Calisher CH. Medically important arboviruses of the United States and Canada. Clin Microbiol Rev 1994;7:89–116.

Clarke DH, Casals J. Techniques for hemagglutination and hemagglutination-inhibition with arthropod-borne viruses. Am J Trop Med Hyg 1958;7(5):561–73.

Díaz LA, Almiron WR, Ludueña Almeida F, Spinsanti LI, Contigiani MS. Vigilancia del virus Encefalitis de San Luis y mosquitos (Diptera: Culicidae) en la Provincia de Córdoba, Argentina. Entomol Vect 2003;10(4):551–66.

Díaz LA, Ré V, Almiron WR, Farías AA, Vázquez A, Sanchez-Seco MP, et al. Genotype III Saint Louis Encephalitis virus outbreak, Argentina, 2005. Emerg Infect Dis 2006;12(11):1752–4.

Early E, Peralta PH, Johnson KM. A plaque neutralization method for arboviruses. Proc Soc Exp Biol Med 1967;25:741–7.

Jarsún B, Gorjas JA, Zamora E, Bosnero E, Lovera E, Ravelo A, et al. Caracterización general de la provincia. In: Gorjas JA, Tassile JL, editors. Recursos naturales de la Provincia de Córdoba. Los Suelos. BR Copias. Córdoba; 2003. p. 23–60.

Johnson RT. West Nile virus in the US and abroad. Curr Clin Top Infect Dis 2002;22:52–60.

Kuno G, Gómez I, Gubler DJ. Detecting artificial anti-dengue IgM immunocomplexes using an enzime-linked immunosorbent assay. Am J Trop Med Hyg 1987;36:153–9.

Mack TM, Brown BF, Sudia WD, Todd JC, Maxfield H, Coleman PH. Investigation of an epidemic of St. Louis encephalitis in Danville, Kentucky, 1964. J Med Entomol 1967;4:70–6.

Mashimo T, Lucas M, Simon-Chazottes D, Frenkiel MP, Montagutelli X, Ceccaldi PE, et al. A nonsense mutation in the gene encoding 2′-5′-oligoadenylate synthetase/L1 isoform is associated with West Nile virus susceptibility in laboratory mice. Proc Natl Acad Sci USA 2002;99(17):11311–6.

Meehan PJ, Wells WP, Buff E, Lewis A, Muth D, Hopkins R, et al. Epidemiological features of and public health response to a St. louis encephalitis epidemic in Florida, 1990-1. Epidemiol Infect 2000;125:181–8.

Mitchell CJ, Monath TP, Sabattini MS, Cropp CB, Daffner JF, Calisher CH, et al. Arbovirus investigations in Argentina, 1977–1980. II Arthropod collections and virus isolations from argentine mosquitoes. Am J Trop Med Hyg 1985;34(5):945–55.

Monath TP. Epidemiology. In: Monath TP, editor. St. Louis Encephalitis. Washington, DC: American Public Health Association; 1980. p. 239–311.

Monath TP, Nystrom RR, Bailey RE, Calisher CH, Muth DJ. Immunoglobulin M antibody capture enzyme-linked immunosorbent assay for diagnosis of St. Louis encephalitis. J Clin Microbiol 1984;20(4):784–90.

Muckenfuss RS, Armstrong C, McCordock HA. Encephalitis: Studies on experimental transmission. Publ Hlth Reports 1933;48:1341–3.

Rocco IM, Santos CLS, Bisordi I, Petrella SMCN, Pereira LE, Souza RP, et al. St. Louis Encephalitis virus: First isolation from a human in Sao Paulo State, Brazil. Rev Inst Med Trop S Paulo 2005;47(5):281–5.

Sabattini MS. Arbovirus del grupo B en la República Argentina. Su estudio en aves y roedores. Ph.D. thesis. Argentina: Facultad de Ciencias Químicas, Universidad Nacional de Rosario; 1969. p. 96.

Sabattini MS, Avilés G, Monath TP. Historical, epidemiological and ecological aspects of arboviruses in Argentina: Flaviviridae, Bunyaviridae and Rhabdoviridae. In: Travassos da Rosa APA, Vasconcelos PFC, Travassos da Rosa JFS, editors. An Overview of Arbovirology in Brazil and Neighboring Countries. Belem, Brazil: Instituto Evandro Chagas; 1998. p. 113–34.

Spence LP. St. Louis Encephalitis in Tropical America. In: Monath TP, editor. St. Louis Encephalitis. Washington, DC: American Public Health Association; 1980. p. 451–71.

Spinsanti L, Re V, Aguilar J, Contigiani M. An indirect immnunofluorescence assay to detect antibodies against St. Louis Encephalitis virus. Rev Inst Med Trop Sao Paulo 2001;43:339–40.

Spinsanti L, Ré V, Diaz MP, Contigiani MS. Age-related seroprevalence study for St. Louis encephalitis in a population from Cordoba, Argentina. Rev Inst Med Trop Sao Paulo 2002;44:59–62.

Spinsanti L, Basquiera A, Bulacio S, Somale V, Kim SCH, Re V, et al. St. Louis Encephalitis in Argentina: the First Case Reported in the Last Seventeen Years. Emerg Infect Dis 2003;9:271–3.

Tsai TF, Cobb WB, Bolin RA, Gilman NJ, Smith GC, et al. Epidemiologic aspects of a St. Louis encephalitis outbreak in Mesa County, Colorado. Am J Epidemiol 1987;126:460–73.

Tsai TF, Smith GC, Happ CM, Kirk LJ, Jakob WL, Bolin RA, et al. Surveillance of St. Louis encephalitis virus vectors in Grand Junction, Colorado, in 1987. J Am Control Mosq Assoc 1989;5(2):161–5.