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Acupuncture in the Treatment of Paralysis in Chronic and Acute Stroke Patients - Improvement Correlated with Specific CT Scan Lesion Sites

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Abstract:

A total of 20 stroke patients received acupuncture, including 10 chronic and 10 acute patients; 19 of the 20 patients (95%) could be correctly classified regarding beneficial response to acupuncture, versus poor response, based on CT scan lesion site data, alone. Patients with beneficial response had damage to *less than half* of the motor pathway areas on CT scan, especially in the periventricular white matter area (PVWM) at the level of the body of the lateral ventricle. Overall, 8 of the 20 patients receiving acupuncture had beneficial response with measurable objective improvement in motor function, including 3 of the 10 chronic patients treated at > 3 months poststroke, and 5 of the 10 acute patients treated at < 3 months poststroke. Among the 8 patients with beneficial response, significant improvements were observed in knee flexion, knee extension, and shoulder abduction. Neither age, nor months poststroke when acupuncture was begun, was significantly correlated with the total number of improved tests, post-acupuncture. Two chronic patients with beneficial response first began receiving acupuncture at 3 years and 6 years poststroke. Most improvements were sustained for at least 4 months after the last acupuncture treatment.

KEY WORDS: Acupuncture; Stroke; Paralysis; Cerebrovascular disorders; Tomography, X-ray computed

INTRODUCTION

In 1975, Omura reported that acupuncture improved brain circulation and peripheral circulation of a paralyzed part of the body in stroke patients (1). In that study an acupuncture point was stimulated on the left (paralyzed) leg (St 36) in stroke patients, and an increase in cerebral blood flow was observed over the supraorbital artery region of the right forehead area (reflecting right cerebral hemisphere blood flow), ipsilateral to the hemisphere where the stroke had occurred (1). An increase in blood circulation to the paralyzed left hand (and non-paralyzed right hand) of the patients was also observed.

Two other studies have also suggested that acupuncture promotes vasodilation and increases cerebral blood flow (2, 3). A 1977 study by Chen & Erdmann stimulated an acupuncture point on the midline face, above the upper lip (GV 26) in rats, and observed an increase in tissue oxygenation to the frontal cortex areas (bilaterally) (2). A 1979 Chinese study inserted acupuncture needles along "the motor cortex line" of the scalp over the cerebral hemisphere ipsilateral to where the stroke had occurred. This study observed an increase in cerebral blood flow in stroke patients, but not normal controls (3).

Thus, results from these three studies suggest that insertion of acupuncture needles into different acupuncture points on the leg, face, or scalp, may each increase cerebral blood flow and circulation. It is possible that this increase in cerebral blood flow and circulation is one mechanism that is involved with mediating the slow improvement in paralysis following acupuncture treatments in stroke patients.

A few reports suggesting that acupuncture is useful in the treatment of paralysis following stroke were published in English in the 1970's (4, 5). The World Health Organization has listed acupuncture as a possible treatment for paresis in stroke patients since 1979 (6). In more recent studies where controls were used (sham acupuncture or no acupuncture), significantly more patients who received acupuncture treatment for paralysis due to stroke had an outcome level of "Good Response/Markedly Effective," than controls (7-11).

The time poststroke when acupuncture treatments are initiated appears to be important in relationship to functional outcome. For example, significantly more stroke patients who received acupuncture treatment beginning within the first 3 months poststroke had a better outcome level than those who received acupuncture treatments beginning after the first 3 months poststroke (3, 4).

Johansson et al. observed in a study reported in 1993 from Sweden, that when acupuncture treatments were initiated within 4 - 10 days poststroke, there was a significantly better outcome in walking, balance, activities of daily living, and quality of life, mobility and emotion at 1 month, 3 months and 12 months in those patients treated with acupuncture, than those patients who were not treated with acupuncture (10). This study reported a savings of $26,000 per acute stroke patient treated with acupuncture, due to fewer days in nursing homes and rehabilitation facilities. Indeed, some studies have suggested that acupuncture treatments should be initiated within 36 hours poststroke in ischemic infarct cases (4); and within 24 hours poststroke in acute cerebral hemorrhage cases (12). Hu et al. (1993) observed that it is especially important to treat stroke patients with *severe* paralysis during the *acute* stage poststroke (9).

Our research group has published a small, controlled study that demonstrated improvement in poststroke arm/leg paresis after real acupuncture, but not after sham acupuncture (8). The positive effect of real acupuncture was only observed in patients in whom there was damage to *less than half* of the motor pathway areas on CT scan. The critical lesion site on CT scan was in the periventricular white matter area (PVWM area) at the level of the body of the lateral ventricle, containing, in part, descending pyramidal tract pathways and other important intra- and inter-hemispheric pathways.

All patients in our previous study were in the more *acute* phase poststroke, i.e., 1 to 3 months poststroke, when acupuncture treatment commenced (8). The primary purpose of the present

study was to examine the response to acupuncture in stroke patients with arm/leg paresis who were in *later* phases poststroke; however, acute patients were also included in this study. A secondary goal was to analyze again the relationship of lesion site on CT scan to acupuncture response.

MATERIALS AND METHOD

Subjects:

Twenty patients agreed to participate (Table 1). All patients had suffered a left hemisphere infarction and had significant right hemiparesis. Nineteen cases were righthanded. One patient was lefthanded, (case PP), who had a severe aphasia and left ideomotor apraxia after a left hemisphere stroke. Ten patients were treated with acupuncture during the *chronic* phase poststroke, beginning from 4 months poststroke onset (MPO), to 10 years poststroke onset. Ten patients were treated with acupuncture during the *acute* phase poststroke, which ranged from 1 to 3 MPO. All chronic and acute patients had greatly reduced leg and arm power with little or no isolated finger movement. None of the chronic patients was receiving physical therapy during the study. All of the acute patients were receiving physical therapy during the study.

Controls:

The 10 chronic patients served as their own controls, because they were treated beyond the period of greatest spontaneous recovery, i.e., the first 3 months poststroke (13). In addition, we studied three chronic stroke patients who received *no acupuncture treatments* (Table 1). These patients also had suffered a left hemisphere infarction and had significant right hemiparesis. They were examined three times over approximately a one-year period to investigate the stability of paralysis in chronic stroke patients. None of these chronic control patients was receiving physical therapy during the study. The results for the controls for the 10 acute patients (i.e., those acute patients who received sham acupuncture, n=6) were presented in our earlier acupuncture study (8).

Motor Evaluation:

A motor examination, the Boston Motor Inventory test (14), was designed for this research project. This test measured the isolated active range of motion (ROM) on the involved side for 4 leg movements and 3 arm movements, all proximal. The evaluation was performed by one of three physical therapists who were blind to the treatment condition (treatment versus no treatment). The 20 patients receiving acupuncture were tested a few days prior to the first treatment, and within a few days after completing the 20th and 40th treatments. Follow-up testing was also performed at 2 and 4 months following the last acupuncture treatment if the patient was available. The three chronic control patients not receiving acupuncture were tested three times, over approximately a one-year period.

Treatment:

Informed consent was obtained prior to acupuncture treatment. *Chronic* patients received 2 or 3 treatments per week as outpatients, for 2 or 3 months. *Acute* patients received 5 daily treatments per week as inpatients, for 1 or 2 months.

Sterilized disposable, one-time use only, 34 gauge acupuncture needles (approximately 0.1 mm diameter) were inserted into a limited number of standard acupuncture points on the arms and legs (15). See Table 2 and Figures 1A and 1B. The "scalp needle acupuncture technique" was also performed. Sterilized needles were placed with shallow insertion along "the motor cortex line" of the scalp over the cerebral hemisphere where the stroke had taken place. For example, the needles were inserted over the left hemisphere scalp area when the patient had a right-sided arm/leg paralysis. See Figure 2.

Table 1. **Age; months post onset (MPO); number of improved lower extremity (LE), upper extremity (UE) tests; and CT scan extent of lesion data for all cases receiving acupuncture or no acupuncture.**

	Age Enter Study	MPO Enter Study	Total No. Acptr. Tx.'s	Total No. Improved LE/UE Tests	Total Lesion Extent in PVWM (Slices SM+1 and SM) (20 = Complete Lesion; 10 = Half)
ACUPUNCTURE - Beneficial Response Cases					
CP	54	4	40	4	(Cerebral Peduncle)
MJ	55	34	40	4	7.75
#PP	69	74	40	5	10.25
*HN	74	1	20	3	7.5
*CL	44	1	20	2	17.5
*SA	61	1	40	3	8
*SH	65	2	40	5	9
*CR	67	3	20	3	10
ACUPUNCTURE - Poor Response Cases					
NA	61	4	40	0	14.95
HL	54	9	40	0	13
RP	55	21	40	0	19.5
BR	58	34	20	1	(Leg and Arm Motor Cortex Area Lesions)
DE	61	34	40	1	20
GP	63	110	20	1	17.1
ME	70	128	40	0	(Leg and Arm Motor Cortex Area Lesions)
*GD	68.5	2	20	1	(Leg and Arm Motor Cortex Area Lesions)
*SS	56	3	20	1	(Leg and Arm Motor Cortex Area Lesions)
*ES	65	3	40	0	14
*GJ	58	3	20	0	17.6
*RJ	54	3	40	0	19.3
		MPO Test Times			
NO ACUPUNCTURE - All Poor Response Cases					
#PP	67	44/49/60	0	0	1
BH	42	133/137/142	0	0	7
EL	54	25/29/36	0	1	(Leg and Arm Motor Cortex Area Lesions)

#This patient was originally a chronic control case who received no acupuncture treatments up to 5 years post the first stroke. At 6 years post the first stroke, after a "second stroke", acupuncture treatments were begun.

*Patients considered to be acute cases; they entered the study at 1-3 months poststroke onset (MPO).

Table 2. Acupuncture points used for acupuncture treatments

Location of Acupuncture Points	List of Acupuncture Points
Right Arm (Paralyzed Side):[1]	LI (Large Intestine Meridian): #4, #11, #15 TW (Triple Warmer Meridian): #5, #9 Three Distal Baxie Points in web space between fingers
Right Leg (Paralyzed Side):[1]	St (Stomach Meridian): #31, #36 GB (Gall Bladder Meridian): #34, #39 Li (Liver Meridian): #3
Left Arm (Non-paralyzed Side):	LI (Large Intestine Meridian): #4, #11
Left Leg (Non-paralyzed Side):	St (Stomach Meridian): #36
Right and Left Ears:	Shenmen
Scalp Acupuncture on Side of Hemispheric Infarction (Left):[2]	Four or five needles along "the motor cortex line" of the scalp

[1]Low pulse repetition rate electrical stimulation (1-2 Hz.) was used on pairs of needles inserted on the right (paralyzed) arm, hand and leg: LI 11 and TW 9, or LI 4 and LI 11 on the paralyzed arm; TW 5 and the Baxie point at the web-space between the index finger and the third finger on the paralyzed hand; and GB 34 and 39 on the paralyzed leg, for 20 minutes per treatment session. The electrical stimulation was obtained from the Electro Acupunctoscope WQ-10B model from China (16). The intensity of stimulation was controlled by the patient and maintained at a comfortable level. See Figures 1A and 1B.

[2]Low pulse repetition rate electrical stimulation (1-2 Hz.) was also used on the scalp needles (20 minutes). See Figure 2 for location on the scalp where some of the acupuncture needles were inserted.

A low pulse repetition rate electrical stimulation (1-2 Hz.) was applied to selected pairs of needles (Table 2) using the WQ-10B model from China. This model has been described by Omura (16). The intensity of stimulation was controlled by the patient and maintained at a comfortable level. All patients received at least 20 treatments. When logistically possible for the patient to return for additional treatments, we extended the total to 40 treatments.

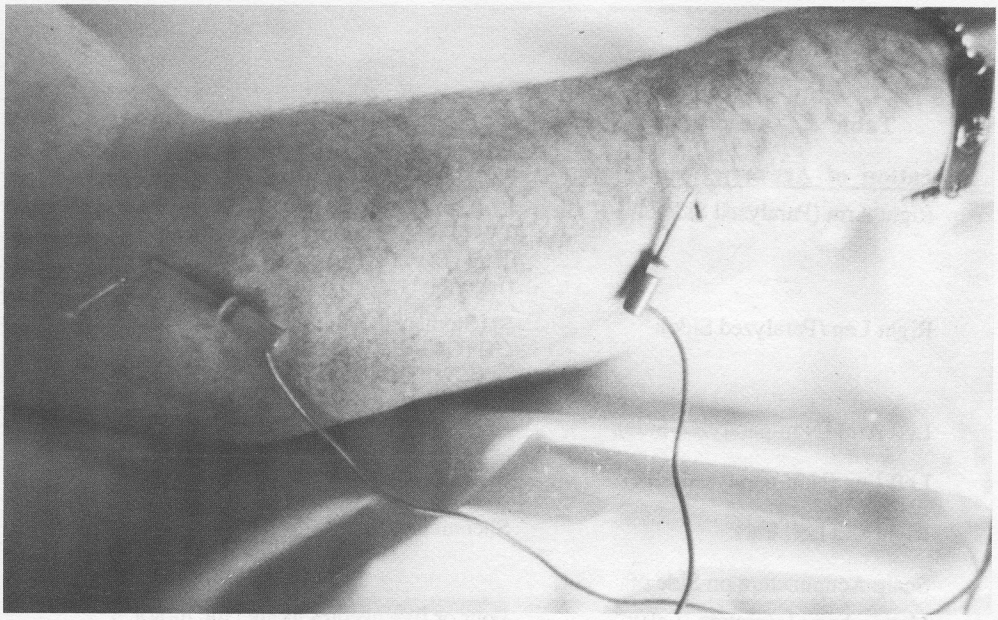

Fig. 1A. Example of acupuncture treatment of arm paralysis in a stroke patient. The sterilized one-time use only acupuncture needles shown here have been inserted into two acupuncture points on the paralyzed arm: LI 11 and TW 9. Electrodes were attached to the needles, and a low pulse repetition rate electrical stimulation (1-2 Hz.) was applied to the needles using the WQ-10B model from China (16). The intensity of stimulation was controlled by the patient and maintained at a comfortable level. Other acupuncture points which were used are listed in Table 2.

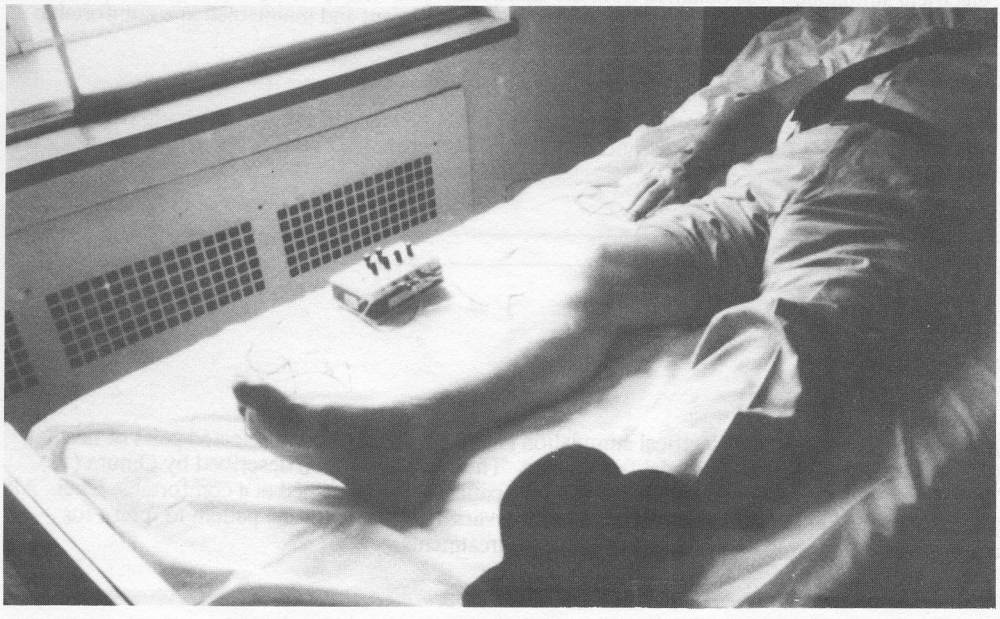

Fig. 1B. Example of acupuncture treatment of leg paralysis in a stroke patient. The needles have been inserted into two acupuncture points on the paralyzed leg: GB 34 and GB 39. Electrodes were attached to the needles, and a low pulse repetition rate electrical stimulation (1-2 Hz.) was applied to the needles using the WQ-10B model from China (16); the model is shown in this picture. Other acupuncture points which were used are listed in Table 2.

Fig. 2. Example of the "scalp needle acupuncture" type of treatment. Sterilized needles were placed with shallow insertion along the "motor cortex line" of the scalp over the cerebral hemisphere where the stroke had taken place. In this case, the needles were inserted into the left hemisphere; the patient had a right-sided arm/leg paralysis. Electrodes were attached to two pairs of needles, and a low pulse repetition rate electrical stimulation (1-2 Hz.) was applied to the needles using the WQ-10B model from China (16). See also Table 2.

CT Scan Lesion Site Analysis:

In most cases, CT scans were performed at 2 MPO or later, in order to better visualize the complete borders of the infarct. The CT scans were analyzed in a retrospective manner, after the entire study had been completed. Neuroanatomical diagrams for the hypothetical location of descending pyramidal tract pathways for the leg and arm on CT scan (Figure 3 and Table 3), were developed for this project from previously published studies (17, 18, 19, 20). The extent of lesion (degree of damage) was visually assessed within each neuroanatomical area on CT scan shown at the bottom of Figure 3, for each patient. These neuroanatomical areas contain, in part, descending pyramidal tract pathways. A 0 to 5 point scale was used, where 0 = no lesion; 1 = equivocal lesion; 2 = small, patchy or partial lesion; 2.5 = patchy, less than half of area has lesion; 3 = half of area has lesion; 3.5 = patchy, more than half of area has lesion; 4 = more than half of area has lesion; 5 = total area has complete lesion.

Lesions were analyzed in a sequential manner from the cortical level to subcortical levels including the periventricular white matter area (PVWM area) and the posterior limb, internal capsule area (PLIC area), to the brainstem level. Extensive lesion at an upper level rendered additional lesion at the lower levels less important. The extent of lesion within specific motor pathway areas on CT scan for each patient is listed in Table 1, last column. These lesion site data were used to classify all patients as having lesion in either *less than half* of the motor pathway areas, or *more than half* of the motor pathway areas, after the study had been completed.

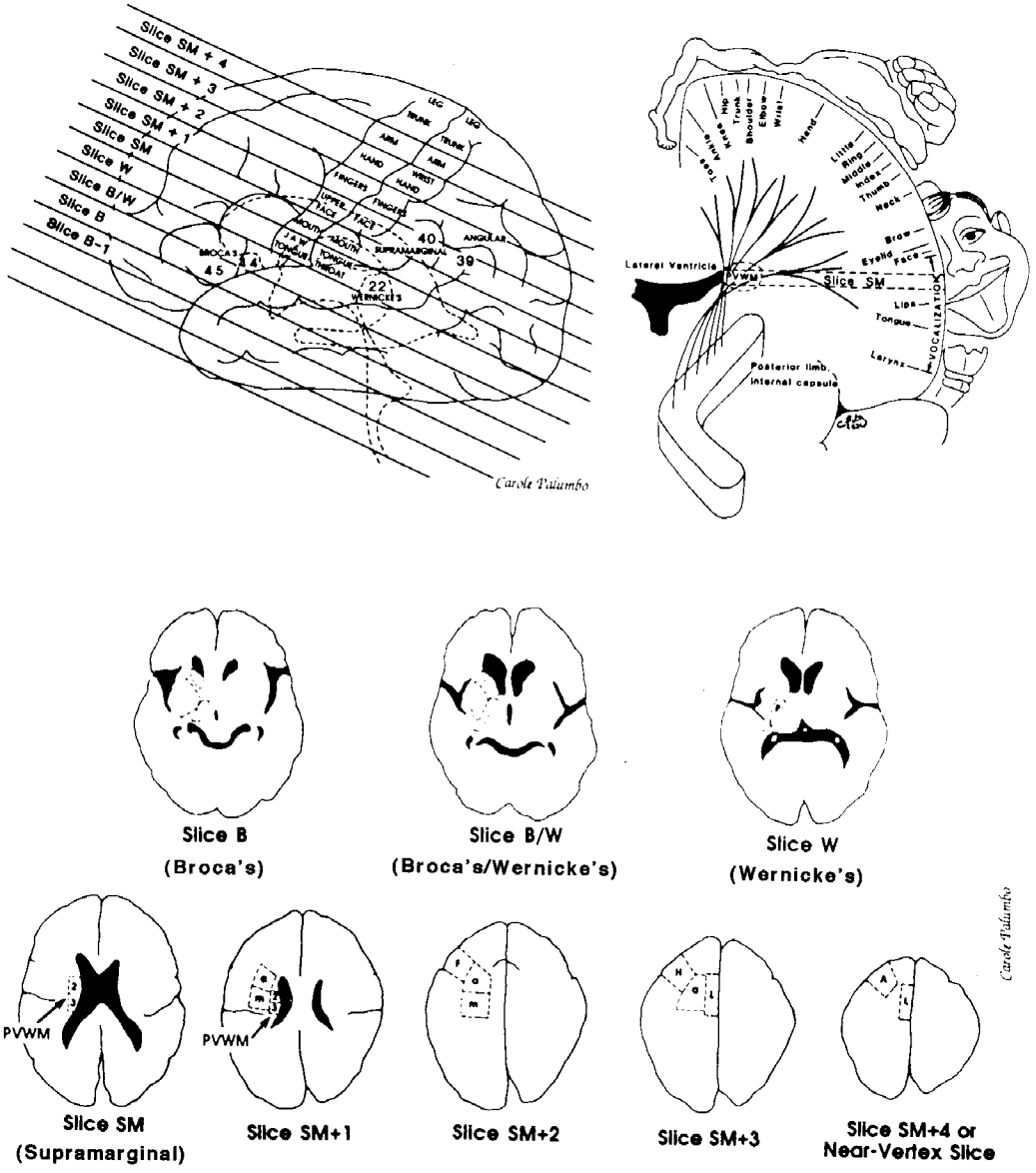

Fig. 3. Lateral, coronal and cross-sectional diagrams showing areas visually assessed for extent of lesion (degree of damage) on CT scan. These areas contain, in part, descending pyramidal tract pathways. The subcortical periventricular white matter area (PVWM) is outlined in the upper right coronal diagram and shown on CT scan slices SM and SM+1 (arrows). The total extent of lesion in the 2nd and 3rd quarters of the PVWM area on slices SM and SM+1 was related to beneficial response, versus poor response, following acupuncture treatments. Abbreviations: L = leg cortex; A = arm cortex; H = hand cortex; F = fingers cortex; a = anterior white matter; m = middle white matter; 2 = 2nd quarter PVWM; 3 = 3rd quarter PVWM; PL = posterior limb, internal capsule (continues on slices B and B/W). CT scan angle is approximately 20 degrees to the cantho-meatal line. The areas containing, in part, leg and arm motor pathways are listed in Table 3. CT scan slice level abbreviations: B=Broca's slice; B/W=Broca's/Wernicke's slice; W=Wernicke's slice; SM=Supramarginal slice; SM+1=one slice above the Supramarginal slice, etc. Reproduced from Naeser MA, Alexander MP, Stiassny-Eder D, et al: Real vs. sham acupuncture in the treatment of paralysis in acute stroke patients: A CT scan lesion site study, J of Neurologic Rehabil **6**, 163-173, 1992, with permission of the authors and publisher, Demos Publications, New York.

Table 3. **Hypothetical location of leg, arm, and hand descending pyramidal tract pathways on separate CT scan slices. These CT scan areas were visually assessed for extent of lesion for each patient. See also Figure 3.**

CT Scan Slice Level	Neuroanatomical Area	Leg	Arm	Hand
Slice SM+4	Leg Motor Cortex Area	+		
Slice SM+4	Arm Motor Cortex Area		+	
Slice SM+3	Leg Motor Cortex Area	+		
Slice SM+3	Hand Motor Cortex Area			+
Slice SM+3	Anterior White Matter		+	+
Slice SM+2	Finger Motor Cortex Area			+
Slice SM+2	Anterior White Matter		+	+
Slice SM+2	Middle White Matter	+	+	
Slice SM+1	Anterior White Matter			+
Slice SM+1	Middle White Matter		+	+
Slice SM+1	2nd Quarter PVWM	+	+	+
Slice SM+1	3rd Quarter PVWM	+	+	+
Slice SM	2nd Quarter PVWM	+	+	+
Slice SM	3rd Quarter PVWM	+	+	+
Slices W, B/W, B	Posterior Limb, Internal Capsule	+	+	+
	Cerebral Peduncle Caudate Putamen	+	+	+

RESULTS

A patient who improved by more than 10%, on at least 2 of the 7 motor tests was considered to have beneficial response. A summary of the total number of improved tests postacupuncture for each patient is presented in Table 1. For the entire group of chronic and acute stroke patients, 8/20 (40%) had beneficial response. This included 3/10 chronic cases (30%), and 5/10 acute cases (50%).

There was no significant correlation between time poststroke when entering the study, and the total number of improved tests for the entire group ($r = -.058$, n.s., $n = 20$), or for the 8 beneficial response cases alone ($r = .58$, n.s., $n = 8$). There was also no significant correlation between age when entering the study, and the total number of improved tests for the entire group ($r = .187$, n.s.; $n = 20$), or for the 8 beneficial response cases alone ($r = .38$, n.s., $n = 8$). There was also no significant correlation between the number of acupuncture treatments (20 or 40), and the total number of improved tests for the entire group ($r = .094$, n.s., $n = 20$). When only the 8 beneficial response cases were considered, however, there was a significant correlation between the total number of acupuncture treatments (20 or 40), and the total number of improved tests ($r = +.748$, $p < .025$, $n = 8$).

By comparison, each of the three chronic control patients not receiving acupuncture did not show improvement of more than 10%, on at least 2 of the 7 motor tests. (See Appendix A.)

In our earlier acupuncture study, we had examined acute stroke patients at 1 - 3 MPO, who received real versus sham acupuncture, and CT scan lesion sites (8). Results from that study showed that significantly more patients had beneficial response following real acupuncture, if lesion was present in only half, or less than half of the motor pathway areas on CT scan. Based on these lesion site results from our previous study, the patients in the present study were separated into two groups - 1) patients with lesion in *less than half* of the motor pathway areas; and 2) patients with lesion in *more than half* of the motor pathway areas. The results for the chronic patients were studied separately, from the results for the acute patients.

Chronic Patients Receiving Acupuncture:

The interaction between CT scan lesion site, and response to acupuncture (beneficial response versus poor response) was analyzed with Fischer's Exact Test for the 10 chronic patients receiving acupuncture. (Fischer's Exact Test is a non-parametric statistic specifically designed for use in studies with small n's.) The following table including lesion site data was produced:

	Chronic Cases Receiving Acupuncture, N = 10	
	Cases with lesion in ≤ 1/2 Motor Pathway Areas, N = 3	Cases with lesion in ≥ 1/2 Motor Pathway Areas, N= 7
Beneficial Response	3	0
Poor Response	0	7

$p < .008$

The application of Fischer's Exact Test to this 2 x 2 table revealed a highly significant difference regarding beneficial response versus poor response for the chronic stroke patients receiving acupuncture, when lesion site information was included as a variable ($p < .008$). All chronic patients receiving acupuncture who had lesion in *less than half* of the motor pathway areas had beneficial response. All chronic patients receiving acupuncture who had lesion in *more than half* of the motor pathway areas had poor response.

Chronic Patients Receiving Acupuncture versus Chronic Patients Not Receiving Acupuncture:

None of the untreated chronic control patients improved by more than 10%, on at least 2 of the 7 tests, but this was not significantly different from the treated group by Fischer's Exact Test.

	Chronic Cases Receiving Acupuncture, N = 10	Chronic Cases Not Receiving Acupuncture, N = 3
Beneficial Response	3	0
Poor Response	7	3

$p < .419$

Based on our previous report (8), this analysis was reperformed with inclusion of the CT scan lesion site data:

	Chronic Cases Receiving Acupuncture		Chronic Cases Not Receiving Acupuncture	
	Cases with lesion in < 1/2 Motor Pathway Areas N = 3	Cases with lesion in > 1/2 Motor Pathway Areas N = 7	Cases with lesion in < 1/2 Motor Pathway Areas N = 2	Cases with lesion in > 1/2 Motor Pathway Areas N = 1
Beneficial Response	3	0	0	0
Poor Response	0	7	2	1

$p < .003$

The application of Fischer's Exact Test to this 2 x 4 table with inclusion of the CT scan lesion site data revealed a highly significant difference in the response categories between the chronic patients receiving acupuncture, versus the chronic patients not receiving acupuncture ($p < .003$). Among all chronic patients with lesion in *less than half* of the motor pathway areas (n = 5), only patients receiving acupuncture had beneficial response (n = 3); chronic control patients not receiving acupuncture had poor response (n = 2). Among all chronic patients with lesion in *more than half* of the motor pathway areas (n = 8), all patients had poor response, including those receiving acupuncture (n = 7), as well as those not receiving acupuncture (n = 1).

All Chronic and Acute Patients, Combined, Receiving Acupuncture:

All 20 patients receiving acupuncture (10 chronic cases and 10 acute cases) were grouped to further assess the relationship between lesion in less than half of the motor pathway areas and beneficial response to acupuncture. The following table including lesion site data was produced:

	All Chronic and Acute Cases Receiving Acupuncture, N = 20	
	Cases with lesion in < 1/2 Motor Pathway Areas, N = 7	Cases with lesion in > 1/2 Motor Pathway Areas, N = 13
Beneficial Response	7	1
Poor Response	0	12

$p < .0001$

The application of Fischer's Exact Test to this 2 x 2 table revealed a highly significant difference in response category (beneficial response versus poor response), for patients with lesion in less than half of the motor pathway areas, versus those patients with lesion in more than half of the motor pathway areas ($p < .0001$). Significantly more chronic and acute stroke patients with lesion in *less than half* of the motor pathway areas had beneficial response following acupuncture, versus those patients with lesion in *more than half* of the motor pathway areas.

For this group of 20 patients, CT scan lesion site information was 95% accurate (19/20) in predicting benefit from acupuncture. All 7 patients with lesion in half, or less than half of the motor pathway areas had beneficial response following acupuncture treatments. Twelve of 13 patients with lesion in more than half of the motor pathway areas had poor response.

Among these 20 patients, in 15 cases, the hemiparesis was due to damage within the PVWM area on CT scan slices SM and SM+1 (Table 1, last column; and Figure 3). For these 15 cases there was a significant negative correlation between extent of lesion in the 2nd and 3rd quarters of the

number of improved tests, postacupuncture. There were too few cases with paralysis secondary to motor cortex, posterior limb internal capsule, or brainstem lesions for independent correlations to be performed for these areas.

Improvement in Specific Leg and Arm Tests:

Of the 7 motor tests, one was very easy (hip abduction/adduction), and two were very difficult (ankle dorsiflexion and forearm supination, elbow extended); and these three tests were inappropriate for further statistical assessment. For the other 4 tests (knee flexion; knee extension; shoulder abduction; and forearm supinaton, elbow flexed) paired t-tests (one-tail) were used to test for possible significant differences between pre- versus post-acupuncture scores for only the 8 cases with beneficial response (3 chronic cases and 5 acute cases). Improvements were significant for knee flexion, knee extension, and shoulder abduction for these 8 cases (Tables 4 and 5, and Figure 4.) The lack of change and lack of improvement for the 12 poor response cases following acupuncture precluded pre- versus post-acupuncture paired t-test comparisons for specific motor tests for this group of patients. The amount of change was near zero for all tests for these poor response cases.

Table 4. **Paired t-test results comparing pre- versus post-acupuncture Lower Extremity test scores for 3 chronic and 5 acute patients; only patients with beneficial response are included.**

		Pre Acptr. Tx.	Post 20 Tx.'s	Change Pre-20 Tx.'s	Pre Acptr. Tx.	Post 40 Tx.'s	Change Pre-40 Tx.'s	Change 20-40 Tx.'s
	n =	8	8	8	5	5	5	5
Knee Flexion	Mean %	16.9	35.5	18.6	22.4	44.6	22.2	4.8
	S.D.	19.8	34.9	21.3	22.2	40	19.6	15.7
	p-Value			*.02			*.03	n.s.
No. Cases who Improved by at least 10%				5 of 8			3 of 5	1 of 5
Knee Extension	Mean %	47.9	65.8	18.9	53.2	81	27.8	18.2
	S.D.	37.8	31.2	32.4	24.3	14.5	17.1	21.8
	p-Value			0.08			**.01	0.06
No. Cases who Improved by at least 10%				5 of 8			5 of 5	3 of 5

Table 5. **Paired t-test results comparing pre- versus post-acupuncture Upper Extremity test scores for 3 chronic and 5 acute patients; only patients with beneficial response are included.**

		Pre Acptr. Tx.	Post 20 Tx.'s	Change Pre-20 Tx.'s	Pre Acptr. Tx.	Post 40 Tx.'s	Change Pre-40 Tx.'s	Change 20-40 Tx.'s
	n =	8	8	8	5	5	5	5
Shoulder Abduction	Mean %	32.9	39.5	6.6	39.4	51	11.6	3.4
	S.D.	36.6	42.4	9.8	38.4	47.3	11.9	4.98
	p-Value			*.04			*.04	0.10
No. Cases who Improved by at least 10%				2 of 8			3 of 5	1 of 5
Supinate Forearm, Elbow Flexed	Mean %	17.4	26.3	9	7.8	28.8	21	16.6
	S.D.	36.1	39.2	18.3	17.4	26.9	24.8	28.7
	p-Value			0.10			0.06	0.13
No. Cases who Improved by at least 10%				2 of 8			3 of 5	2 of 5

Stability of Improvement over Time:

To assess the stability of motor improvement after acupuncture, 5 patients with beneficial response were reevaluated 2 months and 4 months after the last acupuncture treatment. At 2 months post-treatment, 50% of the improved motor test scores were the same, 33% were improved by an additional ten percent, and 16% were worse by ten percent or more. At 4 months, a similar distribution was present, i.e. 55%, 33%, and 11%, respectively. Thus, at least 80% of the improved test scores which were present immediately following the last acupuncture treatment, remained equal to that level of improvement, or improved more, at 2 and 4 months following the last treatment.

Case Examples:

CT scans for two patients with lesion in *more than half* of the motor pathway areas are shown in Figures 5A and 5B. Case SS (Figure 5A) had lesion in all of the motor *cortex* areas for leg and arm near the vertex. Case NA (Figure 5B) had lesion in *more than half* of the *subcortical* PVWM motor pathway area, and the lesion was immediately adjacent to the body of the lateral ventricle. Both patients had poor response to acupuncture.

Case PP (Figure 6A) originally served as a chronic control case and later was treated with acupuncture. A CT scan performed at 3 months poststroke showed only minimal lesion in the PVWM area (Figure 6A). He was tested at 44, 49 and 60 months poststroke as a chronic

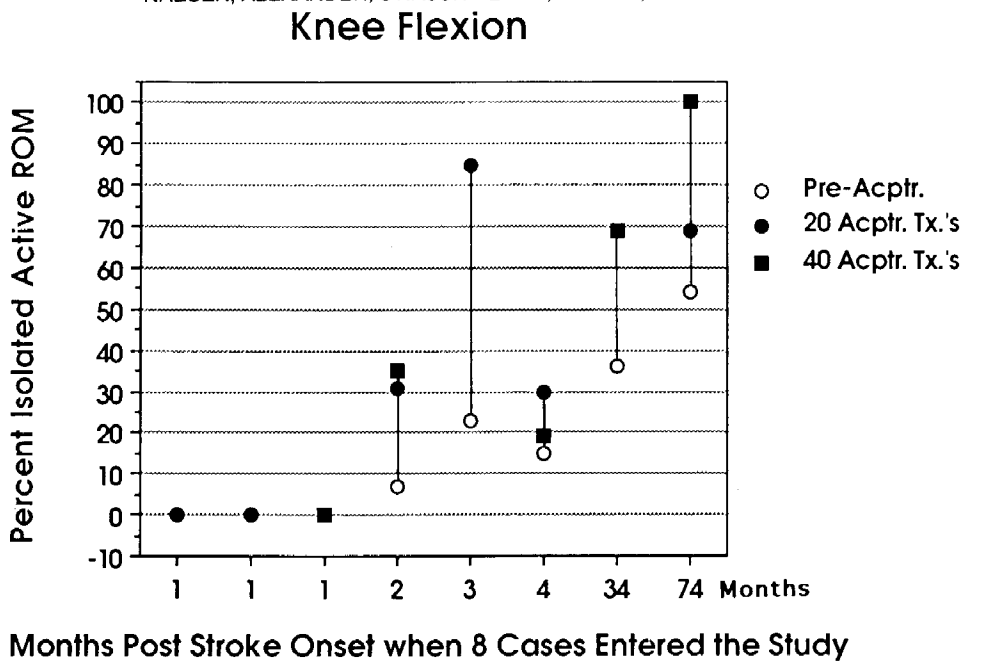

Fig. 4A. Graph for 8 beneficial response cases showing percent isolated active range of motion (ROM) for knee flexion, pre- and post- 20 acupuncture treatments ($p < .02$, $n = 8$); and post- 40 treatments ($p < .03$, $n = 5$).

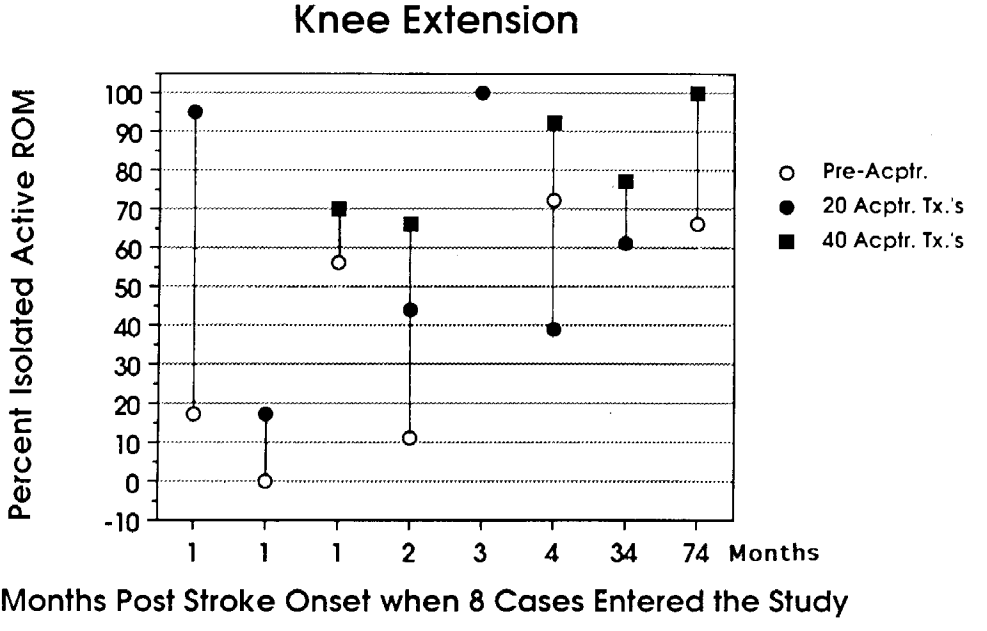

Fig. 4B. Graph for 8 beneficial response cases showing percent isolated active range of motion (ROM) for knee extension, pre- and post- 20 acupuncture treatments; and post- 40 treatments ($p < .01$, $n = 5$). Data are plotted for only the beneficial response cases; note not every beneficial response case improved on every test.

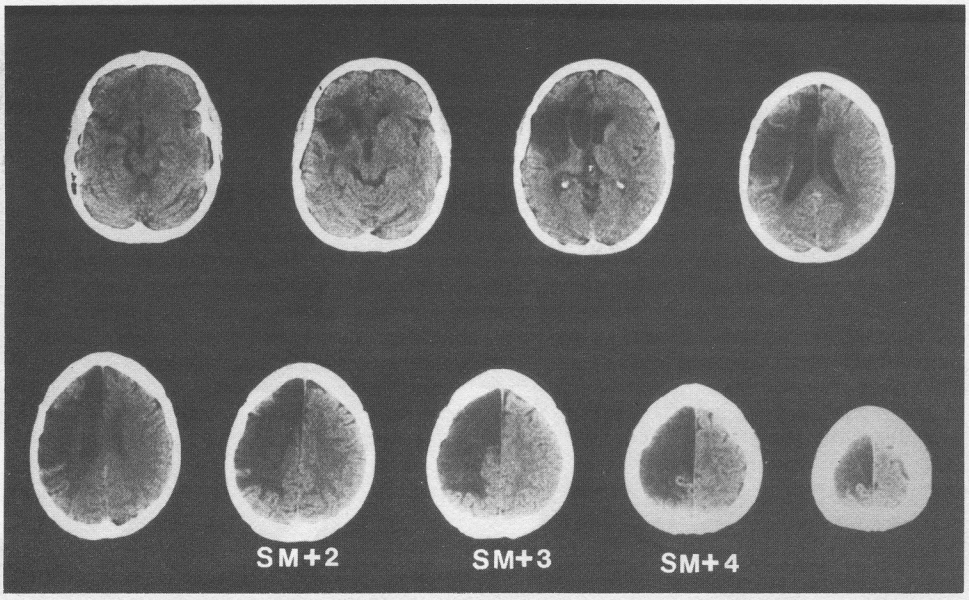

Fig. 5A. CT scan for a patient with lesion in *more than half* of a motor pathway area (*cortical* lesion), with poor response following acupuncture. Case SS, 56 yr. M, who entered the study at 3 MPO. Lesion is present in all of the motor cortex areas and immediate subjacent white matter for leg (SM+4 and SM+3), arm (SM+4), hand (SM+3) and fingers (SM+2). All scores were 0% pre- and post-acupuncture treatment, except for 22% in knee extension. CT scan is 2 Yr. poststroke.

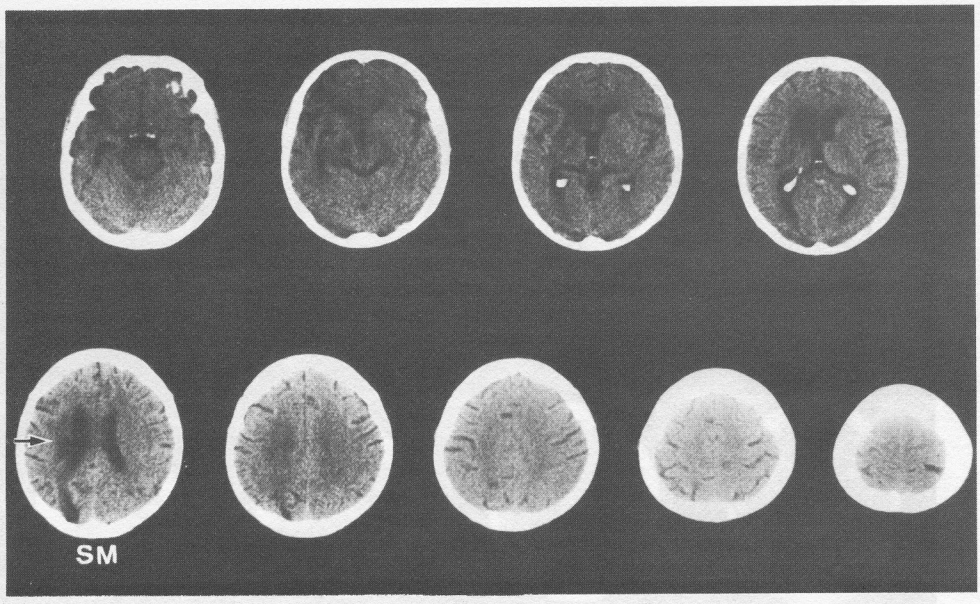

Fig. 5B. CT scan for a patient with lesion in *more than half* of a motor pathway area (*subcortical* lesion), with poor response following acupuncture. Case NA, 61 Yr. M, who entered the study at 4 MPO. No lesion is present in the motor cortex area for leg, arm, hand or fingers. Lesion is present in more than half of the subcortical PVWM area, and it is immediately adjacent to the body of the lateral ventricle on slice SM (arrow). His scores on all tests were 0% pre- as well as post-20 and 40 treatments, as well as at 14 months poststroke. CT scan is 5 months poststroke.

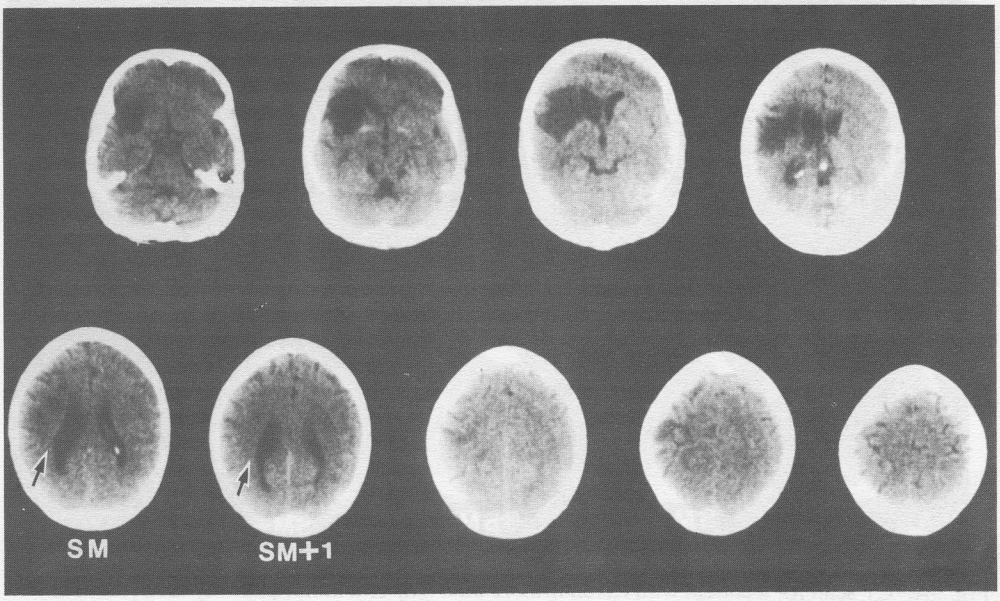

Fig. 6A. CT scan for case PP, 67 Yr. M, who was a chronic control patient receiving no acupuncture when tested at 44, 49, and 60 MPO. No test scores improved by at least 10% from testing Time 1, to Time 3. This 3 MPO CT scan shows only minimal lesion in the PVWM area on slices SM and SM+1 (arrows).

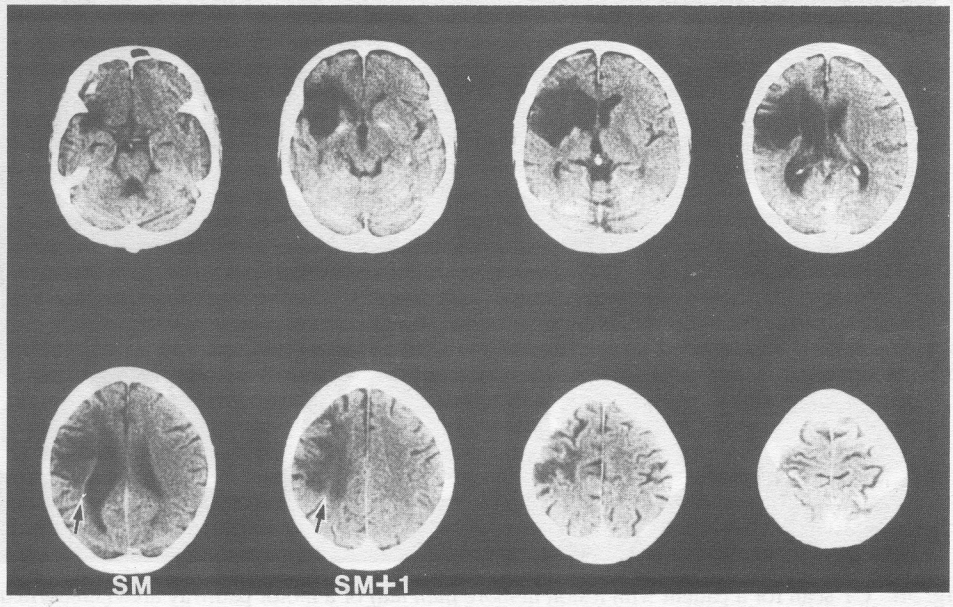

Fig. 6B. CT scan for the same case, PP, done 6 Yr. post original stroke onset, showing additional infarction now present in the PVWM area on slices SM and SM+1, but sparing the PVWM immediately adjacent to the body of the lateral ventricle (arrows), i.e., a good candidate for acupuncture. He improved by at least 10% in five leg/arm tests following 20 and 40 acupuncture treatments. (See Appendix A, Top and Bottom, case PP.)

control patient without improvement in his right hemiparesis (Appendix A, Top, case PP). Although no additional stroke had been noted, a CT scan performed at 74 months poststroke revealed additional infarction now present within the PVWM area (lesion extent value of 10.25). (See Figure 6B.) Motor testing at 74 months poststroke was markedly worse than at 60 months. (See Appendix A, Bottom, case PP.)

Beginning at 74 months poststroke, case PP received acupuncture treatments over a 2-3 month period. Knee flexion, knee extension, shoulder abduction, and forearm supination with the elbow flexed, all improved following acupuncture (Appendix A, Bottom, case PP). For knee flexion and knee extension, the post-acupuncture scores improved to equal or beyond what they had been following the first stroke (Appendix A, Top and Bottom, case PP), despite additional PVWM lesion now present (compare the PVWM area in Figure 6A versus 6B).

DISCUSSION

The portion of the present study including *chronic* stroke patients supports and extends the findings of our previous study with *acute* stroke patients (8). In both studies, patients receiving real acupuncture improved by more than 10% on a greater number of lower extremity/upper extremity motor tests than controls (i.e., chronic patients receiving no acupuncture or acute patients receiving sham acupuncture). Lesion site on CT scan is a critical variable in this phenomenon. In both studies, most cases with lesion in more than half of the motor pathway areas on CT scan did not improve, whether treated with acupuncture or not. In both studies, all cases with lesion in only half, or less than half of the motor pathway areas on CT scan improved in motor function, but only if treated with acupuncture. The two most important motor pathway areas are the motor cortex area, and the subcortical periventricular white matter area (PVWM area) containing pyramidal tract pathways. The PVWM area is located on CT scan slices SM and SM+1, adjacent to the body of the lateral ventricle (arrows in Figure 3). The 2nd and 3rd quarters of the PVWM area are especially important. This region contains, in part, descending pyramidal tract pathways, and is a critical crossroads for other intra- and inter-hemispheric pathways, as explained below.

The 2nd and 3rd quarters of the PVWM area contain the descending pyramidal fibers from motor cortex. Within the 2nd and 3rd quarters of the PVWM area at the level of the body of the lateral ventricle, the descending pyramidal tract pathways for the leg are most medial. The descending pyramidal tract pathways for the arm are slightly more anterior and lateral within the white matter at that level. This distribution within the white matter at the level of the body of the lateral ventricle has recently been observed in an anterograde staining study with rhesus monkeys (21).

The 2nd and 3rd quarters of the PVWM area also contain the body of the caudate nucleus, and numerous other intra- and inter-hemispheric pathways. These pathways include: 1) the mid-callosal pathways; 2) the medial subcallosal fasciculus containing connections to the caudate from the supplementary motor area and the supraventricular cingulate gyrus (22, 23, 24); 3) the occipito-frontal fasciculus (23); and 4) the superior lateral thalamic peduncle which includes projections from the dorso-medial nucleus and the anterior nucleus to the cingulate (25) and projections from the ventrolateral nucleus to the motor cortex. Thus, even within this small region there are numerous motor systems that might, if incompletely damaged, respond to acupuncture. These systems include dorsal striatum, supplementary motor area, or the frontal-striatal-ventrolateral thalamic-frontal loop, as well as the descending pyramidal system.

An acupuncture study from China with general CT scan lesion information in stroke patients demonstrated that although acupuncture was found to be beneficial in some cases, in other cases where the paresis was due to large or deep lesions, bilateral or multifocal lesions, or brainstem lesions, it was not (7). The single case in the present study who had paralysis associated with a brainstem lesion did, however, have a beneficial response. New techniques of scalp needle acupuncture from Japan may also be effective for treatment of paralysis (including quadriplegia) due to a partial pontine lesion, even when started as late as 6 years poststroke (26).

With the development of modern neuroimaging techniques such as CT scan, an increasing number of rehabilitation studies are carefully examining the relationship between exact location of lesion site in the motor pathway areas, and functional outcome in stroke patients (27, 28). It may take 2 months or more for CT scan to demonstrate precise lesion boundaries (20). Thus, for chronic cases, CT scan performed at the start of treatment in the chronic phase will help with prognosis. In the chronic phases poststroke, acupuncture appears to be less successful for cases with severe paralysis, however, and more successful for cases with mild-moderate paresis.

For acute cases, the acute CT scan performed at less than 3 months poststroke will not be helpful to predict prognosis. We have observed, however, a high success rate (100%) for acupuncture treatment of *hand paresis* in milder stroke patients, whether treated in the acute or the chronic phase poststroke (11). These hand paresis cases had no other arm/leg paralysis.

Some simple clinical observations may be useful for predicting "beneficial response" to acupuncture treatment for the arm. The presence of voluntary grip, even a weak grip, at 1 month poststroke predicts some functional recovery by 6 months poststroke (29). If a patient has *no* voluntary, isolated finger/hand movement at 1 or 2 months poststroke (or even later in the chronic phase), it is unlikely there will be significant improvement in the arm even with acupuncture.

As mentioned in the Introduction, the physiological mechanisms involved with mediating improvement in paralysis in stroke patients treated with acupuncture are unknown. The first study conducted by Omura (1975) observed an increase in cerebral blood flow to the forehead area (representing cerebral hemisphere blood flow) ipsilateral to the hemisphere where the stroke had occurred. An increase in blood circulation to the hands of the patients was also observed (1). See Figure 7. Two subsequent studies, using different acupuncture points, and different measuring techniques also observed increased cerebral blood flow following needle acupuncture (2, 3).

These studies in the area of cerebral blood flow in relationship to needle stimulation of acupuncture points were conducted in the 1970's. In order to learn more about this topic, it would be important to study needle (or low-level laser) stimulation of acupuncture points in stroke patients with modern neuroimaging techniques such as positron emission tomography, PET (30, 31), or functional magnetic resonance imaging, functional MRI (32).

There are likely other mechanisms, as well, which are involved with mediating slow improvement in paralysis following acupuncture treatments. This would include, for example, neurotransmitter release, such as ß-endorphins, especially when low-frequency electro-acupuncture is used (33, 34, 35, 36).

In 1975, Omura also observed an increase in blood cortisol levels following acupuncture treatment (1). Other studies have also observed this increase (37, 38). This increase in blood cortisol levels may have an effect on mediating the slow improvement in paralysis following acupuncture treatments. The best outcome levels were observed when the acupuncture treatments were initiated at less than 3 months poststroke (5, 7), and especially when the acupuncture treatments were initiated less than 24 hours and 36 hours poststroke (9, 12). Thus, because brain swelling can be a major problem during the first few days poststroke, it is possible that the increase in the cortisol levels following acupuncture has a positive effect on reducing the brain swelling, and therefore promoting a condition where there is less overall brain damage.

In the treatment of paralysis due to stroke, it appears that acupuncture should be included as a complementary, adjunctive treatment. It should be initiated as soon as possible following stroke onset. Johansson has reviewed the advantages of early intervention with sensory stimulation (acupuncture) in stroke patients (39). Because it may increase cerebral blood flow, however, it is advisable to withhold acupuncture until bleeding has ceased (4-6 hours postonset), in hemorrhagic stroke cases. Otherwise, there appear to be no contraindications to initiation of acupuncture treatment as soon as possible following stroke onset in acute stroke patients.

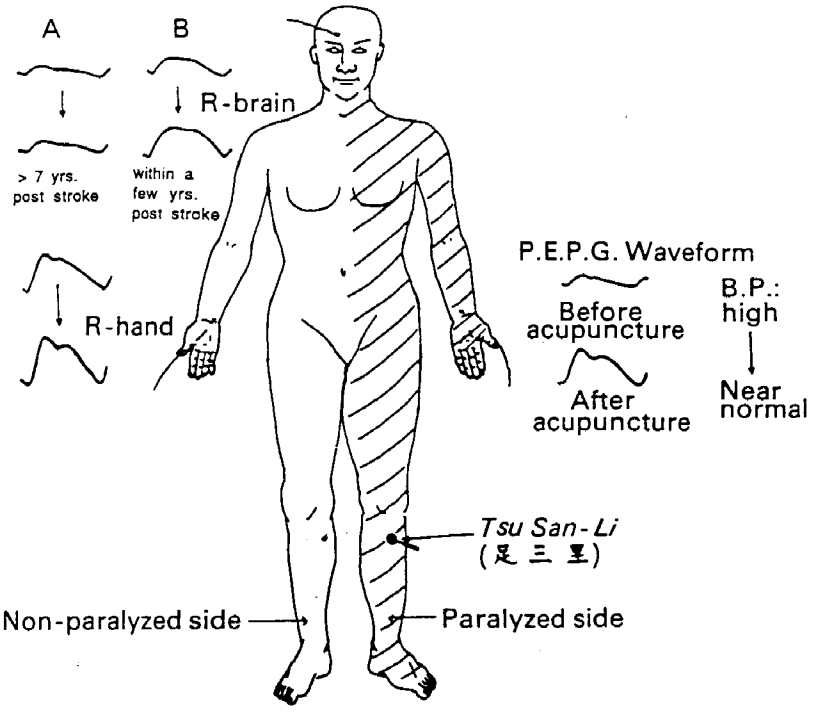

Fig. 7. The effects of acupuncture on stroke patients with paralysis of one side of the body. When acupuncture was given at *Tu San Li* point of the paralyzed side, usually a significant vasodilation was observed at the paralyzed hand with slight increase in skin temperature. However, the less significant changes result in the hand of the non-paralyzed side. The brain circulation, studied from the supra-orbital artery and its branches, showed either response A which did not have a significant effect, or response B where there is an improvement in the circulation. Response A was more commonly seen in the patients who had had a stroke more than 7 years ago and response B was more commonly seen in the patients who had had a stroke within the past few years. Reproduced from Omura Y: Pathophysiology of acupuncture treatment: Effects of acupuncture on cardiovascular and nervous systems. Acupuncture & Electro-Therapeutics Research, The International Journal **1**, 51-141, 1975, with permission of the author and publisher, Pergamon Press, New York.

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Note: Information regarding the status of acupuncture in the various states in the U.S., and names of Licensed Acupuncturists may be obtained from the American Association of Acupuncture and Oriental Medicine, 433 Front Street, Catasauqua, PA 18032-2506; (610) 433-2448.

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Appendix A. Lower extremity and upper extremity test scores for chronic control stroke patients with right-sided paralysis who received no acupuncture treatments.

BR = Beneficial Response PR = Poor Response

			LOWER EXTREMITY TESTS Percent Isolated Active ROM												UPPER EXTREMITY TESTS Percent Isolated Active ROM											
	Age Enter Study	Months Post Onset (MPO) Test Times T1/T2/T3*	Hooklying Abd./Add.			Knee Flexion			Knee Extension			Ankle Dorsiflexion			Shoulder Abduction			Forearm Supination Elbow Flexed			Forearm Supination Elbow Extended			Total Number Tests Improved by > 10%	Total Lesion Extent in PVWM** (Slices SM+1 and SM) 20 = Complete Lesion 10 = Half Lesion
			T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3		
NO ACUPUNCTURE Tx.'s Chronic Control Cases: Cases, Lesion < 1/2 Motor Pathways																									
BH	42	133/137/143	100	100	100	100	92	100	94	83	94	83	83	83	100	100	100	100	100	100	50	50	50	0 PR	7
*** PP	67	44/49/60	100	100	100	100	100	100	90	94	93	45	45	45	94	83	83	80	73	55	0	0	0	0 PR	1***
Cases, Lesion > 1/2 Motor Pathways																									
EL	54	25/29/36	56	100	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1 PR	(Leg and Arm Motor Cortex Area Lesions)
***Case PP after additional infarct at 6 Yrs., when acupuncture treatments (Tx's) were begun		Pre Tx./ Post 20 Tx./ Post 40 Tx.	Pre Tx.	Post 20 Tx.	Post 40 Tx.	Pre Tx.	Post 20 Tx.	Post 40 Tx.	Pre Tx.	Post 20 Tx.	Post 40 Tx.	Pre Tx.	Post 20 Tx.	Post 40 Tx.	Pre Tx.	Post 20 Tx.	Post 40 Tx.	Pre Tx.	Post 20 Tx.	Post 40 Tx.	Pre Tx.	Post 20 Tx.	Post 40 Tx.		
PP	69	74/75/77	100	100	100	54	69	100	66	100	100	45	45	45	75	83	89	39	61	50	0	0	0	5 BR	10.25***

* T1 = Time 1 testing; T2 = Time 2 testing; T3 = Time 3 testing

** PVWM = Periventricular white matter adjacent to the body of the left lateral ventricle containing pyramidal tract pathways for lower extremity and upper extremity and other important intra- and inter-hemispheric pathways.

*** This patient, case PP, showed relative stability in the right-sided paralysis when tested at 44, 49, and 60 MPO. At 74 MPO, however, his Lower Extremity and Upper Extremity test scores had markedly diminished. A CT scan repeated at this time showed additional lesion extension in the PVWM; it was now rated 10.25; it had previously been rated 1.