# Patients with Systemic Sclerosis Have Unique and Persistent Alterations in Gastric Myoelectrical Activity with Acupressure to Neiguan Point PC6

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*ABSTRACT.* ***Objective.*** To assess the effect of acupressure on gastric myoelectrical activity (GMA) in patients with systemic sclerosis (SSc) and its possible influence on SSc-associated gastrointestinal (GI) dysmotility disorders.

***Methods.*** Acupressure to Neiguan point PC6 (GI, antiemetic point) was applied while SSc patients and healthy control subjects were monitored by 4-channel surface electrogastrography (EGG) during 30-minute baseline, acupressure, and recovery intervals. Frequency of GI symptoms and modified Rodnan skin scores (mRSS) of SSc patients were recorded. Acupressure to PC10 (non-GI, sham) was also performed on SSc patients to assess the validity of PC6 as a modulator of GI gastric rhythms.

***Results.*** In the SSc patients, PC6 acupressure resulted in significant, persistent percentage mean normal wave decreases with concomitant percentage mean bradygastria and tachygastria increases during the recovery interval. Increases in percentage mean coupling seen in controls were blunted in SSc patients. In SSc patients, PC6 acupressure resulted in significant percentage normal wave and percentage bradygastria changes in the recovery interval that were not obtained with PC10 acupressure. In SSc patients, mRSS were significantly correlated to baseline GMA percentage mean normal waves and bradygastria and frequency of abdominal bloating. The frequency of symptoms for heartburn were significantly correlated with changes in GMA (δGMA, baseline vs recovery).

***Conclusion.*** In SSc patients, PC6 acupressure revealed significant, persistent, and possibly unique alterations in GMA during the recovery interval. δGMA was significantly correlated with the frequency of heartburn symptoms. Further studies will assess if acupressure to PC6 can provide a therapeutic or prognostic utility with GMA or GI symptoms in SSc patients. (J Rheumatol 2005; 32:494–501)

*Key Indexing Terms:*
SCLERODERMA ACUPRESSURE GASTRIC MYOELECTRICAL ACTIVITY

Gastrointestinal (GI) involvement may occur in up to 90% of patients with systemic sclerosis (SSc), reported predominantly as esophageal dysmotility[1,2]. Upper GI symptoms frequently experienced by SSc patients with GI dysmotility include heartburn, nausea, vomiting, early satiety, abdominal bloating, regurgitation, and abdominal pain. Studies have characterized the abnormalities of the gastric myoelectrical activity (GMA) in SSc patients using scintigraphy and multichannel surface electrogastrography (EGG)[3,4].

EGG is a noninvasive method for accurately measuring the GMA of the stomach and has been used as a cost-effective method to investigate gastric dysmotility in irritable bowel syndrome, diabetic gastroparesis, and GI involvement in SSc[3-9]. The GMA is composed of 2 parts: the rhythmic slow wave (also called electrical control activity, reflecting pacemaker potential) and spikes (electrical response activity or action potentials). The gastric slow wave (also called normal wave) determines the frequency and propagation of gastric contractions. The normal gastric wave propagates from the corpus of the stomach distally towards pylorus, maintaining a basal rhythm of 2–4 cycles/min[10]. The spikes (superimposed on normal waves) determine the presence or absence of contractions.

Acupuncture and acupressure have been used in China for centuries to treat and normalize physiologic abnormalities[11,12]. In acupressure, a discrete nonpuncturing pressure is applied to stimulate the Neiguan point. The Neiguan point, well characterized in acupuncture, is the precise cutaneous point for treatment of various ailments by stimulation

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through neurogenic mechanisms. A recent study showed that electrical stimulation of the Neiguan point PC6 increased the percentage of normal gastric waves in the stomach (with concomitantly decreased percentage of tachygastria) in healthy subjects[13]. Acupressure has been reported to be beneficial in pregnancy-related nausea using the Neiguan point[14,15]. Studies have shown that stimulation of acupuncture points can promote the release of specific neuropeptides in the central nervous system, eliciting physiological and normalizing effects[16].

The current prokinetic medications used to manage gastric dysmotility in SSc (i.e., erythromycin, metoclopramide, promethazine, and prochlorperazine) are often of modest and unpredictable benefit and have many intolerable side effects such as drowsiness, agitation, hypo- or hypertension, tardive dyskinesia, and anticholinergic effects[17]. A nonpharmacological, noninvasive, easily learned and applied maneuver such as acupressure to modulate GMA and possibly improve GI symptoms, would be appealing in the SSc patient population. We assessed the effects of acupressure of the Neiguan PC6 antiemetic point on the GMA in patients with SSc.

## MATERIALS AND METHODS

*Patients.* Sixteen patients satisfying the American College of Rheumatology criteria for SSc[18] were enrolled between May 2001 and March 2002. There were 13 women and 3 men, 9 patients with limited SSc and 7 with diffuse SSc. All but one patient were antinuclear antibody (ANA) seropositive. Of the 9 patients with limited SSc, 3 were anticentromere antibody (ACA) seropositive. One of 5 patients with diffuse SSc in whom Scl-70 antibody results were available from patient records was Scl-70 seropositive. The research protocol was approved by the UTMB Institutional Review Board and written informed consent was obtained from each participant before enrollment. Patients were excluded if they were (1) unable to give informed consent; (2) using prokinetic medications or other medications that could potentially affect gastric motility within 72 h of testing; (3) unable to recline with a head elevation of 30° for 1 h; or (4) had a history of abdominal surgery that might alter gastric landmarks. At the beginning of the study, the modified Rodnan skin score (mRSS, range 0 to 51) was also determined[19].

Seventeen healthy subjects (10 men, 7 women) with no history of GI symptoms and on no prokinetic medications were recruited from the UTMB campus and served as controls. EGG recordings in healthy subjects have been reported to be unaffected by age or sex[20,21].

*Multichannel surface electrogastrogram.* The abdominal skin was cleaned with sandy skin preparation paste to reduce electrical impedance before electrode attachment. The patient was placed in the recumbent position with a head and chest elevation of 30°. Six silver chloride EGG electrodes were secured to the abdominal skin, 4 active electrodes, one ground, and a reference electrode[9,21]. Four-channel EGG signals were derived by connecting each of the active electrodes to the common reference electrode, with Channel 1 reflecting the proximal corpus, Channel 2 distal corpus, Channel 3 antrum, and Channel 4 distal antrum. Electrocardiography (EKG) was performed simultaneously with the EGG using 3 leads. The EKG was recorded to assess the variation of heart rate with or without acupressure.

GMA of each participant was measured using surface EGG with a specially designed multichannel device (Medtronic-Synectics, Shoreview, MN, USA). The electrogastrograph consisted of 4 identical amplifiers with cutoff frequency ranges of 1.0 to 12.0 cpm. A 12-bit analog to digital converter was installed in the recording device for online digitization of the EGG with a sample frequency of 4 Hz.

*Frequency of symptoms questionnaire.* A self-administered GI questionnaire was developed by the investigators to address the duration in years from disease diagnosis, use of prokinetic medication, and frequency of GI symptoms. Symptoms of dyspepsia and abnormal upper GI motility including heartburn, nausea, vomiting, abdominal bloating, early satiety, regurgitation, and abdominal pain were assessed by the frequency (days per week) that the patient reported experiencing the symptoms. As no questionnaire has been validated for SSc-associated GI symptoms, it was felt that a questionnaire based on the frequency of GI symptoms would generate the most objective responses from patients. The frequency of GI symptoms occurring the week prior to EGG testing (before medications were discontinued) was graded as never = 0; 1–3 times per week = 1; ≥ 4 times per week = 2; and the symptoms were experienced daily = 3. The maximum total frequency of symptoms score for each patient was 18, calculated by addition of the individual scores. Each SSc patient completed a questionnaire prior to undergoing the first EGG study. Healthy controls had no GI symptoms and were not taking any prokinetic or heartburn-related medications.

*Acupressure.* Patients and controls were asked to fast for 6 h before testing, and to stop use of prokinetic agents (such as erythromycin, metoclopramide, promethazine, and prochlorperazine) for 72 h prior to their visit. Controls were placed in the recumbent position at 30° of elevation. They were asked to remain awake and silent throughout the recording period to decrease any motion artifacts. Two researchers trained in the same sessions applied the acupressure on all patients to minimize variability in testing.

EGG and EKG tracings were recorded during 3 consecutive 30-min intervals: baseline, acupressure, and recovery. During the baseline interval, EGG and EKG recordings were performed with no treatment intervention of the subject. During the acupressure interval, acupressure was performed at PC6 (GI, the antiemetic point) or PC 10 (non-GI, sham) of the nondominant arm for 30 min, with continuous EGG and EKG monitoring. Neiguan point PC6, the acupuncture antiemetic point (GI), is located about 3 cm proximal to the wrist crease between the tendons of the palmaris longus and the flexor carpi radialis[11,12]. PC10 is a non-GI point located 10 cm proximal to PC6. A 3-lb dumbbell with a pointed tip was applied to the acupressure point for 1-min periods alternating with 1-min periods of rest, for a 30-min acupressure interval. Acupressure was applied at a single point during each visit. The recovery period consisted of continuous recordings of EGG and EKG for 30 min after the acupressure interval, without intervention. Patients received acupressure at PC6 (n = 16) and PC10 (n = 10). The patients were unaware of which point was related to the GI system. Controls underwent the same protocol, but received acupressure at PC6 only (n = 17).

*Data analysis and presentation.* Computerized spectral analysis methods were applied to derive the following parameters from the 4-channel EGG[10]: (1) dominant frequency of the EGG (df), which reflected the frequency of the gastric slow (normal) wave; (2) changes in dominant power of the EGG (dp), reflecting gastric contractility; (3) percentage mean normal waves, usually the predominant gastric wave (2–4 cpm, percentage Normal); (4) percentage mean bradygastria, which are gastric waves slower than the gastric normal wave (0.5–2.0 cpm waves, percentage Brady); (5) percentage mean tachygastria, which are gastric waves faster than the gastric normal wave (4–9 cpm waves, percentage Tachy); and (6) percentage mean slow wave coupling, reflecting the coordination of contractions between 2 gastric regions. The change in GMA percentage normal waves will be concomitantly reflected by changes in percentage bradygastria or percentage tachygastria or percentage arrhythmia (not discussed).

Multichannel EGG results are reported as mean values ± standard error. The percentage mean Normal, percentage mean Brady, percentage mean Tachy, and df are presented in this study. Analyses of Neiguan point PC6 and sham point PC10 were assessed in the same SSc patients who underwent both testings on separate days. Multivariate correlations were assessed by Pearson product-moment analysis; paired and unpaired Student

t tests were also used to compare values between intra- and inter-patient testing intervals, using GraphPad Prism 4.02 (GraphPad Software, San Diego, CA, USA) and Statistica (Statistica, Tulsa, OK, USA) software. A value of $p < 0.05$ was considered significant.

## RESULTS

*SSc and frequency of GI symptoms.* Table 1 shows the clinical profiles and frequency of symptoms of the 16 SSc patients, as obtained from the frequency of symptoms questionnaire. The average age for the group was 52.25 ± 2.62 years. The mean years diagnosed with SSc was 7.12 ± 0.89 years. The mean mRSS for the SSc patient group was 8.88 ± 1.44 (range 3–21). The patients scored between 0 and 3 for "no symptoms" to "daily GI symptoms." Mean values were obtained for heartburn (1.50 ± 0.26), nausea and vomiting (0.94 ± 0.17), abdominal bloating (1.50 ± 0.22), early satiety (1.31 ± 0.23), regurgitation (0.88 ± 0.85), and abdominal pain (0.88 ± 0.22) and total score for frequency of symptoms (7.0 ± 0.84, maximum = 18). The symptoms of heartburn and abdominal bloating were experienced significantly more frequently than regurgitation or abdominal pain ($p = 0.048$ and $p = 0.04$, respectively) based on the results of the GI questionnaire.

*mRSS and frequency of GI symptoms compared to GMA in SSc patients.* Table 2 shows the results of correlation analyses pertinent to mRSS, the frequency of GI symptom scores, baseline GMA, and differences between percentage GMA of baseline and recovery intervals (δGMA) in the SSc patients. The mRSS was significantly correlated with the number of years diagnosed with SSc ($p = 0.05$, data not shown) and frequency of abdominal bloating ($p = 0.02$). Comparing mRSS to GMA scores, the mRSS was found to be significantly inversely correlated to percentage mean normal waves in channel 2 ($r^2 = –0.52$, $p < 0.04$) and channel 3 ($r^2 = –0.60$, $p = 0.01$). mRSS was significantly correlated to percentage mean bradygastria in channel 2 ($r^2 = 0.67$, $p < 0.01$) and channel 3 ($r^2 = 0.62$, $p = 0.01$).

δGMA and frequency of symptom scores were also analyzed. Significant associations were found with frequency of heartburn symptom scores and δGMA channel 2 percentage mean normal waves ($r^2 = 0.72$, $p = 0.002$), δGMA percentage mean bradygastria ($r^2 = 0.50$, $p = 0.047$), and channel 3 percentage normal waves ($r^2 = 0.5$, $p = 0.05$). There were no significant correlations between the other frequency GI symptoms scores and baseline GMA, recovery GMA, δGMA, dp, df, or with disease duration as an independent variable.

*GMA fluctuations during acupressure intervals for patients and controls.* Figure 1 shows the percentage mean normal waves and percentage mean bradygastria in 2 of 4 channels of EGG recordings during PC6 (GI) acupressure between controls (n = 17) and SSc patients (n = 16). Figure 1A shows minimal changes in percentage mean normal waves between baseline, acupressure, or recovery intervals in the controls during PC6 acupressure (ranges of channels 1–4: 82% ± 2% to 91% ± 3%, as shown for channels 2 and 3). The majority of gastric waves in fasting controls are normal waves.

In contrast, the SSc patients demonstrated 2 marked differences in the percentage mean normal waves in response to PC6 acupressure. As shown for channel 2 and channel 3, the SSc patients showed a decline in percentage mean normal waves during the PC6 acupressure intervals, which continued during the recovery intervals. The channel 2 and channel 3 acupressure interval in the SSc patients showed significantly lower percentage mean normal waves compared to the baseline intervals (Figure 1A; $p = 0.034$ and 0.038, respectively). Moreover, the declines in percentage mean normal waves persisted and reached significance during the recovery intervals compared to baseline intervals in channels 1–4, ($p = 0.021$, 0.003, 0.001, and 0.047, respectively; ranges for channels 1–4: 49% ± 4% to 70% ± 5%). Significantly decreased percentage mean normal wave in SSc patients compared to controls in the fasting state was also seen, as previously reported[7,9].

Figure 1B shows the percentage mean bradygastria recordings from SSc patients and controls during PC6 acupressure in channel 2 and channel 3. In controls, the percentage mean bradygastria scores were generally lower compared to SSc patients. In controls, there were no signif-

*Table 1.* SSc patient profiles (n = 16) and frequency of GI symptom scores. Frequency of symptoms is scored as follows: 0: no symptoms, 1: sometimes, 1–3 days/week; 2: frequently, ≥ 4 days/week but not every day; 3: experience symptoms daily.

| | Age, yrs | Yrs Diagnosed with SSc | mRSS | Heartburn | Nausea/ Vomiting | Abdominal Bloating | Early Satiety | Regurgitation | Abdominal Pain | Total Symptom Score | Meds |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Average score | 52.25 | 7.12 | 8.88 | 1.50 | 0.94 | 1.50 | 1.31 | 0.88 | 0.88 | 7.0 | 6 |
| SE | 2.62 | 0.89 | 1.44 | 0.26 | 0.17 | 0.22 | 0.23 | 0.85 | 0.22 | 0.84 | |
| Patient range* | 35–71 | 3–16 | 3–21 | 0–3 | 0–2 | 0–3 | 0–3 | 0–2 | 0–2 | 0–11 | 0–3 |
| $p < 0.05$** | | | | 0.048 | | 0.040 | | | | | |

mRSS: Modified Rodnan total skin score (range 0–51). Total Symptom Score: total frequency of symptom score per patient (range 0–18). Meds: number of patients currently taking or with a history of taking ≥ 1 medication for GI dysmotility. SSc patients reported using 0–3 prokinetic agents for their symptoms (e.g., erythromycin, metoclopramide, promethazine, and prochlorperazine). No patient had a history of using octreotide. * The range of scores derived from 16 SSc patients. ** Frequency of symptoms of heartburn or abdominal bloating compared to regurgitation or abdominal pain, respectively, indicating that SSc patients reported heartburn and bloating as symptoms they experienced significantly more frequently than regurgitation or abdominal pain.

*Table 2.* Modified Rodnan skin scores (mRSS) of the SSc patients were correlated to frequency of GI symptom scores and baseline GMA for channels 1–4.

| Variable | mRSS $r^2$ | mRSS p | Heartburn $r^2$ | Heartburn p |
|---|---|---|---|---|
| Frequency of GI symptoms | | | ΔGMA | |
| Heartburn | –0.03 | 0.90 | Ch 2 % normal waves | 0.72 | 0.002 |
| Bloating | 0.57 | 0.02 | Ch 2 % bradygastria | 0.50 | 0.047 |
| Regurgitation | 0.48 | 0.06 | Ch 3 % normal waves | 0.50 | 0.050 |
| Baseline GMA | | | | | |
| Ch 2 % normal waves | –0.52 | < 0.04 | | | |
| Ch 2 % bradygastria | 0.67 | < 0.01 | | | |
| Ch 3 % normal waves | –0.60 | 0.01 | | | |
| Ch 3 % bradygastria | 0.62 | 0.01 | | | |

Heartburn: Frequency of heartburn symptom; ΔGMA: comparison between baseline and recovery GMA. Correlation analyses were performed using the Pearson product-moment correlation.

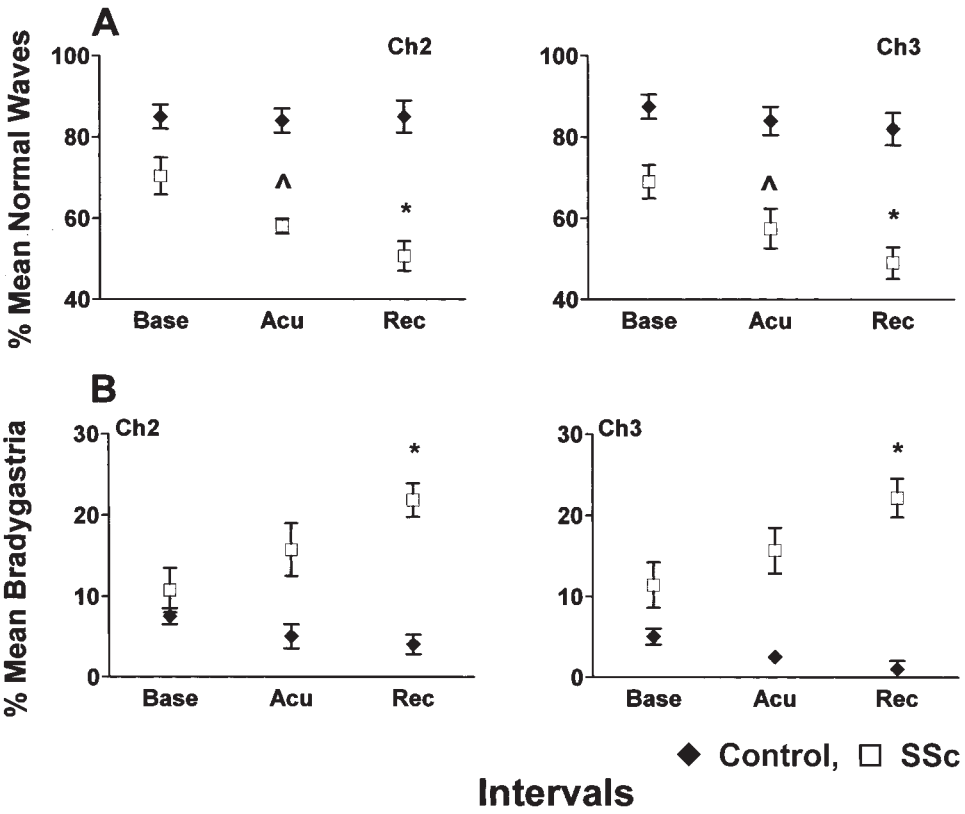


*Figure 1.* Changes in percentage mean normal waves (A) and percentage mean bradygastria (B) during PC6 acupressure intervals in controls (n = 17) compared to patients with SSc (n = 16). Controls and patients underwent PC6 acupressure during EGG monitoring for GMA during 30-min intervals of baseline, acupressure, and recovery. Data are mean values and standard error bars for percentage mean normal waves (also called slow waves) and percentage mean bradygastria in channel 2 and channel 3, which are representative of changes also seen in channels 1 and 4 (not shown). ^Significant differences ($p < 0.05$) in percentage mean gastric waves between baseline and acupressure intervals in SSc patients; *significant differences ($p < 0.05$) in percentage mean gastric waves between baseline and recovery intervals in SSc patients.

icant changes in percentage mean bradygastria between acupressure or recovery intervals compared to baseline interval scores in any channel (range 1% ± 1% to 16% ± 3%, for channels 1–4).

SSc patients demonstrated 2 marked differences in the percentage mean bradygastria in response to PC6 acupressure, compared to controls. The percentage mean bradygastria scores were higher in fasting SSc patients compared to

controls during most test points. Increased percentage mean bradygastria were seen in the acupressure compared to the baseline intervals in channels 1–4. The increments in percentage mean bradygastria in SSc patients persisted and were significant into the recovery intervals in all channels ($p = 0.02$, 0.004, 0.008, and 0.002, respectively; ranges for channels 1–4: 10.38% ± 2.62% to 24% ± 2.75%). This reflects the robust response of percentage bradygastria to PC6 testing compared to the relatively blunted response in controls.

There were significant decreases in percentage mean tachygastria in channel 4 ($p < 0.05$; range 37.2% ± 2.5% to 23.1% ± 1.7%) in controls during PC6 acupressure and recovery intervals (data not shown). The baseline percentage mean tachygastria scores were lower in the SSc patients compared to controls in channels 1–3 (37.2% vs 14.4%, respectively). In patients there were significant and persistent increases in percentage mean tachygastria during PC6 acupressure and recovery intervals in channel 2 ($p = 0.04$ and 0.01, respectively; range: 14.036% ± 2.6% to 20.9% ± 2.48%) and channel 3 ($p = 0.01$ and 0.01; range: 13.92% ± 2.6% to 21.50% ± 2.8%, respectively; data not shown).

Figure 2 illustrates the percentage mean wave coupling in SSc patients and controls during PC6 acupressure. The percentage mean wave coupling scores, reflecting coordinated contractions between 2 gastric areas, were assessed for channels 1 and 2, 1 and 3, 1 and 4, 2 and 3, 2 and 4, and 3 and 4. Figure 2A shows the percentage mean wave coupling between channels 2 and 3 during PC6 acupressure. Controls showed the greatest increase and persistent increment in percentage mean wave coupling between channel 2 and channel 3 during the PC6 acupressure and recovery intervals ($p = 0.001$ and 0.001, respectively, compared to baseline; range: 9.6% ± 1.7% to 37.1% ± 4%). The controls did not show significant changes in percentage mean wave coupling with other channel combinations (data not shown). Figure 2B shows that the percentage mean wave coupling for all channel coupling combinations ($n = 6$, average) in the controls did not increase significantly during PC6 acupressure or recovery intervals (range 7.43% ± 0.6% to 12.82% ± 4.6%).

In the SSc patients, there was a nearly significant increase in percentage mean wave coupling between channels 2 and 3 during the acupressure interval ($p = 0.055$) that was not sustained during the recovery interval (Figure 2A, range 23.35% ± 4.47% to 36.02% ± 6.22%). In the SSc patients, there was a significant increase in percentage mean wave coupling during the acupressure interval for all wave coupling combinations (Figure 2B, average; $p = 0.023$; range 16.49% ± 2.9% to 23.45% ± 4.7%). This increase in percentage mean wave coupling was not sustained through the recovery interval. SSc patients also showed significant increases in percentage mean wave coupling in channels 1 and 4 ($p = 0.035$; range 16.64% ± 2.8% to 22.90% ± 4.99%) and channels 2 and 4 ($p = 0.044$; range 14.41% ± 3.51% to 20.96% ± 4.9%) during the PC6 acupressure intervals, which was not sustained in the recovery intervals (data not shown).

Neiguan point PC6 (GI, antiemetic point) and sham point PC10 (non-GI) acupressure applications were directly compared in the same SSc patients to assess their influences on

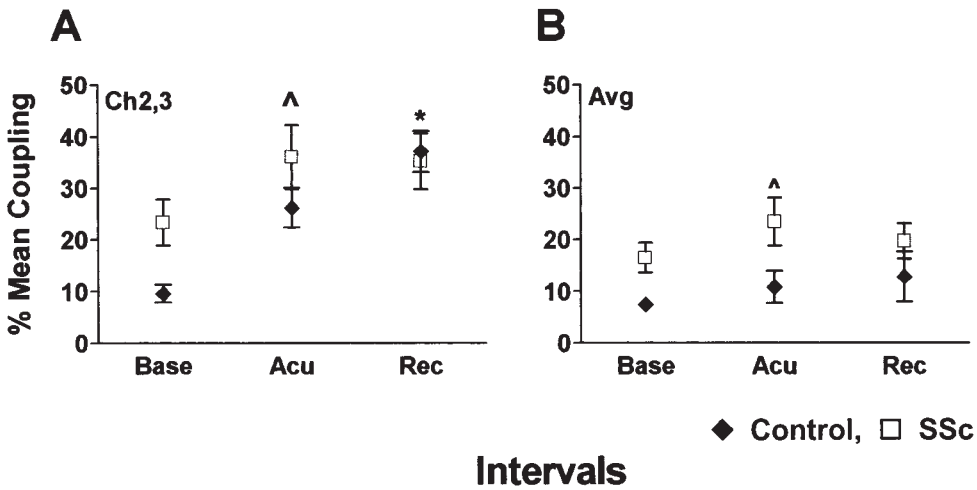


*Figure 2.* Changes in the percentage mean channel coupling during PC6 acupressure intervals in controls compared to patients with SSc. Channel coupling reflects the gastric wave coordination between 2 gastric areas as measured by EGG. Data are presented as average values with standard error bars for baseline, PC6 acupressure, and recovery intervals. (A) Percentage mean coupling between channels 2 and 3. (B) Percentage mean coupling, average of all 6 coupling combinations between channels 1–4 tested. ^Significant difference ($p < 0.05$) in percentage mean gastric wave coupling between baseline and acupressure intervals in controls (A) and SSc patients (B); *significant difference ($p < 0.05$) in percentage mean gastric waves between baseline and recovery intervals in controls (B).

*Table 3.* Comparison of GMA during mean baseline and recovery intervals using acupressure to Neiguan point PC6 and sham point PC10. Ten SSc patients were tested using both PC6 and PC10 on separate days. GMA variables tested included the dominant frequency (df) of the EGG, percentage normal waves (% Normal), percentage bradygastria (% Brady), and percentage tachygastria (% Tachy). Mean values with standard error (SE) are presented for baseline and recovery intervals for channel 2 and channel 3.

| | PC6 (GI) Acupressure | | | | PC10 (non-GI) Acupressure | | | |
|---|---|---|---|---|---|---|---|---|
| | df | % Normal | % Brady | % Tachy | df | % Normal | % Brady | % Tachy |
| Ch 2 baseline | | | | | | | | |
| Average | 3.22 | 65.81 | 14.11 | 14.99 | 3.23 | 66.93 | 7.39 | 21.08 |
| SE | 0.087 | 5.5 | 3.94 | 2.98 | 0.125 | 7.01 | 2.90 | 3.37 |
| Ch 2 recovery | | | | | | | | |
| Average | 2.98 | 51.16 | 23.39 | 19.71 | 3.1 | 57.47 | 15.29 | 20.14 |
| SE | 0.11 | 4.13 | 1.8 | 3.3 | 0.10 | 5.95 | 2.94 | 3.90 |
| p | 0.037 | 0.015 | 0.014 | 0.13 | 0.120 | 0.228 | 0.101 | 0.871 |
| Ch 3 baseline | | | | | | | | |
| Average | 3.21 | 66.48 | 12.98 | 15.05 | 3.23 | 68.60 | 8.68 | 20.74 |
| SE | 0.076 | 4.71 | 3.44 | 3.18 | 0.125 | 8.16 | 3.40 | 5.29 |
| Ch 3 recovery | | | | | | | | |
| Average | 2.90 | 47.81 | 20.98 | 23.89 | 3.2 | 58.71 | 16.25 | 21.64 |
| SE | 0.114 | 5.1 | 2.78 | 4.25 | 0.103 | 5.29 | 2.34 | 4.129 |
| p | 0.012 | 0.004 | 0.029 | 0.040 | 0.621 | 0.305 | 0.107 | 0.892 |

Paired Student t test: a p value < 0.05 was considered significant.

GMA. Table 3 compares the percentage mean normal waves and percentage mean bradygastria in channels 2 and 3 during the acupressure testing intervals in SSc patients on 2 separate days to assess the validity of PC6 vs PC10 as a GMA modifier. The differences noted in mean df, percentage Normal, percentage Brady, and percentage Tachy between baseline and recovery intervals in EGG recordings of channels 2 and 3 are presented. Similar percentage GMA recordings were noted in baseline and most acupressure intervals between PC6 and PC10 acupressure points in the patients with SSc. Acupressure to PC6 resulted in significant differences between baseline and recovery intervals, whereas acupressure to PC10 did not. There were also significant differences between baseline and recovery intervals during PC6 treatment in channel 1 and channel 4 (percentage mean normal waves; p = 0.035 and 0.031, respectively) and channel 4, percentage mean bradygastria (p = 0.009).

There were no significant changes in percentage mean normal waves during PC10 acupressure testing in the same SSc patients in baseline and recovery intervals (Table 3). In the PC10 acupressure testing, there were significant increases in percentage mean bradygastria between baseline and acupressure intervals in channel 2 and channel 3 (p = 0.001 and 0.002, respectively) that were not seen with PC6 acupressure (data not shown). However, the PC10 GMA fluctuations in the acupressure intervals normalized toward baseline levels during the recovery intervals, so the GMA changes were not sustained past the interval of direct acupressure stimulation.

## DISCUSSION

This study assessed the influence of acupressure on GMA in SSc patients and the correlation of frequency of GI symptoms to GMA parameters. In patients, application of PC6 acupressure produced significant and unique alterations in percentage mean normal waves, bradygastria, and tachygastria between baseline and recovery intervals in all channels compared to controls. To our knowledge, the reported persistence in percentage mean gastric wave alterations during the recovery intervals have not been previously described in acupressure. The significant and persistent GMA changes seen during the recovery intervals may reflect unique neurogenic or endocrine influences, or possibly sympathetic nervous system influences, that are sustained past direct acupressure stimulation in SSc-associated GI dysmotility.

Acupuncture and acupressure manipulations are thought to modulate through neurotransmitter release. Acupuncture has been shown to induce changes in sympathetic and parasympathetic nervous systems[22]. Acupressure-induced δGMA may be similar to the effect seen with glucagon, where a "sympathetic dominance" related to catecholamine excess is promoted as an important influence[23,24]. Autonomic dysfunction of both sympathetic and parasympathetic nervous systems has been reported in patients with SSc[25,26], so their modulation may have clinical relevance. Reported neuropeptide release or modulation from discrete acupuncture manipulations include cholecystokinin-8, substance P, angiotensin II, arginine vasopressin, and dynorphin, from brain hypothalamus, hippocampus, and spinal cord in animal models[16,27]. One study has shown that electroacupuncture modulated endothelin-1 levels and improved circulation of the hand in patients with SSc[27]. Vascular influences may also contribute to the pathology[28].

The validity of the PC6 antiemetic point as a directed

focus for GMA modulation in SSc patients was also tested. Acupressure at PC6 resulted in significant alterations in GMA between baseline and recovery intervals not seen with PC10 acupressure in the same patients. Acupressure at PC10 modulated GMA in SSc patients only during direct acupressure stimulation during the acupressure intervals, which was not sustained during the recovery intervals. PC10 acupressure modulation of SSc GMA during the acupressure interval may be due to direct or indirect sympathetic or neuroendocrine influences; or possibly the corpus might be easily stimulated with several acupressure points during direct application, allowing differential or independent activation during direct PC10 acupressure[22].

A self-administered pretest questionnaire addressing the frequency of GI symptoms and mRSS of the SSc patients was also obtained. Analyses revealed significant correlations between mRSS and the frequency of abdominal bloating and baseline interval GMA in channel 2 and channel 3. There was also a significant correlation between the frequency of heartburn symptoms and δGMA in channels 2 and 3. Studies have revealed a correlation of antral hypomotility to GI symptoms[29,30], and sympathetic dysfunction and antral hypomotility have been described in SSc patients[1,31]. A review of the literature revealed no validated instrument to assess abdominal symptom frequency or severity of gastric dysmotility in SSc patients. Validated questionnaires including the IBS-36 exist for irritable bowel syndrome, but are largely disease-specific[32,33]. The development of a validated questionnaire to quantitate frequency and severity of abdominal symptoms in SSc patients will be necessary to facilitate and confirm the assessment of any correlations between GMA alterations and their possible clinical significance. Future studies will include larger sample sizes, a greater range of scores (i.e., 0–3 may not be adequately expansive for correlation analyses), use of a validated GI symptom questionnaire when available, and addition of questions to investigate intensity of symptoms and influence on the patient's quality of life.

Increased percentage bradygastria has been described in other patient groups during PC6 acupressure to treat nausea[14,15]. Increased percentage bradygastria was found to be correlated with strong antral contractions in dogs, but has been associated with the absence of antral contractions in human studies[24]. δGMA was correlated with the frequency of symptoms for heartburn. The effects of PC6 acupressure on SSc GI symptoms were not specifically obtained in our study, but no reports of worsening symptoms after PC6 or PC 10 acupressure were noted.

Several reports address skin scores as a correlation or predictor of the presence or absence of disease activity or prognosis in patients with SSc[34-36]. In this study, mRSS in patients were found to be significantly correlated to baseline GMA percentage mean normal waves and percentage mean bradygastria and the frequency of abdominal bloating. In a previous study, SSc patients had a higher prevalence of late potentials in the cardiac rhythm compared to healthy subjects[37]. Median skin score was higher (mRSS = 10 vs 6) in patients with diffuse SSc with late potentials compared to patients without late potentials, independent of antibody subsets, with the mRSS presumably reflecting other areas of fibrosis. This may indirectly reflect a similar phenomenon influencing GMA in the upper GI tract. Further studies addressing the influence of diffuse in contrast to limited cutaneous involvement, disease duration, and correlations with clinical progression will be needed to delineate this relationship.

These data expand previous results illustrating gastric dysmotility by also showing that patients with SSc may respond uniquely to acupressure or related stimuli, possibly reflecting the neurogenic influences of the underlying pathology. Further studies will determine if GMA changes correlate directly to the underlying pathology, disease severity, cutaneous involvement, or to any improvement in GI symptoms in the SSc patient population. Acupressure, acupuncture, or other neurogenic modifiers may modulate GMA, eventually to serve as a monotherapy or adjunct therapy for GI dysmotility in patients with SSc, or possibly to predict disease activity and to direct appropriate disease-modifying treatments.

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