

CLINICAL THERAPEUTICS

Acupuncture for Chronic Low Back Pain

Brian M. Berman, M.D., Helene H. Langevin, M.D.,
Claudia M. Witt, M.D., M.B.A., and Ronald Dubner, D.D.S., Ph.D.

This Journal feature begins with a case vignette that includes a therapeutic recommendation. A discussion of the clinical problem and the mechanism of benefit of this form of therapy follows. Major clinical studies, the clinical use of this therapy, and potential adverse effects are reviewed. Relevant formal guidelines, if they exist, are presented. The article ends with the authors' clinical recommendations.

A 45-year-old construction worker with a 7-year history of intermittent low back pain is seen by his family physician. The pain has gradually increased over the past 4 months, despite pain medications, physical therapy, and two epidural corticosteroid injections. The pain is described as a dull ache in the lumbosacral area with episodic aching in the posterior aspect of both thighs; it worsens with prolonged standing and sitting. He is concerned about losing his job, while at the same time worried that continuing to work could cause further pain. The results of a neurologic examination and a straight-leg-raising test are normal. Magnetic resonance imaging (MRI) shows evidence of moderate degenerative disk disease at the L4–L5 and L5–S1 levels and a small midline disk herniation at L5–S1 without frank nerve impingement. The patient wonders whether acupuncture would be beneficial and asks for a referral to a licensed acupuncturist.

THE CLINICAL PROBLEM

From the Center for Integrative Medicine, University of Maryland School of Medicine (B.M.B.), and the University of Maryland Dental School (R.D.) — both in Baltimore; the Department of Neurology and the Program in Integrative Health, University of Vermont College of Medicine, Burlington (H.H.L.); and the Institute for Social Medicine, Epidemiology, and Health Economics, Charité University Medical Center, Berlin (C.M.W.). Address reprint requests to Dr. Berman at the University of Maryland School of Medicine, 2200 Kernan Dr., Baltimore, MD 21207, or at bberman@compmed.umm.edu.

N Engl J Med 2010;363:454-61.

Copyright © 2010 Massachusetts Medical Society.

An estimated 70% of persons in Western industrialized countries have back pain sometime in their lives.¹ In the United States, low back pain is one of the most common reasons for visits to a physician.¹⁻³ Approximately 90% of acute episodes resolve within 6 weeks. However, 25% or more of patients have recurrent pain within the next year,⁴ and chronic low back pain develops in up to 7% of patients.⁵

The full differential diagnosis of low back pain is extensive, but most of the causes are infrequently seen in general medical practice.⁶ Cancer, infection, and inflammatory disorders each account for less than 1% of cases. Structural disorders of the spine itself, such as compression fractures, spinal stenosis, and disk herniation, are somewhat more common and together account for some 10 to 15% of cases. However, the most common problem (85% of cases) is “nonspecific” or “idiopathic” low back pain, and it is this disorder that is most often associated with chronic or recurrent symptoms.

Low back pain results in substantial morbidity. By one estimate, 6.8 million U.S. adults had physical disability associated with back pain in 1999.⁷ Patients with back pain account for more than \$90 billion annually in health care expenses, with approximately \$26 billion of that amount directly attributable to the treatment of back pain.⁸

PATHOPHYSIOLOGY AND EFFECT OF THERAPY

The pathophysiology of chronic low back pain is poorly understood, but is increasingly recognized as complex and multifactorial. Progress in elucidating mechanisms

has been impeded by difficulties in defining suitable animal models that are clearly relevant to the human disorder and in conducting informative physiological studies of chronic pain in humans.

Some of the above-mentioned structural abnormalities of the spine are well established as causes of low back pain. Other abnormalities do not correlate well with clinical symptoms.⁶ Findings such as disk herniation and facet-joint degeneration, when associated with central spinal stenosis or nerve-root impingement, have been correlated with low back pain, most often in association with sciatica or neurologic deficits. However, there is a high prevalence of such spinal abnormalities in asymptomatic persons,^{9,10} and such findings are poor predictors of back pain in longitudinal studies.^{11,12} Muscular and soft-tissue abnormalities have also been described,^{13,14} but their role in low back pain remains uncertain.

More recent investigations focus on alterations in the central nervous system, detected with various imaging methods, that are associated with chronic low back pain.¹⁵ Studies using functional MRI have shown alterations in cerebral activation,^{16,17} and anatomical studies have shown changes in regional volume and density in the brain.¹⁸⁻²⁰ It has been suggested that these alterations may reflect or contribute to changes in central nervous system processing of sensory stimuli. However, the specific findings of these studies have not been entirely consistent with one another, and it is not clear whether the observed alterations are a cause or a consequence of chronic low back pain.

In addition, psychological and behavioral factors, including fear of movement, appear to play an important role in patients with chronic low back pain.²¹⁻²⁴ Such patients have been shown to have altered brain-activation patterns at subcortical and cortical sites associated with emotion and postural control.²⁵⁻²⁸ Studies comparing psychosocial variables with anatomical findings have shown the former to have greater predictive value than the latter.^{11,12}

Acupuncture is a therapeutic intervention characterized by the insertion of fine, solid metallic needles into or through the skin at specific sites.^{29,30} The technique is believed to have originated in China, where it has remained a fundamental component of a system of medical theory and practice that is often termed "traditional Chinese medicine." Although a number of different techniques or schools of acupuncture prac-

tice have arisen, the approach used in traditional Chinese medicine appears to be the most widely practiced in the United States.³¹

Traditional Chinese medicine espouses an ancient physiological system (not based on Western scientific empiricism) in which health is seen as the result of harmony among bodily functions and between body and nature. Internal disharmony is believed to cause blockage of the body's vital energy, known as *qi*, which flows along 12 primary and 8 secondary meridians (Fig. 1). Blockage of *qi* is thought to be manifested as tenderness on palpation. The insertion of acupuncture needles at specific points along the meridians is supposed to restore the proper flow of *qi*.

Efforts have been made to characterize the effects of acupuncture in terms of the established principles of medical physiology on which Western medicine is based. These efforts remain inconclusive, for several reasons. First, the majority of studies have been conducted in animals, and it is difficult to relate findings from such studies to effects in humans. Second, acupuncture has been shown to activate peripheral-nerve fibers of all sizes, rendering a systematic study of responses complex. Third, the acupuncture experience is dominated by a strong psychosocial context, including expectations, beliefs, and the therapeutic milieu.³²⁻³⁴

Despite these limitations, some physiological phenomena associated with acupuncture have been identified. Local anesthesia at needle-insertion sites completely blocks the immediate analgesic effects of acupuncture, indicating that these effects are dependent on neural innervation.³⁵ Acupuncture has been shown to induce the release of endogenous opioids in brain-stem, subcortical, and limbic structures.^{36,37} In the rat, electroacupuncture has been shown to induce pituitary secretion of adrenocorticotropic hormone and cortisol, leading to systemic antiinflammatory effects.³⁸ Functional MRI studies in humans have shown immediate effects of prolonged acupuncture stimulation in limbic and basal forebrain areas related to somatosensory and affective functions that are known to be involved in pain processing.³⁹ Results on positron-emission tomography have shown that acupuncture increases μ -opioid-binding potential for several days in some of the same brain areas.⁴⁰ Acupuncture also has effects on local tissues, including mechanical stimulation of connective tissue,⁴¹ release of adenosine at the site of needle stimu-

ory regarding the effect of acupuncture on mechanisms of chronic pain.

CLINICAL EVIDENCE

A number of clinical trials have evaluated the efficacy of acupuncture for chronic low back pain. A meta-analysis in 2008, which involved a total of 6359 patients,⁴⁴ showed that real acupuncture treatments were no more effective than sham acupuncture treatments. There was nevertheless evidence that both real acupuncture and sham acupuncture were more effective than no treatment and that acupuncture can be a useful supplement to other forms of conventional therapy for low back pain. These conclusions were supported by a subsequent meta-analysis from the Cochrane Back Review Group.⁴⁵ Details of several of the major recent clinical trials that were included in these meta-analyses are provided in the Supplementary Appendix, available with the full text of this article at NEJM.org.⁴⁶⁻⁵⁰

In a large German study, 1162 patients with a history of chronic low back pain for a mean of 8 years were randomly assigned to real acupuncture, sham acupuncture, or conventional therapy (a combination of drugs, physical therapy, and exercise).⁴⁷ Acupuncture treatments consisted of needle insertions at standardized acupuncture points plus some additional points chosen by the practitioner. Brief manual manipulation was used to stimulate the needles after insertion. Sham acupuncture consisted of shallow insertion of needles at non-acupuncture points without stimulation. The primary outcome was a treatment response, defined as either a 33% improvement on the Von Korff Chronic Pain Grade Scale or a 12% improvement on the Hannover Functional Ability Questionnaire. At 6 months, there was no significant difference between the response rate with real acupuncture (47.6%) and the rate with sham acupuncture (44.2%; $P=0.39$), but both real and sham acupuncture were significantly better than conventional therapy (27.4%; $P<0.001$ for both comparisons).

A large trial in Germany,⁵⁰ 3093 patients with chronic low back pain for a mean of 7 years were randomly assigned to receive either acupuncture or no acupuncture in addition to usual medical care. The primary end point was back function, as assessed with the use of the Hannover Functional Ability Questionnaire, which generates a

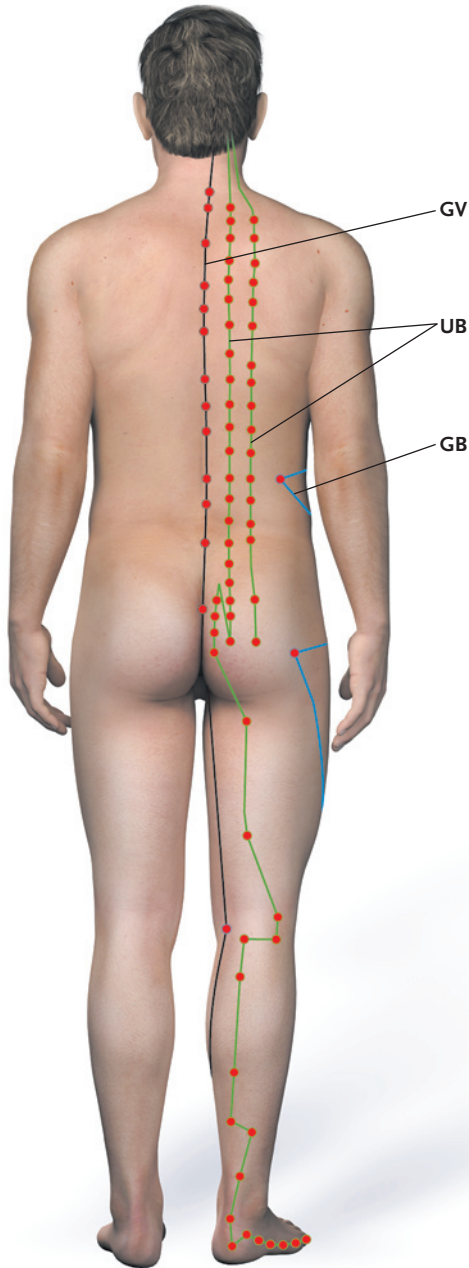


Figure 1. Acupuncture Meridians.

Twelve of the major acupuncture meridians are associated with a specific internal organ (e.g., heart, lung, or spleen), and an additional eight meridians are considered to be vessels or reservoirs of energy (*qi*) not associated with internal organs. Shown are the governing vessel (GV) meridian (black), the urinary bladder (UB) meridian (green), and the gallbladder (GB) meridian (blue).

lation,⁴² and increases in local blood flow.⁴³ However, the various observations that have been made are not sufficient to permit a unified the-

score ranging from 0 to 100, with 100 representing perfect back function. At 3 months, the mean back-function score in the acupuncture group had increased from 61.8 to 74.5 (a mean increase of 12.1 points), and the mean score in the control group had increased from 63.3 to 65.1 (a mean increase of 2.7 points), for a difference in mean between-group improvement of 9.4 points (95% confidence interval, 8.3 to 10.5; $P < 0.001$).

CLINICAL USE

Acupuncture is considered to be a form of alternative or complementary medicine, and as noted above, it has not been established to be superior to sham acupuncture for the relief of symptoms of low back pain. As a result, it is not often regarded as the first choice of therapy. However, since extensive clinical trials have suggested that acupuncture may be more effective than usual care, it is not unreasonable to consider acupuncture before or together with conventional treatments, such as physical therapy, pain medication, and exercise. Many pain specialists incorporate acupuncture into a multidisciplinary approach to the management of chronic low back pain.

Acupuncture is a regulated discipline, and patients should be referred only to practitioners who are licensed by the state in which they practice. A diploma from the National Certification Commission for Acupuncture and Oriental Medicine is a requirement for licensure in most states. Physicians may practice acupuncture in the United States after completing one of several medical acupuncture programs.

It is essential that all patients with chronic or recurrent low back pain undergo a careful diagnostic evaluation before selecting a course of therapy. Patients with serious spinal disease, such as cancer or infection, are not appropriate candidates for acupuncture and require specific medical or surgical intervention as dictated by the underlying disorder. Clinical practice guidelines emphasize clinical “red flags,” such as a neurologic deficit, unexplained weight loss, fever, and structural deformity.⁵¹ Imaging is recommended for patients older than 50 years of age and for those with signs or symptoms suggesting systemic disease.⁵²

Contraindications to acupuncture include clotting and bleeding disorders (e.g., hemophilia and advanced liver disease), warfarin use, severe psy-

chiatric conditions (e.g., psychosis), and local skin infections or trauma to the skin (e.g., burns).⁵³ In addition, electroacupuncture should be avoided at the site of implanted electrical devices, such as pacemakers. Acupuncture is not contraindicated during pregnancy. However, some specific acupuncture points are known to be especially sensitive to needle insertion; these sites, as well as acupuncture points in the abdominal regions, should be avoided in pregnant women.⁵⁴

In the traditional practice of acupuncture, needle insertion itself may be accompanied by a variety of ancillary procedures, including palpation of the radial artery and other areas of the body, examination of the tongue, and recommendation of herbal medications. All of these steps are based on the application of principles of traditional Chinese medicine, as opposed to Western physiological and medical concepts. To what extent such procedures may contribute to the psychological milieu of acupuncture is unknown, and only a few studies have examined the context in which acupuncture treatment is delivered.^{32,55}

During an acupuncture session for low back pain, the patient lies prone on a treatment couch, with the sites of intended needle insertion exposed. Acupuncturists typically individualize the selection of insertion points for each patient at each treatment session on the basis of the history and physical examination. Nonetheless, there are certain commonly used acupuncture points for low back pain, which are listed in Table 1 and shown in Figure 2.^{56,57} A practitioner may modify the treatment protocol by adding supplemental points. The depth of needle insertion (6.4 to 38.1 mm) and the diameter (0.1 to 0.3 mm), length (12.7 to 76.2 mm), and number (4 to 20) of needles used all vary among practitioners and acupuncture schools.

After insertion of the needles, the patient is advised to relax and rest with the needles left in place, typically for 15 to 30 minutes. Frequently, the needles are stimulated manually by the practitioner in order to elicit a dull, localized, aching sensation that is termed *de qi*, as well as “needle grasp,” a tugging sensation perceived by the acupuncturist and caused by mechanical interaction between the needle and connective tissue.⁵⁸ The practitioner may further stimulate the needle with electrical current (electroacupuncture), moxibustion (burning the herb *artemisia vulgaris* at the end of the acupuncture needle), or heat.

Table 1. Acupuncture Points Commonly Used in the Treatment of Chronic Low Back Pain.*

Point Name†	Location‡
UB 23 (<i>shenshu</i>)	At the level of the lower border of the spinous process of the second lumbar vertebra, 1.5 <i>cun</i> lateral to GV 4
UB 25 (<i>dachangshu</i>)	At the level of the lower border of the spinous process of the fourth lumbar vertebra, 1.5 <i>cun</i> lateral to GV 3
GV 3 (<i>yaoyangguan</i>)	Below the spinous process of the fourth lumbar vertebra, at the level with the iliac crest
UB 40 (<i>weizhong</i>)	At the midpoint of the transverse crease of the popliteal fossa, between the tendons of the biceps femoris muscle and the semitendinosus muscle
GB 30 (<i>huantiao</i>)	At the junction of the lateral third and medial two thirds of the distance between the greater trochanter and the sacral hiatus

* Data are adapted from Cheng.⁵⁶ GB denotes gallbladder, GV governing vessel, and UB urinary bladder.

† Acupuncture points are conventionally identified in one of two ways: by the meridian on which they are located and the numerical position on that meridian or by their Chinese name. Both are listed here (e.g., the acupuncture point *shenshu* is the 23rd acupuncture point on the UB meridian).

‡ A measurement that is traditionally used to locate acupuncture points in proportion to the patient's body is called *cun*. It is equivalent to the width of the interphalangeal joint of the middle finger when it is flexed.

The number and frequency of acupuncture treatments vary; however, most practitioners do not consider one treatment to be adequate. In the recent trials of acupuncture for low back pain, a minimum of 12 sessions of acupuncture were administered, often starting with 2 sessions a week and tapering off after 4 weeks to once weekly.^{46,47,49,50} Booster treatments, monthly or every other month, are sometimes used in follow-up. However, if no effects are evident after 10 to 12 sessions, treatment should be discontinued.⁵⁹ The cost of acupuncture treatment varies across the country and may range from \$65 to \$125 per session. Medicare and Medicaid do not cover acupuncture; however, the proportion of third-party plans providing coverage increased from 32% in 2002 to 47% in 2004.⁶⁰

ADVERSE EFFECTS

Major adverse effects of acupuncture appear to be rare. Two prospective surveys, covering a total of more than 60,000 acupuncture sessions, did not reveal any serious adverse events.^{61,62} Significant minor adverse events, all occurring in less than 0.1% of cases, included needle-site pain, nausea

and vomiting, and dizziness or fainting. In another survey, which included 9429 physicians performing more than 760,000 sessions of acupuncture, two instances of pneumothorax, one exacerbation of depression, an acute hypertensive crisis, a vasovagal reaction, and an asthma attack with hypertension and angina were reported.⁶³ Nonserious adverse events included needle-site pain in 3% of patients, hematoma in 3%, bleeding in 1%, and orthostatic symptoms in 0.5%.

In a German study involving more than 2 million acupuncture treatments in 229,230 patients, 8.6% reported at least one adverse event, and 2.2% reported one that required treatment.⁶⁴ The most common adverse effects were bleeding or hematoma (6.1%) and pain (1.7%). Two patients had a pneumothorax. One adverse event, a nerve injury in a lower limb, persisted for 180 days.

AREAS OF UNCERTAINTY

There is continuing debate in the medical community regarding the role of the placebo effect in acupuncture. As noted above, the most recent well-powered clinical trials of acupuncture for chronic low back pain showed that sham acupuncture was as effective as real acupuncture. The simplest explanation of such findings is that the specific therapeutic effects of acupuncture, if present, are small, whereas its clinically relevant benefits are mostly attributable to contextual and psychosocial factors, such as patients' beliefs and expectations, attention from the acupuncturist, and highly focused, spatially directed attention on the part of the patient.^{34,65,66} These studies also seem to indicate that needles do not need to stimulate the traditionally identified acupuncture points or actually penetrate the skin to produce the anticipated effect. On the other hand, acupuncture-needle stimulation has analgesic effects in studies in animals, and a number of imaging studies in humans have shown changes in limbic structures after traditional acupuncture that are distinct from changes after sham acupuncture, even though the active and sham treatments have equivalent analgesic effects.^{32,40,67} These findings suggest that it is difficult to design a sham procedure that is both believable to patients and physiologically inactive.

Future studies should focus on the association between the acupuncture procedure and the psychosocial context within which it is applied —

for example, by comparing acupuncture performed in a neutral environment with that performed in the context of traditional ancillary techniques. It may also be important to try to identify the optimal candidate for acupuncture on the basis of individual beliefs, expectations, and psychological profile and to study the relative effectiveness of acupuncture in comparison with other non-pharmacologic approaches, such as cognitive behavioral approaches, relaxation therapy, massage therapy, and biofeedback. Finally, we recommend that additional studies further evaluate the efficacy of sham acupuncture without skin penetration, since it may be possible to achieve the benefits of acupuncture without an invasive procedure.

GUIDELINES

The American College of Physicians and the American Pain Society have issued joint clinical practice guidelines recommending that clinicians consider acupuncture as one possible treatment option for patients with chronic low back pain who do not have a response to self-care.^{68,69} The level of supporting evidence for this recommendation was characterized as fair, and it was noted that recommendations may change as new studies become available.

Furthermore, the North American Spine Society recently concluded that acupuncture provides better short-term pain relief and functional improvement than no treatment and that the addition of acupuncture to other treatments provides a greater benefit than other treatments alone.⁷⁰ This review also identified a need for additional high-quality, randomized, controlled trials comparing acupuncture with no treatment and with sham acupuncture. Finally, the U.K. National Institute for Health and Clinical Excellence has recommended acupuncture as a treatment option for patients with low back pain. As a result, the U.K. National Health Service now provides a maximum of 10 sessions of acupuncture over a period of 12 weeks for people with low back pain that has persisted for more than 6 weeks.⁷¹

RECOMMENDATIONS

The patient in the vignette has chronic back pain that has not responded to a number of medical treatments. First, we would reassure him that the

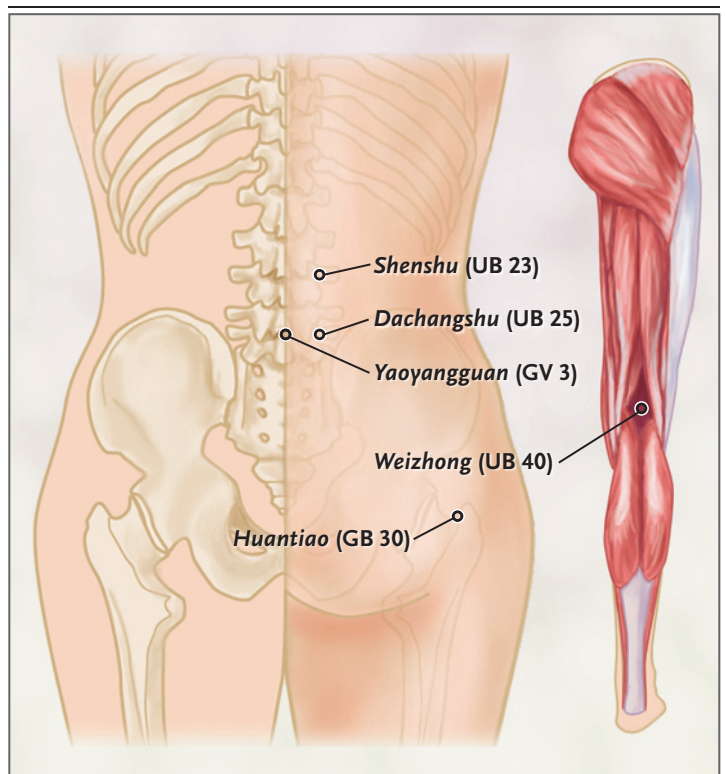


Figure 2. Acupuncture Points Used in the Treatment of Chronic Low Back Pain.

Shown are the locations of acupuncture points that are commonly used in the treatment of chronic low back pain, including UB 23 (*shenshu*), UB 25 (*dachangshu*), GV 3 (*yaoyangguan*), UB 40 (*weizhong*), and GB 30 (*huantiao*). GB denotes gallbladder, GV governing vessel, and UB urinary bladder.

clinical examination and MRI showed no evidence of a serious underlying condition requiring specific therapy, such as cancer or spinal infection. We would encourage him to stay active in order to improve function and to consider a tailored stretching and strengthening exercise program. He has specifically requested a referral for acupuncture, and we would suggest a course of 10 to 12 treatments over a period of 8 weeks from a licensed acupuncturist or a physician trained in medical acupuncture. The National Certification Commission for Acupuncture and Oriental Medicine and the American Academy of Medical Acupuncture are potential resources for finding a qualified local practitioner. At the end of treatment, we would assess the patient's response, particularly his level of pain, mood, and general activity level, and make a determination about whether he should receive additional acupuncture treatments.

Dr. Langevin reports being a member of the board of directors of Stromatec and receiving grant support and payment for travel and accommodation expenses from Stromatec. No other potential conflict of interest relevant to this article was reported.

Disclosure forms provided by the authors are available with the full text of this article at NEJM.org.

We thank Eric Manheimer, M.S., and Lixing Lao, Ph.D., of the University of Maryland Center for Integrative Medicine, Susan Hartnoll, B.A., of the Institute for Integrative Health, Gary Kaplan, D.O., of the Kaplan Clinic, and James Swyers, M.A., for their comments and advice on the manuscript and Katrina Farber for her administrative assistance.

REFERENCES

- Andersson GB. Epidemiological features of chronic low-back pain. *Lancet* 1999;354:581-5.
- Hart LG, Deyo RA, Cherkin DC. Physician office visits for low back pain: frequency, clinical evaluation, and treatment patterns from a U.S. national survey. *Spine* 1995;20:11-9.
- Deyo RA, Mirza SK, Martin BI. Back pain prevalence and visit rates: estimates from U.S. national surveys, 2002. *Spine* 2006;31:2724-7.
- Stanton TR, Henschke N, Maher CG, Refshauge KM, Latimer J, McAuley JH. After an episode of acute low back pain, recurrence is unpredictable and not as common as previously thought. *Spine* 2008;33:2923-8.
- Speed C. Low back pain. *BMJ* 2004;328:1119-21.
- Deyo RA, Weinstein JN. Low back pain. *N Engl J Med* 2001;344:363-70.
- Prevalence of disabilities and associated health conditions among adults — United States, 1999. *MMWR Morb Mortal Wkly Rep* 2001;50:120-5.
- Luo X, Pietrobon R, Sun SX, Liu GG, Hey L. Estimates and patterns of direct health care expenditures among individuals with back pain in the United States. *Spine* 2004;29:79-86.
- Jarvik JJ, Hollingworth W, Heagerty P, Haynor DR, Deyo RA. The Longitudinal Assessment of Imaging and Disability of the Back (LAIDBack) Study: baseline data. *Spine* 2001;26:1158-66.
- Jensen MC, Brant-Zawadzki MN, Obuchowski N, Modic MT, Malkasian D, Ross JS. Magnetic resonance imaging of the lumbar spine in people without back pain. *N Engl J Med* 1994;331:69-73.
- Carragee EJ, Alamin TF, Miller JL, Carragee JM. Discographic, MRI and psychosocial determinants of low back pain disability and remission: a prospective study in subjects with benign persistent back pain. *Spine J* 2005;5:24-35.
- Jarvik JG, Hollingworth W, Heagerty PJ, Haynor DR, Boyko EJ, Deyo RA. Three-year incidence of low back pain in an initially asymptomatic cohort: clinical and imaging risk factors. *Spine* 2005;30:1541-8.
- Demoulin C, Crielaard JM, Vanderthommen M. Spinal muscle evaluation in healthy individuals and low-back-pain patients: a literature review. *Joint Bone Spine* 2007;74:9-13.
- Langevin HM, Stevens-Tuttle D, Fox JR, Badger GJ, Bouffard NA, Krag MH. Ultrasound evidence of altered lumbar connective tissue structure in human subjects with chronic low back pain. *BMC Musculoskelet Disord* 2009;10:151.
- Borsook D, Moulton EA, Schmidt KF, Becerra LR. Neuroimaging revolutionizes therapeutic approaches to chronic pain. *Mol Pain* 2007;3:25.
- Giesecke T, Gracely RH, Grant MA, et al. Evidence of augmented central pain processing in idiopathic chronic low back pain. *Arthritis Rheum* 2004;50:613-23.
- Kobayashi Y, Kurata J, Sekiguchi M, et al. Augmented cerebral activation by lumbar mechanical stimulus in chronic low back pain patients: an fMRI study. *Spine* 2009;34:2431-6.
- Apkarian AV, Sosa Y, Sonty S, et al. Chronic back pain is associated with decreased prefrontal and thalamic gray matter density. *J Neurosci* 2004;24:10410-5.
- Buckalew N, Haut MW, Morrow L, Weiner D. Chronic pain is associated with brain volume loss in older adults: preliminary evidence. *Pain Med* 2008;9:240-8.
- Schmidt-Wilcke T, Leinisch E, Ganssbauer S, et al. Affective components and intensity of pain correlate with structural differences in gray matter in chronic back pain patients. *Pain* 2006;125:89-97.
- Hurwitz EL, Morgenstern H, Yu F. Cross-sectional and longitudinal associations of low-back pain and related disability with psychological distress among patients enrolled in the UCLA Low-Back Pain Study. *J Clin Epidemiol* 2003;56:463-71.
- Pincus T, Burton AK, Vogel S, Field AP. A systematic review of psychological factors as predictors of chronicity/disability in prospective cohorts of low back pain. *Spine* 2002;27(5):E109-E120.
- Dionne CE. Psychological distress confirmed as predictor of long-term back-related functional limitations in primary care settings. *J Clin Epidemiol* 2005;58:714-8.
- Woby SR, Watson PJ, Roach NK, Urnston M. Adjustment to chronic low back pain — the relative influence of fear-avoidance beliefs, catastrophizing, and appraisals of control. *Behav Res Ther* 2004;42:761-74.
- Apkarian AV, Bushnell MC, Treede RD, Zubieta JK. Human brain mechanisms of pain perception and regulation in health and disease. *Eur J Pain* 2005;9:463-84.
- Baliki MN, Chialvo DR, Geha PY, et al. Chronic pain and the emotional brain: specific brain activity associated with spontaneous fluctuations of intensity of chronic back pain. *J Neurosci* 2006;26:12165-73.
- Derbyshire SW. Meta-analysis of thirty-four independent samples studied using PET reveals a significantly attenuated central response to noxious stimulation in clinical pain patients. *Curr Rev Pain* 1999;3:265-80.
- Tsao H, Galea MP, Hodges PW. Reorganization of the motor cortex is associated with postural control deficits in recurrent low back pain. *Brain* 2008;131:2161-71.
- White A, Ernst E. A brief history of acupuncture. *Rheumatology (Oxford)* 2004;43:662-3.
- Lewis K, Abdi S. Acupuncture for lower back pain: a review. *Clin J Pain* 2010;26:60-9.
- Cherkin DC, Deyo RA, Sherman KJ, et al. Characteristics of licensed acupuncturists, chiropractors, massage therapists and naturopathic physicians. *J Am Board Fam Pract* 2002;15:378-90.
- Kong J, Kaptchuk TJ, Polich G, et al. Expectancy and treatment interactions: a dissociation between acupuncture analgesia and expectancy evoked placebo analgesia. *Neuroimage* 2009;45:940-9.
- Pariente J, White P, Frackowiak RS, Lewith G. Expectancy and belief modulate the neuronal substrates of pain treated by acupuncture. *Neuroimage* 2005;25:1161-7.
- Liu T. Acupuncture: what underlies needle administration? *Evid Based Complement Alternat Med* 2008;6:185-93.
- Wang SM, Kain ZN, White P. Acupuncture analgesia: I. The scientific basis. *Anesth Analg* 2008;106:602-10.
- Han JS. Acupuncture: neuropeptide release produced by electrical stimulation of different frequencies. *Trends Neurosci* 2003;26:17-22.
- Pomeranz B. Scientific research into acupuncture for the relief of pain. *J Altern Complement Med* 1996;2:53-60.
- Li A, Lao L, Wang Y, et al. Electroacupuncture activates corticotrophin-releasing hormone-containing neurons in the paraventricular nucleus of the hypothalamus to alleviate edema in a rat model of inflammation. *BMC Complement Alternat Med* 2008;8:20.
- Dhond RP, Kettner N, Napadow V. Neuroimaging acupuncture effects in the human brain. *J Altern Complement Med* 2007;13:603-16.
- Harris RE, Zubieta JK, Scott DJ, Napadow V, Gracely RH, Clauw DJ. Traditional Chinese acupuncture and placebo (sham)

- acupuncture are differentiated by their effects on mu-opioid receptors (MORs). *Neuroimage* 2009;47:1077-85.
41. Langevin HM, Churchill DL, Wu J, et al. Evidence of connective tissue involvement in acupuncture. *FASEB J* 2002;16:872-4.
 42. Goldman N, Chen M, Fujita T, et al. Adenosine A1 receptors mediate local anti-nociceptive effects of acupuncture. *Nat Neurosci* 2010 May 30 (Epub ahead of print).
 43. Sandberg M, Lundeberg T, Lindberg LG, Gerdle B. Effects of acupuncture on skin and muscle blood flow in healthy subjects. *Eur J Appl Physiol* 2003;90:114-9.
 44. Yuan J, Purepong N, Kerr DP, Park J, Bradbury I, McDonough S. Effectiveness of acupuncture for low back pain: a systematic review. *Spine* 2008;33:E887-E900.
 45. Rubinstein SM, van Middelkoop M, Kuijpers T, et al. A systematic review on the effectiveness of complementary and alternative medicine for chronic non-specific low-back pain. *Eur Spine J* 2010 March 14 (Epub ahead of print).
 46. Brinkhaus B, Witt CM, Jena S, et al. Acupuncture in patients with chronic low back pain: a randomized controlled trial. *Arch Intern Med* 2006;166:450-7.
 47. Haake M, Muller HH, Schade-Brittinger C, et al. German Acupuncture Trials (GERAC) for chronic low back pain: randomized, multicenter, blinded, parallel-group trial with 3 groups. *Arch Intern Med* 2007;167:1892-8. [Erratum, *Arch Intern Med* 2007;167:2072.]
 48. Cherkin DC, Sherman KJ, Avins AL, et al. A randomized trial comparing acupuncture, simulated acupuncture, and usual care for chronic low back pain. *Arch Intern Med* 2009;169:858-66.
 49. Thomas KJ, MacPherson H, Thorpe L, et al. Randomised controlled trial of a short course of traditional acupuncture compared with usual care for persistent non-specific low back pain. *BMJ* 2006; 333:623.
 50. Witt CM, Jena S, Selim D, et al. Pragmatic randomized trial evaluating the clinical and economic effectiveness of acupuncture for chronic low back pain. *Am J Epidemiol* 2006;164:487-96.
 51. Dagenais S, Tricco AC, Haldeman S. Synthesis of recommendations for the assessment and management of low back pain from recent clinical practice guidelines. *Spine J* 2010;10:514-29.
 52. Jarvik JG, Deyo RA. Diagnostic evaluation of low back pain with emphasis on imaging. *Ann Intern Med* 2002;137:586-97.
 53. Chung A, Bui L, Mills E. Adverse effects of acupuncture. Which are clinically significant? *Can Fam Physician* 2003;49: 985-9.
 54. Ee CC, Manheimer E, Pirodda MV, White AR. Acupuncture for pelvic and back pain in pregnancy: a systematic review. *Am J Obstet Gynecol* 2008;198:254-9.
 55. Kaptchuk TJ, Kelley JM, Conboy LA, et al. Components of placebo effect: randomised controlled trial in patients with irritable bowel syndrome. *BMJ* 2008;336: 999-1003.
 56. Cheng X. Chinese acupuncture and moxibustion. In: Cheng X, ed. *Chinese acupuncture and moxibustion*. Beijing: Foreign Language Press, 1987:322-9.
 57. Sherman KJ, Cherkin DC. Developing methods for acupuncture research: rationale for and design of a pilot study evaluating the efficacy of acupuncture for chronic low back pain. *Altern Ther Health Med* 2003;9:54-60.
 58. Langevin HM, Churchill DL, Cipolla MJ. Mechanical signaling through connective tissue: a mechanism for the therapeutic effect of acupuncture. *FASEB J* 2001;15:2275-82.
 59. Helms J. Getting to know you: a physician explains how acupuncture helps you be the best you. Berkeley, CA: Medical Acupuncture Publishers, 2007.
 60. Employer health benefits 2004 annual survey. Menlo Park, CA: Kaiser Family Foundation and Health Research and Educational Trust, 2004.
 61. MacPherson H, Thomas K, Walters S, Fitter M. The York Acupuncture Safety Study: prospective survey of 34 000 treatments by traditional acupuncturists. *BMJ* 2001;323:486-7.
 62. White A, Hayhoe S, Hart A, Ernst E. Adverse events following acupuncture: prospective survey of 32 000 consultations with doctors and physiotherapists. *BMJ* 2001;323:485-6.
 63. Melchart D, Weidenhammer W, Streng A, et al. Prospective investigation of adverse effects of acupuncture in 97 733 patients. *Arch Intern Med* 2004;164:104-5.
 64. Witt CM, Pach D, Brinkhaus B, et al. Safety of acupuncture: results of a prospective observational study with 229,230 patients and introduction of a medical information and consent form. *Forsch Komplementarmed* 2009;16:91-7.
 65. Paterson C, Dieppe P. Characteristic and incidental (placebo) effects in complex interventions such as acupuncture. *BMJ* 2005;330:1202-5.
 66. Linde K, Witt CM, Streng A, et al. The impact of patient expectations on outcomes in four randomized controlled trials of acupuncture in patients with chronic pain. *Pain* 2007;128:264-71.
 67. Napadow V, Liu J, Li M, et al. Somatosensory cortical plasticity in carpal tunnel syndrome treated by acupuncture. *Hum Brain Mapp* 2007;28:159-71.
 68. Chou R, Qaseem A, Snow V, et al. Diagnosis and treatment of low back pain: a joint clinical practice guideline from the American College of Physicians and the American Pain Society. *Ann Intern Med* 2007;147:478-91.
 69. Chou R, Huffman LH. Nonpharmacologic therapies for acute and chronic low back pain: a review of the evidence for an American Pain Society/American College of Physicians clinical practice guideline. *Ann Intern Med* 2007;147:492-504. [Erratum, *Ann Intern Med* 2008;148:247-8.]
 70. Ammendolia C, Furlan AD, Imamura M, Irvin E, van Tulder M. Evidence-informed management of chronic low back pain with needle acupuncture. *Spine J* 2008;8: 160-72.
 71. Low back pain: early management of persistent non-specific low back pain. Clinical guideline no. 88. London: National Institute for Health and Clinical Excellence, 2009.

Copyright © 2010 Massachusetts Medical Society.

IMAGES IN CLINICAL MEDICINE

The *Journal* welcomes consideration of new submissions for Images in Clinical Medicine. Instructions for authors and procedures for submissions can be found on the *Journal's* Web site at NEJM.org. At the discretion of the editor, images that are accepted for publication may appear in the print version of the *Journal*, the electronic version, or both.