Anesthesiology 2001; 95:349–56

Preoperative Intradermal Acupuncture Reduces Postoperative Pain, Nausea and Vomiting, Analgesic Requirement, and Sympathoadrenal Responses

Naoki Kotani, M.D., Hiroshi Hashimoto, M.D.,* Yutaka Sato, M.D.,† Daniel I. Sessler, M.D.,‡ Hideki Yoshioka, M.D.,§ Masatou Kitayama, M.D.,§ Tadanobu Yasuda, M.D.,§ Akitomo Matsuki, M.D.‖*

Background: **In a controlled and double-blind study, the authors tested the hypothesis that preoperative insertion of intradermal needles at acupoints 2.5 cm from the spinal vertebrae (bladder meridian) provide satisfactory postoperative analgesia.**

Methods: **The authors enrolled patients scheduled for elective upper and lower abdominal surgery. Before anesthesia, patients undergoing each type of surgery were randomly assigned to one of two groups: acupuncture (n = 50 and n = 39 for upper and lower abdominal surgery, respectively) or control (n = 48 and n = 38 for upper and lower abdominal surgery, respectively). In the acupuncture group, intradermal needles were inserted to the left and right of bladder meridian 18–24 and 20–26 in upper and lower abdominal surgery before induction of anesthesia, respectively. Postoperative analgesia was maintained with epidural morphine and bolus doses of intravenous morphine. Consumption of intravenous morphine was recorded. Incisional pain at rest and during coughing and deep visceral pain were recorded during recovery and for 4 days thereafter on a four-point verbal rating scale. We also evaluated time-dependent changes in plasma concentrations of cortisol and catecholamines.**

Results: **Starting from the recovery room, intradermal acupuncture increased the fraction of patients with good pain relief as compared with the control ($P < 0.05$). Consumption of supplemental intravenous morphine was reduced 50%, and the incidence of postoperative nausea was reduced 20–30% in the acupuncture patients who had undergone either upper or lower abdominal surgery ($P < 0.01$). Plasma cortisol and epinephrine concentrations were reduced 30–50% in the acupuncture group during recovery and on the first postoperative day ($P < 0.01$).**

Conclusion: **Preoperative insertion of intradermal needles reduces postoperative pain, the analgesic requirement, and opioid-related side effects after both upper and lower abdominal surgery. Acupuncture analgesia also reduces the activation of the sympathoadrenal system that normally accompanies surgery.**

* Assistant Professor, § Instructor, ‖ Professor and Chair, Department of Anesthesiology, University of Hirosaki School of Medicine. † Vice President and Head, Department of Anesthesiology, Goshogawara Seihoku Hospital. ‡ Associate Dean for Research, Director, Outcomes Research™ Institute, Weakley Distinguished University Professor of Anesthesiology, University of Louisville, and Professor and Vice Chair, Ludwig Boltzmann Institute, University of Vienna, Vienna, Austria.

Received from the Department of Anesthesiology, University of Hirosaki, Hirosaki, Japan; the Department of Anesthesiology, Goshogawara Seihoku Hospital, Goshogawara, Japan; and Outcomes Research™ Institute and the Department of Anesthesiology, University of Louisville, Louisville, Kentucky. Submitted for publication May 17, 2000. Accepted for publication February 19, 2001. Supported by Grant-in-Aid for Scientific Research No. 08457399 from the Ministry of Education, Tokyo, Japan; grant No. GM58273 from the National Institutes of Health, Bethesda, Maryland; the Joseph Drown Foundation, Los Angeles, California; and the Commonwealth of Kentucky Research Challenge Trust Fund, Louisville, Kentucky. Presented in part at the annual meeting of the American Society of Anesthesiologists, San Francisco, California, October 16–18, 2000. The authors do not consult for, accept honoraria from, or own stock or stock options in any company related to this research.

Address reprint requests to Dr. Kotani: Department of Anesthesiology, University of Hirosaki School of Medicine, Hirosaki 036-8562, Japan. Address electronic mail to: nao@cc.hirosaki-u.ac.jp. On the World Wide Web: www.or.org. Individual article reprints may be purchased through the Journal Web site, www.anesthesiology.org.

EPIDURAL analgesia or patient-controlled analgesia relieves postoperative pain in most patients undergoing abdominal surgery. However, analgesic drugs are expensive, and opioid analgesics are associated with complications, including drowsiness, pruritus, nausea and vomiting, and respiratory depression. Even a small reduction in the requirement for opioid analgesics is thus likely to be beneficial. Among the potential methods of reducing perioperative pain is acupuncture.[1–5]

In traditional Chinese theory, there is a series of acupoints called viscera-associated points. Among them are points located 2.5 cm from the spinal vertebrae (bladder meridian [BL]). The viscera-associated BL acupoints are mainly located on middle and lower thoracic vertebrae for upper abdominal organs and on lower thoracic to lumbar vertebrae for lower abdominal organs. Stimulation of these points reduces pain induced by visceral dysfunction. Acupuncture to these points may thus alleviate pain after abdominal surgery. However, traditional needle acupuncture cannot easily be performed at these sites because it would interfere with operative maneuvers and require unusual positioning during recovery. An alternative is insertion of fine intradermal needles. These needles are virtually painless; they can be inserted preoperatively and then maintained in position with adhesive tape throughout surgery and for several postoperative days.

An excellent objective measure of postoperative pain is the plasma concentration of adrenal hormones.[6–10] Several studies showed that intraoperative analgesia reduces plasma concentration of adrenal hormones.[6–8] We therefore tested the hypothesis that preoperative insertion of intradermal needles at visceral-associated BL acupoints reduces postoperative pain scores, opioid requirement, opioid-related side effects, and adrenal responses induced by surgical stress in patients undergoing upper and lower abdominal surgery.

Methods

The protocol of this study was approved by the Institutional Review Board of University of Hirosaki (Hirosaki, Japan), and written informed consent was obtained from all participating patients. We studied patients scheduled for elective upper and lower abdominal surgery. We excluded those having one or more of the following conditions: (1) American Society of Anesthesiologists physical status greater than II; (2) preoperative

opioid or epidural analgesia for cancer pain; (3) contraindication to epidural analgesia (*i.e.*, coagulopathy, skin infection); (4) body mass index greater than 30; (5) chronic obstructive or restrictive pulmonary disease; or (6) neurologic disease or immunocompromise.

Protocol

We evaluated 107 patients undergoing elective upper abdominal surgery. On the day before surgery, an epidural catheter was inserted into the T7–T10 intravertebral space in the patients undergoing upper abdominal surgery. Epidural catheterization was performed with an 18-gauge Tuohy needle *via* a median approach and the loss-of-resistance method. A 20-gauge catheter was inserted and advanced 5–7 cm; subarachnoid placement was excluded by injection of 3 ml of 2% lidocaine, and correct catheter position was tested by injection of 7–10 ml of 1% lidocaine. We next determined the area of analgesia by administering an additional 7 ml of 1% lidocaine. Patients were then observed for at least 90 min. Technical difficulties, analgesic dermatomes, and complications of the epidural technique were recorded.

After epidural catheterization, patients who chose to participate in the study were randomly assigned to acupuncture (n = 54) or control (n = 53). The randomized treatment assignment was maintained in sequentially numbered, sealed opaque envelopes. The envelopes were opened after epidural catheterization and confirmation of correct catheter placement.

A physician visited all patients 2 h before induction of anesthesia. Patients were positioned prone, and appropriate acupuncture sites for the planned surgery were identified with a skin marker. We chose 2.5 cm to the left and right of the T9–L3 spinal vertebrae (BL18–BL24). We thus chose a total of 14 points in each patient. Then we showed the 5-mm-long intradermal needles (Asahi Industry, Inc., Kawaguchi, Japan; fig. 1) to each patient in both groups. The diameter of these needles was 0.16 mm, and they had pencil-point tips. The loop at the end of each needle prevented it from completely entering the skin.

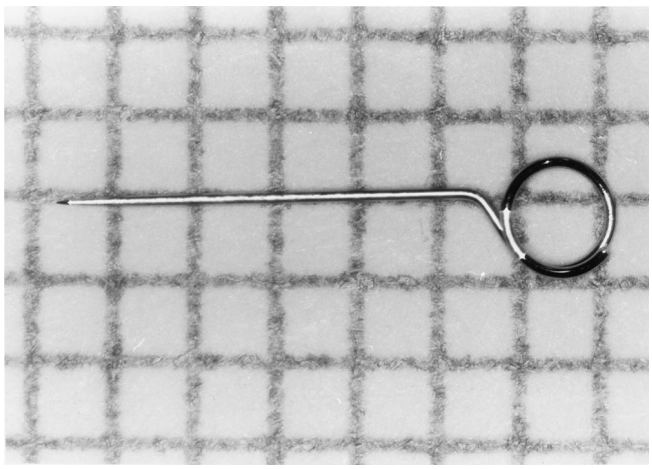

Fig. 1. Photograph of intradermal needle used in this clinical study. Scale markings are in millimeters.

We also evaluated 84 patients undergoing lower abdominal surgery. Epidural catheterization was nearly the same as in those undergoing upper abdominal surgery, with an exception of choice of intervertebral space (T10–L1). After epidural catheterization, patients choosing to participate in the study were also randomly assigned to acupuncture (n = 41) and control (n = 41) groups. Before induction of anesthesia, intradermal needles were inserted with the same method used in patients undergoing upper abdominal surgery. We chose 2.5 cm to the left and right of the T11–L5 spinal vertebrae (BL20–BL26) in patients undergoing lower abdominal surgery.

We accurately explained to each patient that insertion of intradermal needles is virtually painless and that they may or may not feel slight pain during insertion. In patients undergoing both upper and lower abdominal surgery assigned to acupuncture, the intradermal needles were inserted almost horizontally into the skin at each acupoint. In patients in control groups for upper and lower abdominal surgery, a needle was positioned at each acupoint, but the needle was not inserted into the intradermal space. The needles were secured with opaque adhesive tape and remained in position for 4 postoperative days. Insertion of these thin, short intradermal needles is painless or very nearly painless. Because we inserted the needles to the back while patients were placed in prone position, they could not see our procedure. It is thus unlikely that individual patients were able to determine whether they were in the active treatment group. The physician in charge of intradermal acupuncture was, of course, aware of the group assignment. However, the anesthesiologists providing intraoperative care, physicians evaluating pain and opioid-related side effects, and the investigators measuring various biochemical mediators were fully blinded to the group assignments.

To assure that patients were blinded to needle insertion, we performed a preliminary study in 40 patients undergoing upper abdominal surgery who were randomly assigned to acupuncture (n = 20) or control (n = 20) groups. Intradermal needles were inserted in the acupuncture patients as previously described. On the third operative day, patients were asked which group they thought they were assigned to. In both groups, 50–60% of the patients were unable to guess to which group they had been assigned, 20–30% guessed acupuncture, and the remaining 20% patients thought they were in the control group.

Patients were premedicated with 0.01–0.02 mg/kg oral diazepam and 75 mg oral roxatidine (an H_2 blocker) 90 min before induction of anesthesia. Anesthesia was

induced with 1–2 μg/kg fentanyl, 5 mg/kg thiopental, and 0.08 mg/kg vecuronium. We maintained anesthesia with 0.15 mg/kg droperidol, 10–20 μg/kg fentanyl, and vecuronium. During anesthesia, all patients were mechanically ventilated with 30% oxygen and 70% nitrous oxide to maintain the arterial carbon dioxide tension between 35 and 45 mmHg. Epidural anesthesia was not used intraoperatively. Radial arterial pressure, electrocardiogram, and pulse oximeter saturation were monitored in all patients. Lactated Ringer's solution (8–10 ml · kg^{-1} · h^{-1}) was administered per the judgment of the attending anesthesiologist.

Evaluation and Treatment of Pain

We evaluated incisional pain during bed rest and during coughing, as well as deep visceral pain with a verbal rating scale (VRS; 0 = no pain, 1 = mild pain, 2 = moderate pain, 3 = severe pain). These pain parameters were finally graded to two categories: good pain relief (VRS = 0 or 1) or poor pain relief (VRS = 2 or 3). Patients assessed drowsiness, pruritus, and nausea and vomiting with a VRS (0 = none, 1 = mild, 2 = moderate, 3 = severe). One week after surgery, we asked patients to rate the overall adequacy of pain treatment: 0 = excellent, 1 = good, 2 = fair, and 3 = poor. We could not evaluate the incidence of urinary retention because each patient had an indwelling catheter for the initial postoperative days. Postoperative pain and analgesia-related complications (below) was evaluated in the recovery room before epidural morphine was administered (elapsed time zero), and at 8 AM on the subsequent 4 postoperative days. After the first evaluation, we injected 3 mg morphine in 7–10 ml bupivacaine into the epidural catheter. Epidural morphine (3 mg) was then administered at 12-h intervals (9 PM and 9 AM) for 3 postoperative days. No other epidural morphine was given.

Residual pain was treated with intravenous morphine as needed. We calculated the daily consumption of morphine during the first 4 postoperative days. The physician in charge of evaluating pain and analgesic-related complications visited the patients at approximately 8 AM, 2 PM, and 8 PM for 4 postoperative days. When patients complained of pain at rest or during coughing (VRS ≥ 2), a bolus dose of 5 mg morphine was administered intravenously. If pain persisted (VRS ≥ 2), additional morphine was given at 30-min intervals until the VRS became less than 2. The maximum dose of morphine permitted between physician visits was 20 mg; the maximum daily allowance for intravenous morphine was thus 60 mg. On patients' request, midazolam was given intravenously at 10 PM. Respiratory depression (arterial carbon dioxide tension > 55 mmHg) accompanied by drowsiness was treated with intravenous naloxone. Pruritus was treated with antihistamines. Metoclopramide was administered as necessary for treatment of nausea and vomiting.

Measurements of Adrenal Hormones

Arterial blood for determination of cortisol, epinephrine, norepinephrine, and dopamine concentrations was sampled before induction of anesthesia, immediately before surgery, 1 h after the beginning of surgery, on emergence from anesthesia in the recovery room, and on the first postoperative day. The blood was anticoagulated with 10 mg EDTA and centrifuged immediately; the resulting plasma was stored at −80°C until analysis.

The plasma concentration of all hormones were measured in duplicate. Cortisol was measured in 0.5 ml of plasma by a slight modification of a spectrophotometric method.[11] The excitation and emission wavelengths were 470 and 530 nm, respectively. The coefficient of variation was less than 5%. Catecholamines were measured by our established method.[12] Briefly, catecholamines in 1 ml of plasma were extracted to activated almina (Wako, Tokyo, Japan) and concentrated in 150 μl methylalcohol containing 5% acetate. Pentafluoropropionic anhydride derivatives of catecholamines were synthesized and analyzed by gas chromatography–mass spectrometry (JMS-D300, JEOL, Tokyo, Japan) with a multiion detector. We used dopamine-D3 as an internal standard. A glass column contained 10% silicone GE SE-30 (80–100 mesh; GL Sciences Inc., Tokyo, Japan). The temperature of the column was 190°C. We used helium as the carrier gas at 1.2 kg/cm^2. The mass spectrum showed molecular ions at mass numbers 428, 431, 590, and 604, corresponding to the pentafluoropropionic anhydride derivatives of dopamine, dopamine-D3, norepinephrine, and epinephrine, respectively. Minimum detection concentrations of epinephrine, norepinephrine, and dopamine were 2, 1, and 1 pg/ml, respectively. The coefficient of variation was less than 7% for each.

Data Analysis

The studies in patients having upper and lower abdominal surgery were considered to be independent because we could hardly randomly assign the type of surgery. We therefore avoided statistical comparisons between the types of surgery, but instead restricted analysis to the randomized treatment groups within each type of surgery. The first evaluation of pain in the recovery room was designated as elapsed time zero. Each pain parameter was evaluated with a chi-square test.

Patients in each group were allocated to one of two categories: those with good pain relief (VRS = 0 or 1) and those with poor pain relief (VRS = 2 or 3). Other time-dependent intragroup data were evaluated with repeated-measures analysis of variance and Dunnett tests for comparison to elapsed time zero; $P < 0.05$ was considered statistically significant. Differences between the control and acupuncture groups at each time point were evaluated with two-tailed, unpaired *t* tests or chi-square tests, as appropriate. We compared values in the

Table 1. Demographic and Intraoperative Data for Patients Undergoing Upper Abdominal Surgery

	Control	Acupuncture
Number	48	50
Age (yr)	55 ± 14	52 ± 15
Gender (M/F)	30/18	29/21
Weight (kg)	60 ± 10	61 ± 9
Height (cm)	163 ± 9	164 ± 10
ASA physical status (I/II)	13/35	12/38
Duration of surgery (h)	3.4 ± 1.6	3.3 ± 1.5
Surgical procedure		
Stomach or duodenum (n)	16	15
Gall bladder (n)	11	12
Pancreas and/or bile duct (n)	6	7
Liver (n)	3	4
Any combination of the above (n)	7	6
Other upper abdominal (n)	5	6
Duration of anesthesia (h)	4.0 ± 1.7	3.9 ± 1.6
Intraoperative calcium-entry blockers (n)	24	20
Total intraoperative fentanyl (mg)	0.6 ± 0.2	0.5 ± 0.2

Data are expressed as number of patients or mean ± SD. There were no significant differences between the groups.

ASA = American Society of Anesthesiologists.

two groups at five or four (daily consumption of morphine) time points and thus used a Bonferroni correction. Data are expressed as mean ± SD.

Results

We enrolled and randomized 107 patients for upper abdominal surgery and 82 for lower abdominal surgery. Fourteen patients were unavoidably excluded because postoperative artificial respiration was required to treat dyspnea, low partial pressure of oxygen, pulmonary embolism, myocardial ischemia, or massive bleeding. Therefore, final evaluation was completed on 98 patients for upper abdominal surgery and 77 for lower abdominal surgery. Demographic and morphometric characteristics and intraoperative management were similar in the acupuncture and control groups (tables 1 and 2).

More than 30% of patients received calcium blockers for intraoperative hypertension. However, we did not administer β blockers, clonidine, and anti–angiotensin-converting enzymes. No patients complained of pain during insertion of the intradermal needles. All evaluated patients emerged from anesthesia within 10 min after nitrous oxide was discontinued and muscle relaxation was antagonized. No complications such as skin infection or postinsertion discomfort developed in any patients during the 5-day study period. One week after surgery, more than 95% of patients in both groups gave an excellent-to-good judgment of our overall pain treatment.

The degree of pain relief on the VRS for incisional pain at rest and during cough and for deep visceral pain improved significantly over time in patients undergoing upper abdominal surgery in both groups ($P < 0.0001$).

Table 2. Demographic and Intraoperative Data for Patients Undergoing Lower Abdominal Surgery

	Control	Acupuncture
Number	38	39
Age (yr)	55 ± 11	55 ± 10
Gender (M/F)	25/13	27/12
Weight (kg)	61 ± 9	62 ± 8
Height (cm)	165 ± 8	165 ± 8
ASA physical status (I/II)	12/26	10/29
Duration of surgery (h)	2.8 ± 0.9	2.8 ± 1.1
Surgical procedure		
Colon (n)	17	18
Rectum (n)	13	15
Ileum and/or cecum (n)	3	4
Any combination of the above (n)	5	2
Duration of anesthesia (h)	3.5 ± 0.9	3.5 ± 1.1
Intraoperative calcium-entry blockers	11	9
Total intraoperative fentanyl (mg)	0.5 ± 0.1	0.5 ± 0.9

Data are expressed as the number of patients or mean ± SD. There were no significant differences between the groups.

ASA = American Society of Anesthesiologists.

However, from the recovery room to the second postoperative day, postoperative pain relief was significantly better in the acupuncture than in the control group ($P < 0.05$; table 3). Results were nearly similar after lower abdominal surgery: analgesia was significantly better in the acupuncture than in the control groups from the recovery room to the first or second postoperative day ($P < 0.05$; table 4). In patients undergoing both upper and lower abdominal surgery, daily consumption of morphine decreased over time in both groups ($P < 0.0001$) but was up to 50% less in the acupuncture than in the control group on postoperative days 1–4 ($P < 0.01$; fig. 2).

None of the patients experienced respiratory depression. The incidence of other analgesic-related side effects was greatest on the day of surgery and subsequently decreased gradually. None of the observed side effects was severe. The incidence of drowsiness and pruritus was similar in the acupuncture and control groups. Postoperative nausea and vomiting were less

Table 3. Pain after Upper Abdominal Surgery

Elapsed Time (days)	Pain Relief (Good/Poor)				
	0	1	2	3	4
Pain at rest					
Control	12/36	35/13	40/8	46/2	46/2
Acupuncture	25/25*	45/5*	50/0*	50/0	50/0
Pain during cough					
Control	1/47	20/28	38/10	47/1	48/0
Acupuncture	8/42*	35/15*	47/3*	50/0	50/0
Deep pain					
Control	28/20	32/16	44/4	48/0	48/0
Acupuncture	41/9*	41/9*	50/0*	50/0	50/0

Good pain relief = pain score 0 or 1; poor pain relief = pain score 2 or 3. Elapsed time: 0 = at recovery room; 1–4 = postoperative days. Data are expressed as number of patients.

* $P < 0.05$ *versus* control.

Table 4. Pain after Lower Abdominal Surgery

Elapsed Time (days)	Pain Relief (Good/Poor) 0	1	2	3	4
Pain at rest					
Control	12/26	24/14	33/5	37/1	36/2
Acupuncture	21/18*	33/6*	38/1	38/1	38/0
Pain during cough					
Control	2/36	13/25	28/10	37/1	38/0
Acupuncture	8/31*	27/12*	34/5*	37/2	39/0
Deep pain					
Control	23/15	23/15	34/4	38/0	38/0
Acupuncture	34/5*	37/2*	39/0*	39/0	39/0

Good pain relief = pain score 0 or 1; poor pain relief = pain score 2 or 3. Elapsed time: 0 = at recovery room; 1–4 = postoperative days. Data are expressed as number of patients.

* $P < 0.05$ *versus* control.

frequent after upper abdominal surgery in the acupuncture than control groups (24% *vs.* 50%; $P < 0.05$). The incidence of nausea and vomiting was also less in the acupuncture than control patients after lower abdominal surgery (18% *vs.* 47%; $P < 0.01$; fig. 3).

Starting 1 h after the beginning of upper abdominal surgery, plasma concentrations of cortisol, norepinephrine, and epinephrine increased significantly in both groups. Plasma dopamine concentrations were elevated during recovery in both groups. All catecholamine concentrations except norepinephrine peaked at emergence from anesthesia. The increases in plasma concentrations of epinephrine and cortisol were greater in the control than in the acupuncture group during recovery and the subsequent day ($P < 0.01$; fig. 4). The results were comparable during lower abdominal surgery. However, plasma dopamine concentrations failed to increase in either group (fig. 5).

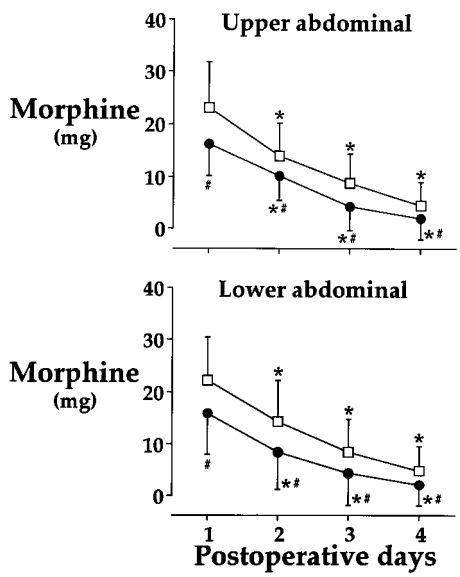

Fig. 2. Daily consumption of morphine in patients undergoing upper and lower abdominal surgery on each postoperative day. For upper abdominal surgery, results were obtained from 50 acupuncture patients (circles) and 48 control patients (squares). For lower abdominal surgery, data were obtained from 39 acupuncture patients (circles) and 38 control patients (squares). Data are expressed as mean ± SD. *Statistically significant differences ($P < 0.0001$) between first and other postoperative days in each group; #statistically significant differences ($P < 0.01$) from the control group.

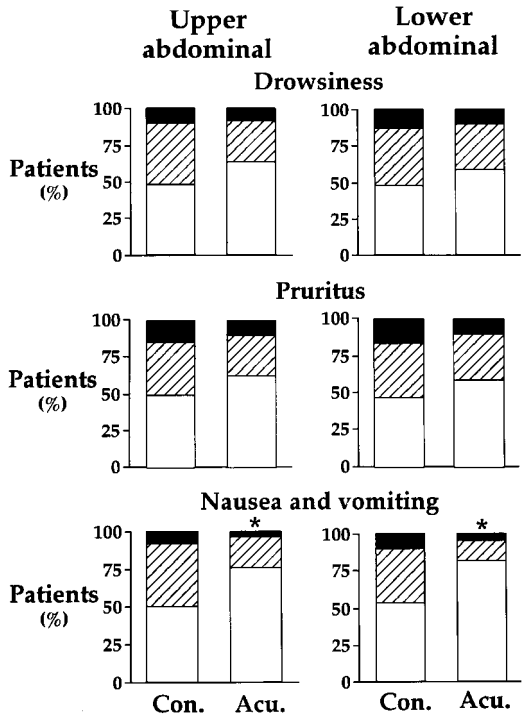

Fig. 3. Side effects (drowsiness, itching, and nausea and vomiting) in patients in the control (Con.) and the acupuncture (Acu.) group undergoing upper (*left*) and lower (*right*) abdominal surgery. The incidence was observed from the recovery room to fourth postoperative day and decreased gradually from the first operative day. Data are expressed as percentile of patients in each group. Open, hatched, and closed bars are no, mild, and moderate degree of side effects, respectively. A severe degree of side effect was not observed. *Statistically significant differences ($P < 0.05$) between the acupuncture and the control groups.

Discussion

Acupuncture increased the fraction of patients with good pain relief from the recovery room to the second postoperative day and reduced analgesic requirements by up to 50%. The mechanism by which acupuncture produces analgesia remains unclear. However, previous clinical studies[1–4] are consistent with a classical "gate control theory" in which sensory stimulation by intradermal needles activates large nerve fibers and changes pain perception in the spinal cord. This then diminishes pain stimulation transmitted *via* smaller fibers. Secretion of endogenous opioids such as endorphins, enkephalins, and dynorphins may also contribute to acupuncture analgesia.[13]

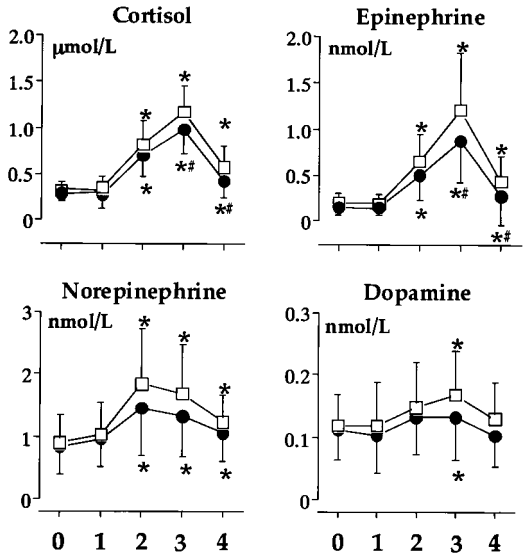

Fig. 4. Plasma concentrations of adrenal hormones in patients undergoing upper abdominal surgery in the acupuncture (n = 50, circles) and control (n = 48, squares) groups. Data are expressed as mean ± SD. 0 = before induction of anesthesia; 1 = immediately before surgery; 2 = 1 h after surgery; 3 = during recovery; 4 = first postoperative day. *Statistically significant differences ($P < 0.01$) between time zero and other time points within each group; #statistically significant differences ($P < 0.01$) from the control group.

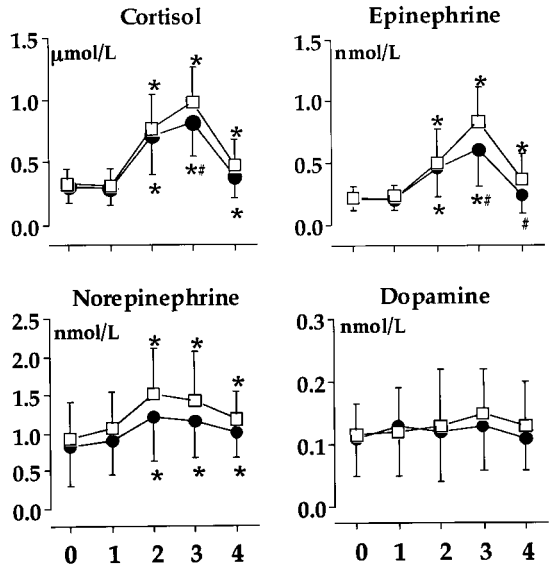

Fig. 5. Plasma concentrations of adrenal hormones in patients undergoing upper abdominal surgery in the acupuncture (n = 39, circles) and control (n = 38, squares) groups. Data are expressed as mean ± SD. 0 = before induction of anesthesia; 1 = immediately before surgery; 2 = 1 h after surgery; 3 = during recovery; 4 = first postoperative day. *Statistically significant differences ($P < 0.01$) between time zero and other time points within each group; #statistically significant differences ($P < 0.01$) from the control group.

Our study improves on previous ones[1–5] because we performed intradermal acupuncture before anesthesia and surgery and thus did not interfere with operative maneuvers and postoperative rest. Our needles were so small and so fine that none of the patients complained of needling pain or postneedling soreness. Intradermal acupuncture is easy to use and requires no special training. Furthermore, the cost/performance ratio is better than with electric acupuncture because a stimulator is not required. An important aspect of our study is that it was double-blinded. Consequently, neither the patients nor the evaluating physicians were aware of the treatment status. This is a key element of the study design because placebo effects in acupuncture can be substantial and have confounded numerous previous investigations.[13,14]

There are two types of pain after abdominal surgery: incisional and visceral. In our experience, sharp incisional pain dominates the early postoperative course. Deep visceral pain thus appeared to be masked by the sharp incisional pain on the first operative day. Incisional pain was successfully treated by opioid analgesics, but deep visceral pain was not relieved and thus dominated after several days. Although acupuncture may have modulated the visceral nociceptive system in animal experiments,[15,16] whether acupuncture improves postoperative visceral pain has not been clear. One study by Smith *et al.*[17] suggested that electroacupuncture was more effective in reducing incisional pain than in relieving visceral pain. An important finding in our study is that preoperative acupuncture reduced deep visceral pain. This is consistent with the fact that stimulation of acupoints of BL is traditionally used for various types of pain caused by vital organ disturbances.

Preoperative intradermal acupuncture reduced the incidence of postoperative nausea and vomiting after upper and lower abdominal surgery. This antiemetic effect can be explained, in part, by better analgesia and a lesser opioid requirement.[1,2,18] In addition to analgesic effects, direct antiemetic effects are also plausible. Dundee *et al.*[19] reported that acupuncture needling of the sixth point on the pericardial meridian (P6, Neikuan) is antiemetic in adult patients undergoing minor gynecologic surgery in whom pain was unlikely to be a major trigger for nausea and vomiting. Ho *et al.*[18] reported the beneficial effect of acupuncture on prevention of nausea and vomiting induced by epidural morphine.

In contrast, two studies[20,21] showed that acupuncture to P6 was not beneficial for postoperative nausea and vomiting after strabismus surgery where pain is not the trigger. This inconsistency can be explained, in part, by timing of acupuncture and selection of acupoints. Dundee *et al.*[19] pointed out that to be effective, acupuncture should be performed before emetic stimulation by anesthesia and surgery. Veroli and Astier[22] pointed out the importance of the choice of acupoints: bladder and gall bladder points are better than P6 for treatment of nausea and vomiting. The marked antiemetic effect we observed is thus presumably in part a result of our selection of acupoints and preanesthetic needling.

Thoracic epidural anesthesia can completely block the endocrine response to lower abdominal surgery.[9,10] However, high thoracic epidural anesthesia failed to suppress the responses.[9,10] Segawa *et al.*[23] showed the importance of afferent stimulation of the phrenic nerve for endocrine responses in upper abdominal surgery. Few studies evaluate the effects of acupuncture on the adrenal hormones.[24,25] Plasma cortisol and epinephrine concentrations increased over time and peaked in the recovery room, but the increases were smaller in patients who received acupuncture than in those who did not. Postoperative pain increases the plasma concentrations of cortisol and epinephrine.[26–29] It is thus likely that cortisol and epinephrine concentrations increased less in the treated than untreated patients because acupuncture significantly reduced postoperative pain.

Intraoperative increases in plasma norepinephrine were similar in the acupuncture and control groups. Plasma norepinephrine does not correlate as closely with pain as do epinephrine and cortisol. Camu and Debucquoy[30] reported that plasma concentrations of epinephrine and cortisol decreased after postoperative opioid administration, whereas norepinephrine did not change. According to Tschernko *et al.*,[6] postoperative pain intensity and the analgesic requirement were much less in patients undergoing thoracoscopic surgery than in those who underwent axillary thoracotomy. Significantly greater plasma epinephrine concentrations were noted in the former than in the latter patients, but there were no significant differences in plasma norepinephrine concentrations. Plasma dopamine concentrations were also similar in the acupuncture and control groups. Plasma dopamine concentrations increase when the adrenal medulla is maximally stimulated.[31] Our results suggest that acupuncture cannot suppress a marked adrenomedullary activation by intraoperative nociceptive stimulation.

Although acupuncture *per se* reduces the sympathoadrenal activity in both animal[32] and human[33,34] studies, our results differ from those reported by Kho *et al.*,[25] who reported no differences in plasma adrenal hormones in patients with and without intraoperative acupuncture. This inconsistency may be a result, in part, of methodologic differences. Moreover, a serious limitation of their study is that they failed to evaluate postoperative pain or analgesic requirements. It therefore remains unclear whether their acupuncture method produced postoperative analgesia.

In summary, preoperative intradermal acupuncture does not require special training, does not interfere with operative maneuvers or postoperative rest, and does not cause complications. Intradermal acupuncture decreased incisional and visceral pain, reduced analgesic requirement, and diminished the incidence of postoperative nausea and vomiting. Acupuncture analgesia also reduced the pain-induced activation of the sympathetic nervous system that normally accompanies surgery. We conclude that preoperative intradermal acupuncture is easy to use, safe, and markedly improves postoperative analgesia.

The authors thank Elisabeth F. Lanzl, A.B., A.M. (University of Chicago, Chicago, Illinois), for editing the manuscript.

References

1. Wang B, Tang J, White PF, Naruse R, Sloninsky A, Kariger R, Gold J, Wender RH: Effect of the intensity of transcutaneous acupoint electrical stimulation on the postoperative analgesic requirement. Anesth Analg 1997; 85:406–13
2. Chen L, Tang J, White PF, Sloninsky A, Wender RH, Naruse R, Kariger R: The effect of location of transcutaneous electrical nerve stimulation on postoperative opioid analgesic requirement: Acupoint versus nonacupoint stimulation. Anesth Analg 1998; 87:1129–34
3. Christensen PA, Noreng M, Andersen PE, Nielsen JW: Electroacupuncture and postoperative pain. Br J Anaesth 1989; 62:258–62
4. Christensen PA, Rotne M, Vedelsdal R, Jensen RH, Jacobsen K, Husted C: Electroacupuncture in anaesthesia for hysterectomy. Br J Anaesth 1993; 71: 835–8
5. Martelete M, Fiori AM: Comparative study of the analgesic effect of transcutaneous nerve stimulation (TNS): Electroacupuncture (EA) and meperidine in the treatment of postoperative pain. Acupunct Electrother Res 1985; 10:183–93
6. Tschernko EM, Hofer S, Bieglmayer C, Wisser W, Haider W: Early postoperative stress: Video-assisted wedge resection/lobectomy vs conventional axillary thoracotomy. Chest 1996; 109:1636–42
7. Varrassi G, Panella L, Piroli A, Marinangeli F, Varrassi S, Wolman I, Niv D: The effects of perioperative ketorolac infusion on postoperative pain and endocrine-metabolic response. Anesth Analg 1994; 78:514–9
8. Moller IW, Dinesen K, Sondergard S, Knigge U, Kehlet H: Effect of patient-controlled analgesia on plasma catecholamine, cortisol and glucose concentrations after cholecystectomy. Br J Anaesth 1988; 61:160–4
9. Kehlet H: The endocrine-metabolic response to postoperative pain. Acta Anaesthesiol Scand Suppl 1982; 74:173–5
10. Kehlet H: Surgical stress: The role of pain and analgesia. Br J Anaesth 1989; 63:189–95
11. Rudd BT, Sampson P, Brook BN: A new fluorimetric method of plasma cortisol assay with a study of pituitary-adrenal function using metyrapone (SU. 4885). J Endocrinol 1963; 27:317–25
12. Kudo M, Kudo T, Oyama T: The simultaneous determination of plasma concentrations of norepinephrine, epinephrine and dopamine by gas chromatography-mass spectrometry. Masui 1984; 33:1099–103
13. Hsu DT: Acupuncture: A review. Reg Anesth 1996; 21:361–70
14. Lewith GT, Kenyon JN: Physiological and psychological explanations for the mechanism of acupuncture as a treatment for chronic pain. Soc Sci Med 1984; 19:1367–78
15. Shu J, Li KY, Huang DK: The central effect of electro-acupuncture analgesia on visceral pain of rats: A study using the [3H] 2-deoxyglucose method. Acupunct Electrother Res 1994; 19:107–17
16. Guoxi T: The action of the visceronociceptive neurons in the posterior group of thalamic nuclei: Possible mechanism of acupuncture analgesia on visceral pain. Kitasato Arch Exp Med 1991; 64:43–55
17. Smith CM, Guralnick MS, Gelfand MM, Jeans ME: The effects of transcutaneous electrical nerve stimulation on post-cesarean pain. Pain 1986; 27:181–93
18. Ho CM, Hseu SS, Tsai SK, Lee TY: Effect of P-6 acupressure on prevention of nausea and vomiting after epidural morphine for post-cesarean section pain relief. Acta Anaesthesiol Scand 1996; 40:372–5
19. Dundee JW, Ghaly RG, Bill KM, Chestnutt WN, Fitzpatrick KT, Lynas AG: Effect of stimulation of the P6 antiemetic point on postoperative nausea and vomiting. Br J Anaesth 1989; 63:612–8
20. Yentis SM, Bissonnette B: Ineffectiveness of acupuncture and droperidol in preventing vomiting following strabismus repair in children. Can J Anaesth 1992; 39:151–4
21. Lewis IH, Pryn SJ, Reynolds PI, Pandit UA, Wilton NC: Effect of P6 acupressure on postoperative vomiting in children undergoing outpatient strabismus correction. Br J Anaesth 1991; 67:73–8
22. Veroli P, Astier V: Acupressure and postoperative vomiting in strabismus correction (letter). Br J Anaesth 1992; 68:634
23. Segawa H, Mori K, Kasai K, Fukata J, Nakao K: The role of the phrenic nerves in stress response in upper abdominal surgery. Anesth Analg 1996; 82:1215–24
24. Leong RJ, Chernow B: The effects of acupuncture on operative pain and the hormonal responses to stress. Int Anesthesiol Clin 1988; 26:213–7
25. Kho HG, Kloppenborg PW, van Egmond J: Effects of acupuncture and transcutaneous stimulation analgesia on plasma hormone levels during and after major abdominal surgery. Eur J Anaesthesiol 1993; 10:197–208

26. Rutberg H, Hakanson E, Anderberg B, Jorfeldt L, Martensson J, Schildt B: Effects of the extradural administration of morphine, or bupivacaine, on the endocrine response to upper abdominal surgery. Br J Anaesth 1984; 56:233–8

27. Motamed S, Klubien K, Edwardes M, Mazza L, Carli F: Metabolic changes during recovery in normothermic versus hypothermic patients undergoing surgery and receiving general anesthesia and epidural local anesthetic agents. ANESTHESIOLOGY 1998; 88:1211–8

28. Brandt MR, Korshin J, Hansen AP, Hummer L, Madsen SN, Rygg I, Kehlet H: Influence of morphine anaesthesia on the endocrine-metabolic response to open-heart surgery. Acta Anaesthesiol Scand 1978; 22:400–12

29. Hall GM, Young C, Holdcroft A, Alaghband Zadeh J: Substrate mobilisation during surgery: A comparison between halothane and fentanyl anaesthesia. Anaesthesia 1978; 33:924–30

30. Camu F, Debucquoy F: Alfentanil infusion for postoperative pain: A comparison of epidural and intravenous routes. ANESTHESIOLOGY 1991; 75:171–8

31. Woolf PD, Akowuah ES, Lee L, Kelly M, Feibel J: Evaluation of the dopamine response to stress in man. J Clin Endocrinol Metab 1983; 56:246–50

32. Li P, Sun FY, Zhang AZ: The effect of acupuncture on blood pressure: The interrelation of sympathetic activity and endogenous opioid peptides. Acupunct Electrother Res 1983; 8:45–56

33. Nishijo K, Mori H, Yosikawa K, Yazawa K: Decreased heart rate by acupuncture stimulation in humans via facilitation of cardiac vagal activity and suppression of cardiac sympathetic nerve. Neurosci Lett 1997; 227:165–8

34. Ernst M, Lee MH: Sympathetic effects of manual and electrical acupuncture of the Tsusanli knee point: Comparison with the Hoku hand point sympathetic effects. Exp Neurol 1986; 94:1–10