Transcutaneous electrical nerve stimulation was administered to 100 patients as a means of relieving post-incisional pain experienced after abdominal or thoracic surgery. Data analysis, which incorporated figures on a control group of patients, indicated that transcutaneous electrical nerve stimulation is a safe and effective means of alleviating post-incisional surgical pain. The end result is a significant reduction in narcotic requirements.

A new method is emerging as an adjunct to the treatment of postoperative incisional pain. It has proved to be virtually free of complications, simple, and highly effective. This method is called transcutaneous electrical nerve stimulation (TENS). Among the reported advantages of this method are a decreased use of postoperative narcotics and a reduced incidence of atelectasis and postoperative ileus.1-8

The TENS system consists of a battery-powered, portable pulse generator, approximately the size of a pocket paging device; a pair of cables; and a pair of sterile electrically conductive tape electrodes that are applied to the skin on each side of the incision.

According to a recent Food and Drug Administration (FDA) report,6 notable efficacy was achieved in treating acute pain states. "Good to excellent" results were obtained in 66% to 80% of cases in sample studies.7-8 This data suggests that TENS has the potential to manage acute pain conditions where narcotic drugs are now being used. Increasing numbers of anesthesiologists as well as neurosurgeons, rehabilitation specialists, and orthopedic surgeons are currently using TENS postoperatively.

History

The ancients were the first to use electrical stimulation. In the first century AD, Scribonius Largus6 used electric fish to treat the pain of headache and gout. In the eighteenth century, Benjamin Franklin10 experimented with electrotherapy in the treatment of several medical problems, including epilepsy. In 1791, Galvani11 published his results on stimulation of frog legs with chemical batteries. During the first half of the nineteenth century, electromagnetic generators and hand-held electrodes were being used to relieve pain.12

At the turn of the twentieth century, electrical devices for the control of pain fell into disrepute for a number of reasons. Namely, these devices had limited clinical effectiveness (most likely due to their crude design). In addition the grandiosity of claims were disproportionate to the results, there was a lack of understanding of the physiologic basis for the action of such devices, and it was at this time that the drug era emerged.

Electronic sophistication, along with the "gate theory of pain"18 proposed by Melzack and Wall...
in 1965, led to the present renewed interest electronic stimulators. TENS was first used in the 1960's as a screening tool to identify suitable patients for surgically implanted dorsal column stimulation. In time, it was realized that TENS was suitable for pain relief in its own right.

**Theory of electrical stimulation**

Melzack and Wall proposed that the input along large-diameter nerve fibers blocks the sensation of pain from small-diameter nerve fibers. Since the large nerve fibers are myelinated, they are more easily stimulated electrically than the unmyelinated pain fibers. The impulses of the myelinated fibers reach the dorsolateral horns of the spinal cord, since they are conducting more quickly and "close the gate" to information coming from the smaller pain fibers.

The gate theory was the first explanation of how electrical stimulation may be effective in preventing pain impulses from reaching the cortex. Since 1965, the initial theory has been refined to include different gates at higher spinal cord and brain levels. The advantage of the gate theory over earlier explanations is that it provides a basis for both the non-destructive and a non-parenteral approach.

Based upon previous theories, medical practice has endorsed three approaches to the pain problem: drugs, surgery, or doing nothing. The new theories suggest that adding input into the pain perception system can be an effective analgesia unto itself.

More recently, work by Richardson using deep brain stimulation indicates that pain relief may be the result of inducing some neurons to release an endogenous morphine-like material called endorphin, which behaves chemically and physiologically like morphine. Analgesia produced by deep brain stimulation has been totally reversed by administering the opiate antagonist naloxone. This finding supports the hypothesis that electrical stimulation may produce an endogenous analgesic.

The use of electronic devices probably produces some placebo effect. However, the placebo effect alone in TENS has a minimal influence on clinical results, and at most, its effect is short term.

**Practical usage: A study of 200 patients**

One hundred patients about to undergo abdominal or thoracic surgery volunteered to participate in a study of the TENS system conducted at Sharon Hospital in Sharon, Connecticut. One hundred control patients were also studied. Prior approval was obtained from the surgical staff and from each patient.

The control group, selected at random, also underwent abdominal or thoracic surgery; postoperative pain was controlled by morphine sulphate or meperidine hydrochloride.

In both groups, the following data were similar: sex, weight, anesthesia, operative time, postoperative hospital stay, and type of postoperative medication. Control patients tended to be slightly younger than the TENS group.

To apply TENS, following completion of surgery and closure of the wound, the area around the incision was cleaned and dried. The electrode strips were removed from their sterile package and swabbed with Skin Prep wipes. Each electrode strip was placed parallel to, and approximately two inches from either side of the incision. As the wipes dried, the electrodes adhered to the skin.

With most patients, treatment was started within the first 24 hours after surgery by the floor nurse. The lead wires were connected to a solid-state, battery-operated pulse generator, delivering a maximal output of 112 milliamps with a fixed pulse width of 135 microseconds. Output was individually adjusted. Pulse rate was set at 100 pulses/sec. Patients were shown how to vary the output (amplitude) according to the level of pain. When a patient complained of pain, the output of the stimulator was increased until a definite "tingle" was felt. If the patient did not obtain pain relief in 30 minutes, medication was administered.

Best results were obtained when the stimulator was not used continuously. The unit was turned on 30 minutes before the patient was ambulated, or coughing exercises were undertaken or any other form of activity that might cause discomfort was initiated.

**Results of the study**

Patients in the TENS group required less morphine sulphate than those in the control group, with a significant reduction on the first (P < 0.05) and second (0.01 < P < 0.02) postoperative days. Likewise the TENS group required less meperidine hydrochloride than the control group, with a significant reduction on the third postoperative day (P < 0.05). (Figure 1.) Within the entire study group of 200 patients, the largest subgroup was the cholecystec-

---

*For this study, we used a NEUROMOD Stimulator and Epi-Strip Electrodes manufactured by Medtronic, Inc., Neuro Division, 3055 Old Highway Eight, Minneapolis, MN 55418. Other companies producing TENS units include: Med-General, Stim-Tech, 3-M, Dynex, and Mentor, all located in Minneapolis."
Figure 1
Total Postoperative Medication (Average Dose ± SE)

- Morphine Sulfate
  - TENS Patients (n = 11)
  - Controls (n = 8)

- Meperidine Hydrochloride
  - TENS Patients (n = 22)
  - Controls (n = 23)

Figure 2
Postoperative Medication: Cholecystectomy Patients (Average Dose ± SE)

- Morphine Sulfate
  - TENS Patients (n = 11)
  - Controls (n = 8)

- Meperidine Hydrochloride
  - TENS Patients (n = 22)
  - Controls (n = 23)
Nineteen of these patients were administered morphine sulphate postoperatively (11 TENS patients and 8 control patients). Forty-five cholecystectomy patients were administered meperidine hydrochloride postoperatively (22 TENS patients and 23 control patients). Post-cholecystectomy patients had a significant reduction in the use of morphine sulphate on the first postoperative day and a significant reduction in the use of meperidine hydrochloride on the first and third postoperative days ($0.02 < P < 0.05$). (Figure 2.) When comparing age groups, the control group received a higher average total mg of Demerol® (meperidine) than did the TENS group. A
slight decrease in average Demerol® usage was noted for the TENS users in the 60-79 age group compared to the 40-59 age group. No difference in Demerol® use was noted between age groups in the control group. (Figure 3.)

Little difference was noted in Demerol® use with reference to sex. The total mg usage of Demerol® was higher for the control group compared to the TENS group. (Figure 4.)

A negative result was obtained when narcotics were used preoperatively. Patients who were administered preoperative narcotics to control pain obtained reduced TENS effectiveness.

Conclusions

This study has shown that TENS can represent a valuable clinical tool in the management of post-incisional pain. No cases of infection or skin reaction were observed. TENS did not mask the pain symptoms from complications.

The results of this study support the conclusions of VanderArk and associates who reported post-incisional surgical pain relief in 77% of their study group patients. The results also support the conclusions of Hymes, Raab, Yonehiro and associates who documented significant pain relief and decreased incidence of postoperative ileus and atelectasis.

With greater experience and better education of patients and hospital personnel, the efficacy of TENS in the relief of post-incisional pain can be improved.

REFERENCES


(6) Personal contact: Veal, JR, Executive Secretary, Panel on Neurologic Devices, FDA BMDP (HFK 450). Silver Spring Plaza, 8757 Georgia Ave., Silver Spring, MD 20910.


(10) Franklin, B. 1752. A relation of a cure performed by electricity to Dr. Cadwallader Evans, student in physics at Philadelphia, September. (letter).


AUTHOR

Jack M. Neary, CRNA, is a graduate of the Alexian Brothers Hospital School of Nursing, Chicago, Illinois and Walter Reed General Hospital School of Anesthesiology for Nurses, Washington, D.C. After serving six years in the U.S. Army Nurse Corps, Mr. Neary joined the Staff of Sharon Hospital, Sharon, Connecticut in 1973. He presently serves as Chief Nurse Anesthetist at Sharon Hospital. Mr. Neary is a Certified Hypnotherapist and is the President of the Connecticut Association of Nurse Anesthetists.