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CME ARTICLE

EFFECTIVE ANALGESIA FOR EXTRACORPOREAL SHOCK WAVE LITHOTRIPSY: TRANSCUTANEOUS ELECTRICAL NERVE STIMULATION

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ABSTRACT

Objectives. Extracorporeal shock wave lithotripsy (ESWL) has revolutionized the treatment of urinary stone disease. However, the most appropriate analgesia offering pain-free treatment, minimal side effects, and adequate cost effectiveness remains to be established. This prospective study was performed to evaluate the efficacy of transcutaneous electrical nerve stimulation (TENS) during ESWL using third-generation lithotripters.

Methods. Two pairs of stimulator electrodes were placed paravertebrally at L1 and near the lithotripter shock tube before ESWL. Treatment was carried out as follows: (a) shock wave administration was begun (no current = sham TENS); (b) in the case of severe pain, TENS was begun; and (c) if patients experienced no pain relief, analgesic drugs were given intravenously.

Results. Of 149 patients, 92 (62%) did not need any analgesia (neither TENS nor medication). In 42 (72%) of the remaining 57 patients, a TENS-related, pain-relieving response was observed. ESWL-induced pain could be reduced by 39.2%. The degree of fragmentation assessed by two urologists was found to be 90% for patients receiving TENS compared with a retrospectively analyzed control group (94%, n = 100).

Conclusions. Two different theories explaining TENS-related analgesia are known: segmental (spinal) and supraspinal (central) inhibition. Since we did not observe any analgesic effect in patients having both pairs of electrodes attached around the shock tube (n = 30), supraspinal inhibition obviously accounts for the abovementioned pain relief. We conclude that TENS is a noninvasive, cost-effective method to achieve side-effect-free analgesia in ESWL using third-generation lithotripters. UROLOGY **54:** 433–436, 1999. © 1999, Elsevier Science Inc.

In the past, extracorporeal shock wave lithotripsy (ESWL) has become a standard procedure for treatment of patients with renal and ureteral stones.[1] Unfortunately, these treatments are painful and originally required general or regional anesthesia.[2] During the past decade, modifications in lithotripters have made ESWL a less painful experience; however, nearly 50% of all patients still need some form of analgesic medication.[3] In addition to commonly used intravenous drugs, several studies have demonstrated a positive effect using different methods, such as local infiltration anesthesia, intercostal blocks, lidocaine-containing creams, and petroleum jelly, on pain reduction.

Transcutaneous electrical nerve stimulation (TENS) is an effective, side-effect-free treatment modality for chronic pain. Electrical impulses produced by a portable stimulator are transmitted by cable to electrodes that are attached to specific areas of the body by tape or other adhesive. Since side effects caused by commonly used intravenously administered drugs such as opioids and benzodiazepines are still a problem, especially in outpatient settings, we investigated whether TENS might reduce pain during ESWL using third-generation lithotripters.

MATERIAL AND METHODS

After informed consent was obtained, we performed a prospective analysis of 156 consecutive patients who underwent ESWL on the Lithostar device. Seven patients were excluded from the study (5 with a cardiac pacemaker and 2 who did not

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TABLE I. *Characteristics of patients (n = 149)*

Men/women	99/50
Age (yr)	53 (16–82)
Weight (kg)	71.4 (43–99)
Upper calyceal stones	20
Lower calyceal stones	10
Renal pelvis stones	5
Upper ureteral stones	39
Mid ureteral stones	35
Lower ureteral stones	40
Treatment side	
Right	73
Left	76

Data presented as median values; numbers in parentheses are the range.

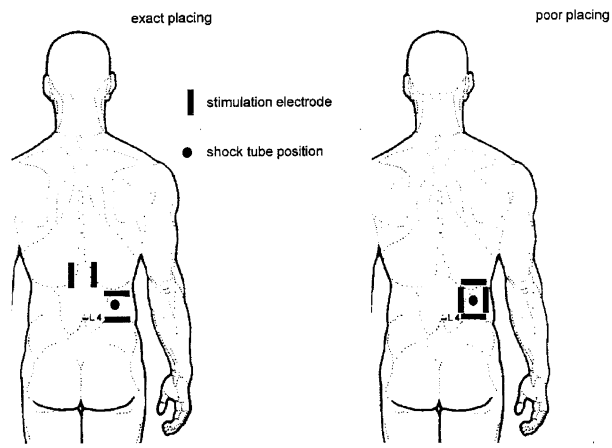

FIGURE 1. *Poor and exact placement of the stimulation electrodes.*

agree). None of the patients received any analgesic/sedative medication before ESWL. Detailed information on the calculi treated is shown in Table I. Ureteral stones were defined as follows: distal ureteral stones were located below the sacroiliac joint, proximal ureteral stones were located between the ureteropelvic junction and 2 cm above the pelvic brim, and midureteral concrements were situated in between proximal and distal calculi.

For TENS we used the ProCura device (Germany) containing a portable stimulator (frequency 70 Hz, voltage 9 V, current 20 to 60 mA) and two pairs of stimulator electrodes.

To determine the most effective placement of the stimulator electrodes, a pilot study was performed (n = 30). Positive results were seen when two electrodes were positioned paravertebrally at L1 and two near the shock tube; almost no analgesic effect was observed when all four electrodes were placed around the shock tube (Fig. 1). Therefore, one pair of stimulator electrodes was placed paravertebrally at L1 and one pair near the shock tube.

All 149 patients were informed that only attaching the stimulator electrodes would result in pain-relieving effects. Shock wave administration was started at low kilovoltage levels and increased depending on the pain development (no current = sham TENS).

In the case of severe pain, TENS was begun and the current increased until a "tickling" sensation was reported by the patient (20 to 60 mA). If patients experienced intolerable pain, analgesic drugs were given intravenously.

At the end of each session, a questionnaire concerning the pain experience was completed by all patients using a visual analog scale (VAS; 0 = no pain, 10 = unbearable pain). Before and after lithotripsy, all patients underwent plain abdominal radiography in our radiology department by standard methods.

Statistical differences were determined by the chi-square test, with $P = 0.05$ considered significant.

RESULTS

The characteristics of all 149 patients are shown in Table I. Of 149 patients, 92 did not need any analgesia (neither TENS nor drugs). Seven patients were excluded from the study (cardiac pacemaker, no agreement). In 42 of the remaining 57 patients, a TENS-related, pain-relieving response was observed. Almost all of them (40 patients, 70%) received no additional medication. ESWL-induced pain could be reduced by 39.2% (pain intensity 0 to 10: 7.4 ± 1 before versus 4.5 ± 1 after TENS). The degree of fragmentation assessed by two urologists (plain film) was found to be 90% (65% considered good and 25% very good disintegration) for the patients receiving TENS (group A, no drugs) compared with a retrospectively analyzed control group (94% = 72% good and 22% very good disintegration, n = 100, group B, intravenous drugs). The average analgesic sedative need of each patient in group B was determined: 826 mg metamizole (nonsteroidal anti-inflammatory drug), 87.5 mg tramadole (opioid), 2.5 mg piritramide (opioid), 2.1 mg pethidine (opioid), 2.3 mg midazolam (benzodiazepine), and 0.8 mg diazepam (benzodiazepine).

Table II demonstrates that TENS treatment was started after an average of 1170 shock waves. At that point, the mean pain intensity was 7.4 at an energy level of 3.5.

We did not find any correlation between stone location and TENS response rates. No studies using first- or second-generation lithotripters have been made. There is a cost saving of $4 (4 stimulator electrodes) versus $8 (intravenous medications, calculating the cost of the average medication of the control group, including preparation and injection). The TENS device costs $170.

COMMENT

Pain during ESWL appears to be a function of the high-energy distribution of the administered shock wave and the related wavefront density on the surface of the patient's body. The pathogenesis of pain in ESWL is still not fully understood. Apart from patient-related factors, several physical variables may be responsible, including shock wave generation and focusing, the configuration of the shock wave front, cavitation effects, shock wave peak pressure, the size of the focal zone, and the area of shock wave entry at the skin. In contrast to older ESWL machines, lithotripsy with second- or third-generation lithotripters is less painful because of modifications in the aperture size of the shock wave source and the decreased acoustic output of the shock wave generators. However, the important advantage of these immersion-free machines is the avoidance of regional anesthesia and thus, treatment on an outpatient basis. Nevertheless, many patients experience severe pain, necessitating intravenous anesthesia or analgesic sedation.

The results of our prospective study demonstrate that TENS significantly reduces pain during ESWL in 70% of all patients treated. In addition, only 38% of the 149 patients required pain treatment. This clearly shows the effect of recent advances in lithotripter development. Considering the abovementioned 70% response rate when reaching comparable disintegration results, it should be stressed that TENS is a noninvasive method of side-effect-free analgesia; hence, it appears to be an appropriate form of pain treatment, especially on an outpatient basis.

For many years, TENS has been used as an acceptable treatment option in patients with chronic pain[4–6]; however, reports on managing postoperative[7] and labor pain,[8,9] as well as migraine,[10] by electrical stimulation have also appeared in the literature, partly with conflicting results.[11–13] Good and very good TENS effects have been observed in patients treated for neurogenic pain, chronic back pain, postoperative pain, labor pain, phantom-limb pain, and chronic headache, with success rates ranging from 30% to 77%.[13]

TENS was originally developed (and later modified[14,15]) as a way of controlling pain through the "gate theory."[16] Nociceptive afferent activities (A-delta and C-fibers) can be inhibited by large-diameter fibers (fast A-beta fibers) at the spinal cord level within the substantia gelatinosa. This results in an inhibitory effect on afferent central transmission cells (spinal inhibition). Another theory explaining TENS-related analgesia is based on the observation that the liquor concentration of endogenous opiates increases after TENS[17,18]; serotoninergic and encephalinergic neurons within the posterior horn of the spinal cord seem to play an important role in mediating these effects (central or supraspinal inhibition). Since we did not see any analgesic effect in patients having both pairs of electrodes attached around the shock tube (n = 30), supraspinal inhibition obviously accounts for the abovementioned pain relief.

We conclude that TENS is a noninvasive, cost-effective method of side-effect-free analgesia in ESWL using third-generation lithotripters.

TABLE II. ***ESWL with and without TENS****

	TENS Start	Shock Wave Intensity (1–5)	VAS (0–10)	TENS/ESWL Stop	Shock Wave Intensity (1–5)	VAS (0–10)	Disintegration Rate† (%)	Stone-Free Rate at 3 mo (%)	Retreatment Rate Within 3 days (%)	Mean Diameter (mm)
TENS group (A)	1170 ± 680	3.5 ± 1	7.4 ± 1	3900 ± 800	3.8 ± 1	4.5 ± 1	90	87.5	28.7	8 (5–19)
Control group (B)	—	—	—	4200 ± 1000	—	4.1 ± 1	94	89.3	31.3	9 (4–20)

Key: ESWL = extracorporeal shock wave lithotripsy; TENS = transcutaneous electrical nerve stimulation; VAS = visual analog scale.
Data presented as mean ± standard deviation, unless otherwise noted.
* *In the case of severe pain, TENS was begun ("TENS Start") depending on a certain shock wave intensity level (10–25 kV = level 1–5). Before and after TENS, pain intensity was determined using a VAS.*
† *Determined by review of plain film radiographs by two urologists.*

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