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THE UNIVERSITY OF ALBERTA

IMPLEMENTING TENS TO CONTROL POST-OPERATIVE PAIN

BY

Sarah Ann Hargreaves

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF NURSING.

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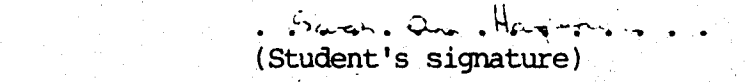

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to my parents for their unfailing support and encouragement

ABSTRACT

The purpose of this study was to examine the effect of transcutaneous electrical nerve stimulation (TENS) on the pain reported by patients who required their abdominal incision packed after surgery. A between subject post test only design with experimental blind and placebo control was employed in the study.

Seventy five subjects (mean age 56.9 years) were randomly assigned to one of three treatment groups: TENS, placebo TENS or no-treatment control. The appropriate pain treatment was administered during the routine dressing change which took place two mornings after surgery. Subjects in the TENS group had one electrode placed at each end of their incision and TENS stimulation was delivered prior to, and during, the packing procedure (average time 31 minutes, standard deviation 5.7). Subjects who received placebo TENS had inactive electrodes applied in the same manner for a similar period of time. Subjects in the no-treatment control group did not have electrodes applied. All subjects continued to receive analgesia, as prescribed, throughout their participation in the study. Following the dressing procedure, subjects reported pain experienced during the dressing using an 11-point self-report pain scale. Neither the subjects nor the nurses who did the dressing were aware of the subjects' group assignment. The experimenter who administered the treatment was unaware of group assignment for the time up until administering the treatment.

Multiple regression demonstrated that subjects who received TENS reported a significantly lower level of pain after the dressing change than did those subjects who received either placebo TENS or no-treatment. [illegible]cates that the reported finding cannot be explained as a placebo effect but [illegible] the analgesic effect of TENS. Other analyses indicated that age had an effect on drug administration practices. In this study there was a tendency for the elderly to receive fewer and smaller doses of narcotics.

ACKNOWLEDGEMENT

This thesis could not have been completed without the special contributions of several people. In particular, I would like to thank Dr. Lander for her friendship and her invaluable assistance in initiating and completing this thesis. I also gratefully acknowledge Dr. Kyriakides for her support and advice, Dr. Thomas for his enthusiasm and guidance throughout the study and Dr. Williams for his support and understanding.

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INTRODUCTION

A review of the pain literature demonstrates that our understanding of pain has increased significantly during the past 100 years. However, it is clear that despite our increased expertise in the area of pain, the pain experience remains an entity which we do not completely understand and over which we do not have complete control. Appendix A provides an historical overview of pain theories and patterns of pain management. It includes a detailed description of the gate-control theory of pain because this theory is currently the most influential pain theory in the Western world. The review also presents evidence that current methods of surgical pain management do not provide adequate pain relief during the post-operative period. Further, it suggests that transcutaneous electrical nerve stimulation (TENS) may be beneficial in the management of post-surgical pain. The present study investigates the use of TENS in the control of pain resulting from the dressing and packing of an abdominal incision.

According to recent research and anecdotal reports, a significant proportion of people having surgery can be predicted to experience inadequate pain control post-operatively (Cohen, 1980; Donovan, 1983; Keeri-Szanto, 1979; Utting & Smith, 1979; Wallace & Norris, 1975). This prediction has implications for patient recovery because surgical patients will suffer needlessly and may develop surgical complications as an indirect consequence of the pain. Cohen (1980) reported that 75% of her surgical sample

experienced moderate to severe pain post-operatively. This incidence of reported pain is accepted by health care professionals while a similar incidence of wound infections or minor atelectasis would not be tolerated.

Inadequate pain relief during the post-operative period can contribute to pulmonary, circulatory, gastrointestinal and urinary dysfunctions as well as thromboembolic processes and undesirable psychological and emotional disturbances (Benedetti, Bonica & Bellucci, 1984). Reflex muscle spasms, involuntary splinting of thoracic and abdominal muscles and fear of deep breathing and coughing can lead to ventilation/perfusion abnormalities. Segmental and suprasegmental reflex responses caused by the presence of continuous pain will increase heart rate, blood pressure, metabolism and oxygen consumption and increase the incidence of ileus and nausea as well as urethral and bladder hypomotility. Unrelieved surgical pain can also promote thrombus formation in the lower limbs related to (1)decreased physical activity and/or (2)cortically-induced anxiety mediated mechanisms: increased blood viscosity and clotting, fibrinolysis, and platelet aggregation. Unrelieved pain can also interfere with patterns of eating, sleeping and social behaviour when its presence occupies a large proportion of the individuals attention (Wall, 1979). In addition, the presence of pain can limit the effect of therapeutic interventions, for example, the adequate cleansing and packing of a surgical incision.

The presence of pain is also closely related to emotional

discomfort which can cause the patient feelings of displeasure and anguish. The most common emotional factors which accompany pain are anxiety, fear and depression, factors which have the potential to augment the pain experience thereby creating a vicious cycle of pain-anxiety-pain (Craig, 1984). This sequence of events is particularly profound in humans because of our ability to anticipate the consequences of events. All of the physiological and psychological effects which are associated with inadequate pain control serve to increase patient discomfort during the post-operative period and they support the need for adequate pain control during this time. The knowledge that prolonged, acute pain may be a precursor for chronic pain (Bonica, 1985) provides further rationale for the adequate control of surgical pain.

Clearly, effective surgical pain control would be of benefit to the patient. Intra-muscular doses of narcotic are presently the most widely used method of surgical pain control during the initial post-operative period because they are easy to administer, readily accessible and inexpensive. Their administration is routinely prescribed according to need and nurses deliver the drug, at their discretion, within a designated dose and time range. However, these drugs must be administered appropriately if they are to provide effective pain control. Unfortunately narcotic administration is frequently associated with the presence of side effects. Some of these effects are uncomfortable for the patient or unwanted by the patient. These include sedation, altered conciousness, dry mouth, nausea, profuse perspiration and pain

and/or irritation at the site of the injection. Other side effects can have a more serious impact on patient recovery, for example, disorientation and hallucinations, cardiac abnormalities and infrequently, respiratory depression. The ability of these side effects to impede patient recovery is a compelling reason to implement, when feasible, additional methods of pain control.

The elderly are one group of individuals who may derive particular benefit from the addition of alternate methods of pain control because they are especially sensitive to the effects of narcotic drugs. This increased sensitivity is related to many factors which include alteration of pain receptors, changes in plasma protein binding and a decrease in narcotic clearance (Boreus, Odar-Cederlof, Bondesson, Holmberg & Heyner, 1986; Harkins, Kwentus & Price, 1984; Kaiko, Wallenstein, Rogers, Grabinski & Houde, 1982). As a result of these changes, the elderly generally require fewer and smaller doses of narcotics than younger adults in order to obtain a similar level of pain relief (Bellville, Forrest, Miller & Brown, 1971; Kaiko, Wallenstein, Rogers, Grabinski, & Houde, 1982). The elderly are also more sensitive to narcotic side effects including respiratory depression, cough suppression and clouding of mental functions (Harkins et al., 1984). In addition, because the elderly frequently have one or more diseases which require medication-they have an increased risk of developing an interaction between the narcotic and other drugs they may be taking (Harkins et al., 1984).

In contrast with narcotics, other forms of analgesia,

including nonsteroidal anti-inflammatory drugs, control pain by acting at the periphery rather than the central nervous system. These analgesics are feasible alternatives to narcotic type drugs but their route of delivery does not make them an appropriate choice for patients immediately following abdominal and/or bowel surgery. For example, the nonsteroidal anti-inflammatory drugs are not presently available in parenteral form because they are practically insoluble in water and they are not stable in solution (Schoepp, 1986).

Witt (1984) states that any pain relieving measure should lie within the scope of the nurses' qualifications. The intervention should be effective and portable and it should not require physician supervision or informed patient consent. In addition, it must not interfere with the patients medical regime. These guidelines suggest that distraction, relaxation, suggestion, imagery and cutaneous stimulation are methods of pain relief which could be used by nurses, at their discretion, in the clinical setting. Distraction, relaxation, suggestion and imagery serve as coping mechanisms by providing the individual with some sense of control over the painful experience. As such, they are techniques designed to promote the psychological control of pain (Craig, 1984). TENS is a method of cutaneous stimulation which provides pain relief using a method of neuromodulation.

Recent research suggests that TENS has a role to play in surgical pain control although its exact mode of operation has not yet been clearly defined. One theory proposes that TENS increases

activity in the A-beta fibres and thereby decreases the transmission of information about painful stimuli to the brain. The TENS mechanism has also been explained using endogenous opiate and non-opiate pain control systems. Cheng (cited in Lapeer, 1986) proposed that low frequency TENS stimulation is responsible for activating the release of endogenous opiates while high frequency TENS stimulation stimulates the release of the neurotransmitters serotonin and norepinephrine. Both of these systems, opiate and non-opiate, activate analgesia via descending inhibition.

As a method of pain control TENS has the advantages of being portable and easy to administer. It is also accepted by a vast majority of the population because it is non-invasive and it has not been associated with the side effects commonly reported following narcotic use. Further, TENS has advantages over alternative clinical methods of counter irritation such as heat and cold therapy because the level of TENS stimulation can be accurately controlled. The only people for whom TENS should not be used are: (1)individuals with a demand cardiac pacemaker because the pacemaker field could be affected by the impulses generated by the TENS unit; (2)women in their first trimester of pregnancy because sufficient data has not been compiled in this area; and (3)individuals with a history of prolonged narcotic use prior to surgery. Research has indicated that people who receive narcotics for an extended period of time prior to TENS treatment obtain little pain relief with TENS (Cooperman, Hall, Mikalacki, Hardy & Sadar, 1977; Solomon, Viernstein & Long, 1980). Future studies

which investigate reasons for this phenomenon could aid in identifying mechanisms which promote TENS analgesia.

The TENS unit delivers a series of small electrical impulses to the skin which are felt as a slight tingling at the sites of the electrodes. It is the presence of this tingling sensation which could complicate TENS research when a placebo is employed because subjects with prior TENS experience could be aware that they are not receiving the treatment.

The impulses which are delivered to the skin must be sufficient to excite an afferent fibre in a controlled manner without causing damage to the skin. Factors which affect the threshold for stimulating peripheral fibres include the size and location of the nerve fibre as well as the pulse width and the frequency of the stimulus (Woolf, 1984). A strength duration curve illustrates that the relationship between pulse width and frequency determines the amplitude of a pulse necessary to activate a nerve.

Factors which influence how effectively TENS will deliver its analgesic effect include electrode placement, stimulation frequency, and period of TENS stimulation. Subjective patient reports indicate that optimal electrode placement for TENS stimulation is as close to the incision or the site of pain as possible (Hymes, Raab, Yonehiro, Nelson & Printy; 1974; Woolf, 1984). Patient preference for impulse frequency is variable. Although TENS studies have reported using frequencies which range from 10 to 150 Hz a low frequency requires an increased amplitude which can produce painful muscle contractions (Woolf, 1984). A

survey of 1500 surgical patients indicated that 100 Hz is the preferred setting (range 70 to 150 Hz) (Bussey & Jackson, 1981). A pulse width of 0.4 msec employed in combination with a frequency of 100 Hz should permit the use of an intensity level which does not produce painful stimulation. The induction time for TENS to produce analgesia ranges from immediately to several hours but the average time is reported to be between 15 and 20 minutes (Bornstein, 1981; Denholz, 1981; H , 1981; Lampe, 1981; Rutkowski, 1981; Shealy, 1981; Woolf, 1984).

In TENS research the number of narcotics received post-operatively is the primary outcome measure reflecting pain level. However, this may be a weak measure in that narcotic delivery is sporadic and related to both patient and nurse characteristics (Seath & Rigney-Radford, 1984; Taylor, Skelton & Butcher, 1984; Taenzer, Melzack & Jeans, 1986). Further, the correlation between narcotic requests and subjective pain ratings is weak (Taenzer, 1983). A more appropriate measure of the effectiveness of TENS is the self-reported pain experience. Research indicates that self-report provides both a reliable and a sensitive measure of pain (Revill, Robinson, Rosen & Hogg, 1976). The validity of the measure is assumed if pain is defined as whatever the patient reports it to be. The McGill Pain Questionnaire is a self-report pain scale which permits an evaluation of the sensory, affective and evaluative qualities of pain. However, the part of the instrument which measures the affective and evaluative dimensions is long. Surgical patients may

have neither the attention span nor the energy to deal with such a complex task during their first 48 hours after surgery. Use of a visual analogue scale facilitates the measure of pain in surgical patients. This type of scale, which measures the sensory dimension of pain, is administered easily (McGuire, 1984; Syrjol & Chapman, 1984). The form in which the scale is presented has not been found to influence the pain rating provided (Jensen, Karoly & Braver, 1986; Kremer, 1981).

Good post-operative care is the right of all patients who undergo surgery and a crucial part of this care includes effective pain management. Investigating pain relieving measures available to nurses is one area of nursing research which requires further exploration to enhance post-operative care. TENS appears to be a feasible method of pain control which nurses could utilize in the clinical setting and there are many aspects of patient care during the post-operative period which could benefit from the analgesic properties of TENS. The packing of an abdominal incision is one procedure which has not been used to evaluate the effect of TENS. Both physiological and psychological processes can serve to make a wound packing an uncomfortable procedure (Benedetti,Bonica & Bellucci, 1984; Craig, 1984). Although this pain may be temporary in nature it can hinder adequate cleansing and repacking of the wound and contribute to the overall general discomfort of the patient. Maximum pain control during all aspects of the post-operative period is a goal towards which health care professionals should strive. The following study is designed to

determine if TENS will decrease the amount of pain patients report after their abdominal incision is packed.

METHOD

Subjects

Seventy five patients who required their abdominal incision packed after surgery participated in the study. A sample size of 75 was considered appropriate as a result of a power test. These 75 subjects were obtained from surgical units of a large teaching hospital and they were asked to participate in the study if they met the following criteria: 18 years of age or older; English speaking; no previous TENS experience; likely to require their incision packed; no cardiac pacemaker; female subjects not in the first trimester of pregnancy; and no history of prolonged narcotic use prior to surgery. Subjects who met the criteria were randomly assigned to one of three groups.

Equipment

TENS stimulation was produced by a portable GRASS SD9 stimulator which could deliver square waves at variable pulse frequencies (0 to 200 Hz), variable pulse widths (0 to 200 msec) and variable pulse amplitudes (0 to 100 volts). The electrical impulses were delivered to the skin by a pair of pre-jelled, sterile, Myo-Trode II electrodes. An eleven-point, visual analogue pain-rating scale was used to measure pain experienced during

dressing change. A sample of the pain scale is located in Appendix B.

Design

A between subject, post-test only design constructed with experimental blind and placebo control was employed in this study.

Procedure

Consent to participate was obtained pre-operatively to facilitate informed decisions without the influence of anaesthetics or narcotics. Obtaining consent in this manner meant that some people who were approached to participate in the study became ineligible to continue because their surgical wound did not need to be packed. A summary of the study was left with each subject when consent was obtained (samples of the consent and study summary are located in Appendix C). Before any treatment was given, subjects who remained eligible for the study were again asked if they wished to participate. All potential subjects received analgesia, as prescribed, from the time of consent until their participation in the study was complete.

The experimenter approached each subject 20 minutes prior to the beginning of the study and instructed him/her in the use of the pain scale. The following procedure was then employed for all subjects: assigned pain treatment - dressing change - self-report of pain. Subjects were assigned to group by selection of a blank data sheet with a predetermined, randomly assigned group designation concealed in the top corner. Treatments had been randomly assigned with the restriction that the three treatment

groups be equally represented on the data sheets. Only after choosing a data sheet could the experimenter discover the group to which the subject was assigned. This method introduced a partial blind because the experimenter was unaware of the assigned treatment during the initial preparation of each subject for the study.

The dressing change employed in the study was the routine dressing change taking place two mornings after surgery. This dressing change was done by the nurse responsible for the subject's care therefore many different nurses were involved in the study. The experimenter waited outside the room during the dressing change.

After the nurse had completed the dressing and left the room, the experimenter returned to assess the subject's pain on an 11-point self-report pain scale. The experimenter activated a tape recorded message which directed the subject to complete the pain scale for the dressing which had just been performed. On this scale zero represented "No Pain" and ten represented "Worst Pain Imaginable". Subjects were asked to choose a point on the scale which best represented the pain they experienced during the dressing. Using a tape recorded message allowed the experimenter to leave the room so that the subjects could complete the scale with a minimum of bias. After recording pain on the pain scale, the subjects placed the sheet in an envelope. If physically unable to mark the scale, the subjects reported the pain rating to the experimenter who then recorded it.

Three pain treatment groups were compared in this study: TENS, placebo TENS and no-treatment control. Subjects in the TENS group had one electrode placed at each end of the incision. The protocol for electrode placement is located in Appendix D. The stimulator was set to deliver a pulse width of 0.4 msec and a frequency of 100 Hz for the duration of the treatment interval. The pulse amplitude or stimulation intensity was individually adapted to a level immediately below that which was reported by the subject to be uncomfortable. TENS treatment was delivered for a minimum period of 15 minutes prior to the dressing change. This length of time was variable because the nurses provided care for more than one patient and it was not always possible to begin the dressing after a fixed period of stimulation. On completion of the dressing the experimenter re-entered the room, deactivated the stimulator and removed the electrodes.

The same procedure was followed for the placebo group with one exception: no stimulation was delivered through the electrodes. However, these subjects thought they received a pain treatment because they believed electrode application placed them in the treatment group. As there were no obvious cues which could be used to distinguish placebo from active TENS both the nurse and the subject were blind to group assignment when the subject received placebo or active TENS.

Subjects in the no-treatment control group did not expect to receive a pain treatment and they received no treatment other than their prescribed analgesia. Both the subject and the nurse knew

when the subject was assigned to this group because no electrodes were applied.

In addition to measuring reported pain, other information was recorded for each subject. This included details on drug administration. Specifically, time and dose of the last documented analgesic received prior to the study dressing and the frequency of narcotic administration post surgery were recorded. Demographic data were also obtained at this time.

In this study the independent variable was the pain treatment with three manipulated values: no-treatment control, placebo TENS and treatment TENS. The subjective report of pain on an eleven-point scale was the dependent variable.

Hypothesis

Subjects who receive TENS will report less pain resulting from an abdominal wound packing than subjects who receive either no-treatment or placebo TENS.

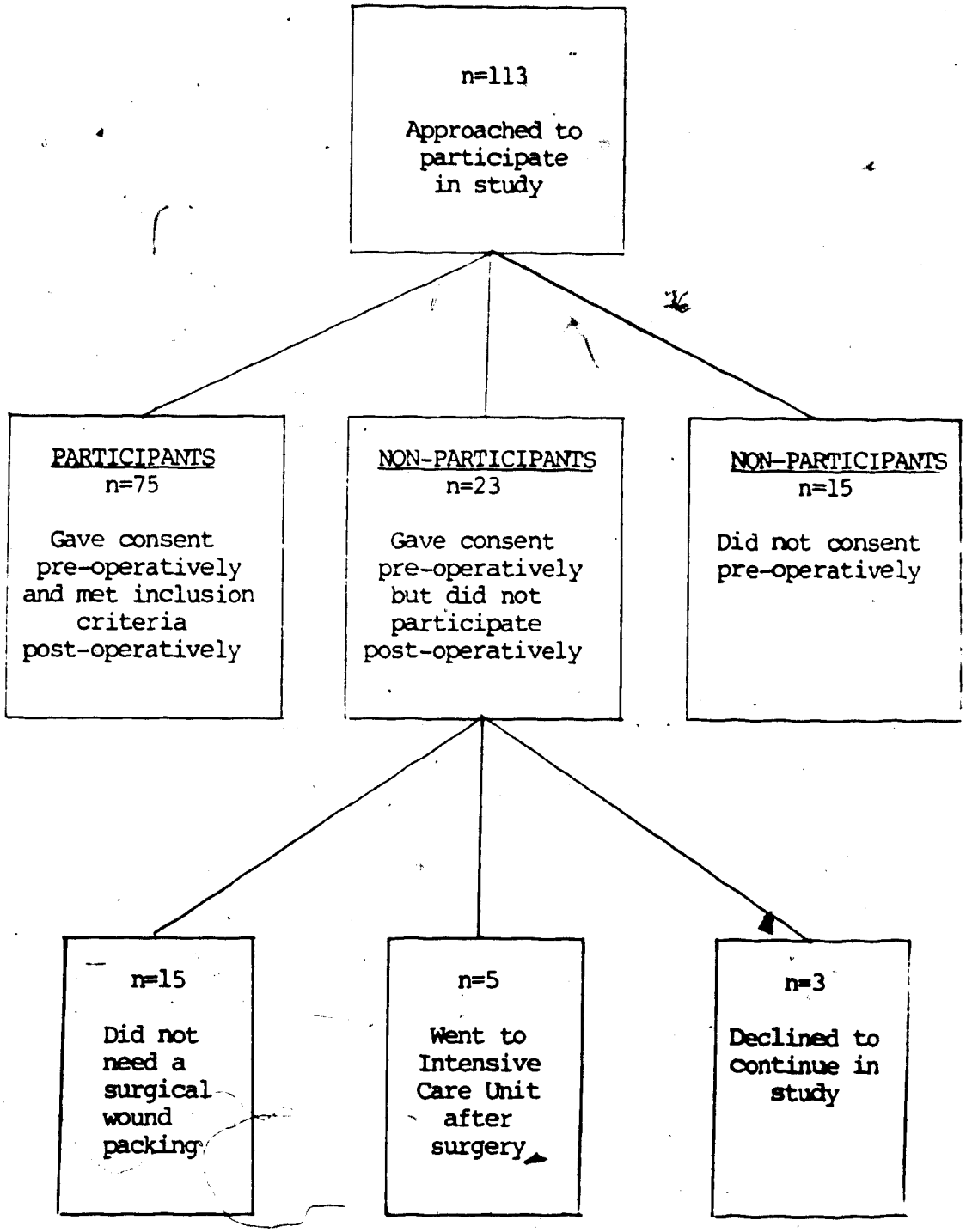
RESULTS

Sample Characteristics

In total, 113 patients were approached to participate in the study. Figure 1 illustrates their patterns of eligibility and participation. Seventy five of the 113 patients consented to participate pre-operatively and met the inclusion criteria post-operatively. Fifteen patients, four male and 11 female, did not consent pre-operatively (mean age 62.4 years; standard

Figure 1.

Patterns of Patient Eligibility and Participation



deviation 14.7). An additional 23 gave consent pre-operatively but did not participate after surgery. Twenty of these patients no longer met the inclusion criteria for one of two reasons: they did not need their surgical wound packed (n=15) or they were admitted to the intensive care unit (n=5). The remaining three did not wish to continue in the study. No patients dropped out once the treatment part of the study had commenced.

Table 1 describes the subjects' demographic characteristics by pain treatment group. The study sample consisted of 75 subjects, 41 males and 34 females, ranging in age from 18 to 89 years (mean 56.9 years; standard deviation 17). These subjects were located on one of five nursing units and they participated in the study from 35 to 50 hours after surgery (mean 42.5 hours; standard deviation 3) depending on time of return from surgery and time of dressing change. Surgery was performed by one of six surgeons. The reasons for surgery varied but they were primarily for cancer, diverticular disease, Crohn's disease, gastric ulcer, ostomy closure, cholelithiasis and colitis. Other infrequent reasons for surgery included bowel or upper abdominal surgery for symptoms unrelated to cancer, for example, a benign mass, revision of a previous surgery or drainage of an abscess.

Subjects' surgical history is summarized for the pain treatment groups in Table 2. Sixty four subjects (85%) had a history of prior surgery. The mean number of previous surgeries was 2.3 (standard deviation 1.8). For those who reported having previous surgery, the time since last surgery to present surgery

Table 1.

Demographic Characteristics by Pain Treatment Group

Variable	Group			All Subjects
	Control	Placebo	TENS	
	n=25	n=25	n=25	n=75
Age				
Mean	56.7	58.1	55.8	56.9
SD	16.7	16.7	18.0	17.0
Gender *				
Male	15 (60)	12 (48)	14 (56)	41 (54.7)
Female	10 (40)	13 (52)	11 (44)	34 (45.3)
Diagnosis *				
Cancer	7 (28)	7 (28)	7 (28)	21 (28.0)
Diverticular disease	4 (16)	8 (32)	3 (12)	15 (20.0)
Crohn's disease	4 (16)	2 (8)	4 (16)	10 (13.3)
Gastric Ulcer	2 (8)	1 (4)	1 (4)	4 (5.3)
Ostomy Closure	2 (8)	0 (0)	4 (16)	6 (8.0)
Cholelithiasis	1 (4)	2 (8)	1 (4)	4 (5.3)
Colitis	0 (0)	1 (4)	1 (4)	2 (2.7)
Other	5 (20)	4 (16)	4 (16)	13 (17.3)
Hours Post Surgery				
Mean	42.2	42.1	43.1	42.5
SD	3.1	2.7	3.4	3.0
Nursing Unit				
1	5 (20)	11 (44)	11 (44)	27 (36)
2	8 (32)	6 (24)	6 (24)	20 (26.7)
3	5 (20)	2 (8)	1 (4)	8 (10.7)
4	3 (12)	3 (12)	6 (24)	12 (16)
5	4 (16)	3 (12)	1 (4)	8 (10.7)

* n (%)

Table 2.

Surgical History by Pain Treatment Group

Variable	Group: Control n=25	Group: Placebo n=25	Group: TENS n=25	All Subjects n=75
History of Prior Surgery *				
Yes	22 (88)	20 (80)	22 (88)	64 (85.3)
No	3 (12)	5 (2)	3 (12)	11 (14.7)
Number of Previous Surgeries				
Mean	2.2	2.4	2.4	2.3
SD	1.7	1.8	2.0	1.8
Years Since Last Surgery				
Mean	7.5	10.4	4.9	7.6
SD	9.6	12.7	7.5	10.2
History of Prior Abdominal Surgery *				
Yes	17 (68)	15 (60)	15 (60)	47 (62.7)
No	8 (32)	10 (40)	10 (40)	28 (37.3)
Years Since Last Abdominal Surgery				
Mean	6.8	16.1	7.2	10.3
SD	8.6	16.8	9.9	13.0

* n (%)

ranged from less than one year to 50 years (mean 7.6 years; standard deviation 10.2). For those who had a history of previous abdominal surgery, the time between last abdominal surgery and present surgery also ranged from less than one year to 50 years (mean 10.3 years; standard deviation 13.0). The pain reported as a result of the dressing change in this study was not correlated with number of previous surgeries ($r = .012$; $p = 0.46$), number of years since last surgery ($r = -.03$; $p = 0.41$) or number of years since last abdominal surgery ($r = .09$; $p = 0.27$).

Table 3 provides a summary of subject wound characteristics by pain treatment group. The incisions were located in the upper or lower abdomen or midline and they were vertical, transverse or diagonal. Two thirds of the subjects required one or more surgical drains post-operatively and one third had vaseline gauze removed from the wound during the pain treatment. Analysis of variance demonstrated that wound characteristics (location, direction and the presence of surgical drains) were not factors which influenced the pain rating provided after the dressing change.

Post Surgical Pain Management

Table 4 describes prescribed and administered narcotic practices (type, dose and frequency). No subject received non-narcotic analgesia during the duration of their participation in the study. Demerol was prescribed post-operatively for 75% of the patients (n=56) and the remaining 25% received morphine (n=19). In practice, these drugs are prescribed to be administered as needed, within a minimum-maximum dose range and at specified

Table 3.

Wound Characteristics by Pain Treatment Group

Variable	Group * Control n=25	Placebo n=25	TENS n=25	All Subjects n=75
Wound Location				
Upper Abdomen	9 (36)	8 (32)	9 (36)	26 (34.7)
Lower Abdomen	9 (36)	6 (24)	7 (28)	22 (29.3)
Midline	7 (28)	11 (44)	9 (36)	27 (36.0)
Wound Direction				
Vertical	6 (24)	11 (44)	9 (36)	26 (34.7)
Transverse	17 (68)	13 (52)	15 (60)	45 (60.0)
Diagonal	2 (8)	1 (4)	1 (4)	4 (5.3)
Surgical Drains				
Present	15 (60)	19 (76)	16 (64)	50 (66.7)
Absent	10 (40)	6 (24)	9 (36)	25 (33.3)
Packing Material				
Vaseline Gauze	7 (28)	11 (44)	6 (24)	24 (32.0)
Normal Saline	18 (72)	14 (56)	19 (76)	51 (68.0)

* n (%)

Table 4.

Prescribed and Administered Narcotics by Pain Treatment Group

Narcotic	Group			
	Control n=25	Placebo n=25	TENS n=25	Total Sample n=75
PRESCRIBED:				
Demerol *	17 (68)	20 (80)	19 (76)	56 (74.7)
Morphine *	8 (32)	5 (20)	6 (24)	19 (25.3)
Maximum Dose (mg of morphine)				
Mean	13.0	12.5	13.3	13.0
SD	2.5	2.0	3.0	2.5
Minimum Dose (mg of morphine)				
Mean	9.5	9.4	9.7	9.5
SD	2.5	1.2	2.5	2.1
Hour Range *				
2-4 hours	4 (16)	1 (4)	1 (4)	6 (8.0)
3 hours	8 (32)	4 (16)	2 (8)	14 (18.7)
3-4 hours	13 (52)	20 (80)	22 (88)	55 (73.3)
ADMINISTERED:				
Dose Before Dressing (mg of morphine)				
Mean	11.7	11.8	11.8	11.8
SD	2.1	2.3	2.5	2.3
Time From Administration to Dressing (hours)				
Mean	3.6	4.3	3.1	3.7
SD	4.3	8.1	3.3	5.6
Frequency of Administration (morphine mg/hr)				
Mean	0.2	0.2	0.2	0.2
SD	0.06	0.07	0.07	0.07

* n (%)

time intervals. When the doses were converted to milligrams (mg) of morphine, a standard of comparison for narcotic type analgesics, the mean maximum dose prescribed was 13 mg of morphine (standard deviation 2.5). The mean minimum prescribed dose was 9.5 mg of morphine (standard deviation 2.1). Prescribed time intervals between doses were: two to four hours (n=6), three hours (n=14) or three to four hours (n=55). Because the drugs were prescribed to be given as needed, the frequency of delivery was variable. A review of the subjects' charts showed that 19% received analgesia every 3 to 4 hours and the remaining 81% received it less frequently than every four hours (range 4.3 to 41 hours).

The length of time between the last recorded analgesic and the dressing done in this study ranged from 5 minutes to 40 hours (mean 3.7 hours; standard deviation 5.6). This last recorded analgesic dose received prior to the study dressing was the maximum dose that could be given, according to prescription, for 52 subjects (69%). For 22 subjects (29%) the wound was packed more than four hours after the last documented analgesic.

Comparisons of Pain Treatment Groups

Chi square analysis demonstrated no significant differences existed among the three treatment groups for the variables gender (Table 1), packing material removed (Table 2) or prescribed type of narcotic (Table 4). Analysis of variance indicated there were no significant differences among the three groups for age; hours post surgery (Table 1); number of previous surgeries (Table 2); frequency of narcotic administration, time from last narcotic to

the dressing and narcotic dose received prior to the dressing (Table 4). Analysis of variance also indicated there were no significant differences between the placebo and the TENS group for the lengths of time the electrodes were in place, both prior to and during the dressing. The times for electrode application for both TENS and placebo TENS are presented in Table 5. The placebo group had the inactive electrodes in place for 15 to 30 minutes pre-dressing (mean 20 minutes; standard deviation 4.5). The total time the inactive electrodes were in place (pre-dressing and dressing time) ranged from 21 to 47 minutes (mean 30 minutes; standard deviation 6). The TENS group had the active electrodes applied for 15 to 30 minutes pre-dressing (mean 21 minutes; standard deviation 4). The total TENS time (pre-dressing and dressing time) ranged from 22 to 43 minutes (mean 31 minutes; standard deviation 5.7) and the voltage varied between 24 and 48 volts (mean 35 volts; standard deviation 7).

Effect of Pain Treatment on Incisional Pain

Multiple regression and analysis of covariance indicated that the use of TENS significantly decreased the pain reported when an abdominal incision was packed. The regression demonstrated that the following variables accounted for 27% of the explained variance in reported pain: age, gender, group assignment, narcotic dose received prior to the dressing, frequency of narcotic administration, time from last narcotic to dressing, and nursing unit (Table 6). Having received TENS treatment and having been admitted to nursing unit 4 made significant contributions to the

Table 5.

Time Period for Electrode Placement - TENS and Placebo TENS Group

Variable	Group: Placebo TENS (inactive electrodes)	Group: TENS (active electrodes)
Electrode Time Pre-Dressing (minutes)		
Mean	20.0	21
SD	4.5	4
Electrode Time During Dressing (minutes)		
Mean	10.4	9.9
SD	3.9	3.4
Total Electrode Time (minutes)		
Mean	30	31.0
SD	6	5.7
Voltage		
Mean	0	35
SD	0	7

Table 6.

Multiple Regression: Influences on Pain Rating

Summary Table

Variable	Beta	t	p
Age	0.15	1.18	0.24
Gender	0.14	1.29	0.20
Placebo Group	-0.08	-0.58	0.56
TENS Group	-0.26	-2.0	0.05
Narcotic Dose Prior to Dressing	0.22	1.76	0.08
Frequency of Narcotic Administration	0.08	0.5	0.62
Time from Narcotic to Dressing	-0.16	-1.2	0.23
Nursing Unit			
1	-0.27	-1.4	0.15
2	-0.19	-1.08	0.29
3	-0.15	-0.98	0.33
4	-0.34	-2.1	0.04

Multiple R = 0.52
R Square = 0.27
F = 2.14; p = 0.03

R-Square.

An analysis of covariance was used to compare group for pain ratings (Table 7). Time from last narcotic to dressing, age, and frequency of narcotic administration were used as covariates. The groups were significantly different ($F = 18.28$; $df = 2,69$; $p = 0.04$). The adjusted mean pain rating for each group was: TENS 3.27; Placebo TENS 4.46; No-Treatment Control 4.93.

To determine if any significant differences existed among subjects who reported lower and higher levels of pain following TENS treatment, the TENS group was split into two by the median pain score: reported pain of ≤ 2 (n=12) and reported pain >2 (n=13). Analysis of variance demonstrated that these two groups did not differ significantly in terms of age, narcotic dose received before the dressing, frequency of narcotic administration, total period of TENS stimulation or TENS intensity. Chi square analysis indicated there were no significant differences between the two sub groups for gender or time from last narcotic to dressing (1.5 hours, 2 hours, 3 hours and 4 hours were tested separately for this variable). Chi square analysis could not be used to compare the two sub groups by nursing unit because too many cells had an expected frequency less than five. However, the data indicates that subjects on nursing unit 4 may have lower pain ratings following TENS treatment. Subjects on this nursing unit were more likely to rate their pain less than two. The observed and expected frequencies for pain rating (≤ 2 and >2) by nursing unit are reported in Table 8.

Table 7.

ANCOVA: Pain Rating by Group

	Summary Table			
Condition	Sum of Squares	DF	F	p
Covariates				
Narcotic dose prior to dressing	27.71	1	5.08	0.03
Age	8.66	1	1.59	0.21
Frequency of narcotic administration	5.80	1	1.06	0.31
Main Effect				
Group	36.55	2	18.28	0.04
Error	376.04	69		

Mean Pain Rating (adjusted for covariates) for Three Treatment Groups

	Summary Table		
Group	n	Mean	SD
Control	25	4.93	2.4
Placebo	25	4.46	2.5
TENS	25	3.27	2.3

Table 8.

Observed and Expected Frequencies: Pain Rating by Nursing Unit

		Location				
	Observed Frequency Expected Frequency	1	2	3	4	5
PAIN RATING	≤2	6 5.3	2 2.9	0 0.5	4 2.9	0 0.5
	>2	5 5.7	4 3.1	1 0.5	2 3.1	1 0.5

Since location was found to influence the pain rating in the multiple regression, an analysis of variance was done to compare the five nursing units for these variables: (1)narcotic dose received before the treatment dressing and (2)frequency of narcotic administration. No significant differences were found among the nursing units.

Factors Influencing Drug Administration

Data analyses demonstrated that age exerted an influence on drug administration variables. Correlations were found between age and narcotic dose received before the dressing, ($r = -.314$; $p = .003$), age and frequency of narcotic administration ($r = -.484$; $p = 0$) and age and maximum prescribed narcotic dose ($r = -.2$; $p = 0.04$). A three to four hour time range for narcotic delivery was prescribed, to be administered as needed, for 92% of subjects. Of the small number who had their narcotics prescribed every two to four hours, as needed, (n=6) the mean age was somewhat higher (mean 62.7 years; standard deviation 10.6) than the other 69 subjects (mean 56.4 years; standard deviation 17.4).

A second multiple regression analysis was used to assess drug prescription and administration variables which correlate with age. In this regression, 28% of age was accounted for by time from last narcotic to dressing, average narcotic dose administered, pain rating, frequency of narcotic administration and narcotic dose received before the dressing (Table 9). Frequency of narcotic administration made a significant contribution to the R-Square ($F = 5.42$; $p = 0.0003$).

Table 9.

Multiple Regression: Age with Drug Administration Variables.

Summary Table

Variable	Beta	t	p
Time From Narcotic to Dressing	-0.15	-1.2	0.25
Average Narcotic Dose Administered	0.03	0.2	0.85
Pain Rating	0.1	0.9	0.35
Frequency of Narcotic Administration	-0.5	-4.0	0.0002
Narcotic Dose Received Prior to Dressing	-0.22	-1.4	0.17

Multiple R = 0.53
R-Square = 0.28
F = 5.4; p = 0.0003

DISCUSSION

The use of TENS was effective in reducing the amount of pain reported when an abdominal incision was packed. Further support is provided for the efficacy of TENS when it is noted that subjects who received no treatment or placebo TENS reported higher mean levels of pain than subjects who received TENS. This indicates that the reported phenomenon cannot be explained as a placebo effect but must be due to the analgesic effect of TENS. This effect could be due to endorphin stimulation and/or increased A-beta fibre activity as has been hypothesized in the literature.

The analgesic property of TENS has important clinical implications because it occurs in the absence of any significant side effects. In addition to being safe and effective, TENS is a method of pain control which can be incorporated easily into the clinical setting. Its application is not complex, as evidenced by the number of people who own and operate their own machines at home. As well, the TENS unit is portable which means it can be transported easily between patient rooms. Finally, there are few people for whom the use of TENS is contraindicated. This makes it a practical method of pain control in the clinical setting.

TENS may have more than one therapeutic use in the clinical setting. First, there is evidence that TENS may have a part to play in surgical pain management which is separate from that provided by narcotic therapy: TENS significantly influenced pain reported after dressing change when the effects of drug

administration were controlled statistically. This suggests that TENS has a unique role in decreasing pain when an abdominal incision is packed. Packing a surgical wound involves applying tension directly at the site of the incision and TENS analgesia may be more appropriate than narcotic analgesia for this type of pain. This finding is consistent with the findings of a previous study which examined the effect of TENS near the incision site on post-cesarean pain (Smith, Guralnick, Gelfand and Jeans; 1986). These researchers reported that TENS was effective in reducing cutaneous, movement-associated incisional pain but it was not effective for relieving gas pains or pain resulting from internal structures.

Second, TENS may enhance surgical pain management when it is used in combination with narcotic therapy. In this study patterns of narcotic administration were not systematically studied as they related to TENS. However, since TENS has a proven analgesic property, it has the potential to decrease the amount of narcotics required to maintain an effective level of pain control. If patients receive less narcotic analgesia they may report a decreased incidence of narcotic related side effects. Since the elderly are more prone to narcotic side effects they may gain particular benefits from combined therapy if TENS decreases the amount of narcotic required. In summary, TENS has the potential to enhance narcotic therapy and it may provide a unique method of pain control for specific types of pain.

Receiving TENS may not always provide patients with a low

level of pain when their abdominal incision is packed. In this study 52% of subjects who received TENS reported a pain level greater than two after the dressing change. Four of these subjects reported their pain at seven or higher. However, because subjects did not provide a pre treatment pain rating it is not possible to determine whether these pain levels reflect pain relief from a level which was initially much higher or if they indicate poor pain control with TENS. If TENS does not always provide a reduction in pain it is important to identify factors which influence the analgesic property of TENS. These factors would include patient characteristics, environmental variables and the stimulation parameters. In this study random assignment to treatment group and non-systematic assignment to nursing unit minimized the possibility that patient characteristics and environmental factors were significantly different among the three treatment groups. Chi square analysis and analysis of variance also suggested the three treatment groups did not differ significantly in terms of demographic variables, drug administration practices or assigned nursing unit.

In this study no significant patient characteristics could be found to explain why different individuals reported a lower or higher level of pain when they had TENS applied during the dressing. However, the sample size for these analyses was small as there were only 25 subjects in the TENS group. Subsequently, when comparing subjects who reported a pain rating ≤ 2 with those who reported a pain rating >2 the numbers were occasionally too small

to perform appropriate parametric and non-parametric tests. This factor increases the probability that a false null hypothesis will not be rejected (a Type II error).

The degree of pain experienced prior to TENS treatment is a patient characteristic which may influence TENS analgesia but this cannot be determined in the present study. The gate-control theory however, can support the hypothesis that pain intensity prior to TENS treatment will influence TENS analgesia: when pain fibres are very active TENS may be unable to stimulate A-beta fibres to a similar level of activity. The increased pain fibre activity relative to the large fibre activity would keep the pain gate open. Consequently, patients may continue to report pain.

It is interesting to note that age did not influence the analgesic effect of TENS in view of the fact that age is known to influence the analgesic effect of narcotics. This difference may be related to several variables. First, duration of analgesia from narcotics is the aspect of narcotic therapy which is influenced most by age. This study evaluated the effect of TENS analgesia at one point in time and was not able to measure the duration of TENS analgesia after the dressing stimulus was removed. Second, the pain stimuli are different. In studies showing that age is related to duration of narcotic effect the pain stimuli arose from a disease process or a surgical procedure. In this study, the pain stimulus arose from the dressing procedure. Third, narcotics begin their effect centrally whereas TENS begins its effect peripherally. Any of these variables, alone or in combination, may

explain why age influences narcotic analgesia but does not influence TENS analgesia.

Environmental factors could also influence TENS analgesia. For example, the nursing unit to which the subject was admitted may have influenced the pain rating obtained in this study. This appeared to be the situation on Nursing Unit 4. Subjects who were admitted to this unit reported a lower level of pain than other subjects. This finding may be explained when it is noted that, unlike the other 4 nursing units, 50% of these subjects received TENS. Since it has been shown that TENS is effective in reducing pain when an abdominal incision is packed it would be expected that, overall, the patients on Nursing Unit 4 would report significantly less pain. In short, the treatment, not the unit per se, could have influenced the overall pain rating of these subjects. However, the additional finding that subjects on this unit were more likely to rate their pain at a low level (≤ 2) following TENS treatment suggests that nurses' dressing techniques may also have influenced the pain rating.

The method used to apply the TENS treatment must also be considered when the analgesic effect of TENS is evaluated. In this study, the subjects who received TENS and reported a pain rating >2 after the dressing may have obtained better pain control if the pulse frequency had been adjusted to meet their individual needs rather than being delivered at a set value. Although a frequency of 100 Hz is reported to be the preferred frequency for surgical pain control this frequency can range from 70 to 150 Hz.

Interesting relationships between age and drug administration are extraneous findings reported in this study. Pearson correlations demonstrated that age was negatively correlated with narcotic dose received before the dressing and negatively correlated with frequency of narcotic administration. In sum, the elderly who participated in this study received fewer, and smaller doses of analgesic post surgery. The reasons for this finding could be related to one of three variables: (1)the physician's narcotic order, (2)nursing practice and/or (3)patient characteristics. A Pearson correlation between age and maximum prescribed narcotic was significant but weak which suggests there is only a slight tendency to prescribe lower narcotic doses for the elderly. This indicates that nurses, not physicians, are making the decision to administer less analgesia to the elderly. The rationale which directs nurses to follow this practice is not known but it is probable that patient characteristics are the factor which significantly influence nurses' patterns of narcotic administration. This hypothesis could not be investigated in the present study. For example, it was not determined if (1)the younger patients received more analgesia because they were more vocal in their demands for pain relief and their complaints of pain and/or (2)nurses administered fewer narcotics to the elderly because they were concerned about the incidence of side effects.

Although the elderly received fewer, and smaller doses of analgesia the almost zero correlation between age and pain rating ($r = .009$) did not indicate the elderly reported significantly

higher or lower levels of surgical pain compared to the younger adults. Since the elderly require fewer, and smaller doses of analgesic for pain control this finding is not unusual. The finding is also consistent with the research which suggests that the elderly are less sensitive to pain than younger adults (as reviewed in Appendix A).

In summary, the correlations between age and narcotic administration variables reported in this study suggest that current drug administration practices employed with the elderly are appropriate in terms of how they are administered relative to younger adults. Because the elderly obtain more pain relief than younger adults following a similar dose of narcotic they do not require the same amount of analgesia as younger adults. However, the data do not indicate whether the amount of narcotic nurses administer to younger surgical patients is appropriate for effective surgical pain control. Therefore, the elderly still may be short-changed in terms of analgesia.

In conclusion, TENS is an effective, safe and practical method of pain control which can be incorporated easily into the clinical setting. It has the potential to enhance narcotic therapy and it may provide a unique method of pain control for certain types of pain. Specifically, it has a role to play in providing effective pain control when an abdominal incision is packed. This is an important finding because 22 of the 75 subjects (29%) in this study rated their pain at six or higher when they had their abdominal incision packed. This suggests that packing a surgical incision

can be an uncomfortable procedure for a significant number of patients and it lends support for the need to implement more effective pain control during this procedure. In addition, because data analyses demonstrated this finding was not related to age or drug administration practices we can conclude that the majority of surgical patients would benefit from improved pain control during this procedure. The significant decrease in mean pain rating for subjects who received TENS while their abdominal incision was packed suggests that implementing TENS during this procedure would be beneficial for the patient.

IMPLICATIONS FOR NURSING

Many factors influence when and why a particular patient will receive analgesia. Individuals who have a responsibility to execute effective surgical pain control must weigh the potential side effects of narcotics against the consequences of inadequate pain management. Because TENS is not associated with any significant side effects its use, in combination with narcotic drugs, could help nurses create an acceptable balance between pain relief and drug induced side effects. Further, if TENS were implemented in the clinical setting it would provide nurses with increased independence in the area of pain management because it is a method of pain control which they can employ at their discretion. This has important implications for the nursing profession since it is striving for independence and attempting to

define areas of nursing practice.

Nurses must also consider the possibility that their interpersonal style and technical skills are variables which can either increase or decrease patient discomfort. In addition, they must recognize that patient characteristics influence experienced and reported pain. Nurses need to integrate their personal characteristics with individual patient characteristics when they develop strategies to relieve pain.

Providing patients with effective pain relief is a powerful mechanism through which overall patient care can be enhanced. Even when pain is temporary in nature, as with the pain which can occur when an incision is packed, it does not mean this pain can be ignored. Nurses are in a position to work actively towards ensuring patients receive effective pain control because they deal directly with patients' pain in the clinical setting. This would include nurses making maximum use of pain relieving techniques currently available. During the past 20 years in particular, pain research has led to more effective methods of pain management. However, the knowledge that patients report inadequate pain control during the post-operative period suggests that nurses are not incorporating these research findings within their daily practice. There is a need to set up programmes which would encourage the communication of research findings and suggest ways in which appropriate research findings could be implemented in the clinical setting.

RECOMMENDATIONS FOR FUTURE RESEARCH

The present study found TENS was effective in reducing pain experienced during the dressing and packing of an abdominal incision. This finding contributes to the general body of knowledge about TENS and pain. Future TENS research should investigate the characteristics of those who obtain significant levels of pain relief with TENS compared to those who do not. It would be beneficial to obtain a pain rating prior to implementing TENS treatment to determine if pre-treatment pain intensity exerts a significant influence on TENS analgesia. Investigating the effects of narcotic therapy on TENS analgesia is a second area which requires further research. Future TENS research could also allow subjects to determine the frequency at which they receive TENS stimulation; their choice would become a variable investigated in the study.

In relation to the effect of age on narcotic administration practices (a matter which requires further study), it is important to determine which factors and beliefs guide nurses' current methods of pain control. Obtaining data on nurses' current methods of pain management and their general pain knowledge would be instrumental in enhancing present patterns of pain management. Further research is also needed to clarify and expand upon the effects of age on the overall pain experience.

Finally, nursing procedures are frequently invasive and they have the potential to cause pain and anxiety. Research is needed

to assess the extent of pain produced during certain procedures. This research should also evaluate (1)nursing strategies which could be used to reduce the pain resulting from these procedures and (2)nursing characteristics which may increase or decrease the pain patients report during various nursing procedures.

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Appendix A

Pain: A Review of the Literature

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PAIN: A REVIEW OF THE LITERATURE

Pain has always influenced human behaviour because it has the ability to affect the lives of people regardless of their age, race or social circumstance. This pervasive quality has encouraged a search for methods of pain control. During the past 100 years in particular, pain research has made significant contributions to the understanding of pain in the Western world. Today we know that pain involves physical and psychological components and its presence can provide both a healing and a protective function. It promotes the healing process by encouraging the rest of an injured body part and it provides the body with a protective mechanism by signalling the presence of injury or disease. Unfortunately pain is not always present when pathology exists and it may occur too late to permit the use of an effective treatment regime.

Pain has also been classified as acute or chronic in nature. Acute pain can usually be attributed to a cause and it is expected to diminish and disappear as the healing process proceeds (Bonica, 1985). Its presence has also been identified as a precursor for chronic pain (Bonica, 1985). Chronic pain is the term used to describe pain which remains when the healing process should be complete. The ability of unremitting pain to incapacitate an individual both physically and psychologically provides a compelling reason to relieve pain which is either acute or chronic in nature. However, despite our increasing knowledge in the area of pain it still remains a phenomenon which is difficult to

describe and which is not completely understood. This is evident when we note the large number of individuals who continue to experience pain over which we have little control. Pain research must continue if we are to provide effective pain relief for these individuals.

At present the gate-control theory is the most influential pain theory in the Western world (Melzack & Wall, 1984). An historical review of major pain beliefs, theories and methods of pain management is presented in this paper for the purpose of demonstrating how each contributed to the evolution of the gate-control theory. The gate-control theory is then described and evaluated and its implications for current methods of pain management and pain research are addressed. Specific attention is given to the role of the gate-control theory in providing support for the use of transcutaneous electrical nerve stimulation (TENS) as a method of pain control. In particular, implementing TENS to relieve post-operative pain will be discussed.

Pain: An Historical Review

Over time pain beliefs and theories specific to a given culture and/or time period have evolved and influenced methods of pain control. A chronological review of some of the prominent pain beliefs and theories in the Western world illustrates how Western medicine has moved toward its present understanding of the pain experience and its current methods of pain control.

Early Pain Beliefs and Pain Relieving Measures

The cold water of lakes and streams and the warmth of the sun and later fire are thought to have been used to relieve pain by ancient people (Archer, 1958). Medicine men, skin tattoos and charms were used to augment or replace these methods when individuals began to attribute pain to the presence of demons (Keys, 1963). The demon of gout was visualized as an enormous, hideous, incorporeal spider whereas an "evil bird" with a sharp beak was believed to produce pain in the head, neck and bowels because of its incessant pecking (Fulop-Miller, 1938).

After the introduction of Christianity the church became influential in the area of pain management. Some believed that ordained church members and prayer possessed the power to heal while others considered pain to be a form of punishment delivered by God. This latter belief served to hinder the search for effective methods of pain control.

Other forms of pain relief which have been recorded over the centuries include the use of flowers and herbs (Robinson, 1946), pressure applied to significant nerves or arteries (Keys, 1963; Raper, 1947), and hypnosis (Raper, 1947). In particular, the history of anaesthesia, which encompasses many centuries, chronicles a search for pain relief. Its introduction in the 1840's was a major breakthrough both for pain research and for individuals who required surgery (Keys, 1963).

Early Pain Theories

The theory of the specificity of nerves introduced by Muller

in 1840 is one of the first formal pain theories. Prior to this time pain had been considered primarily an affect. Aristotle equated pain with unpleasantness and believed it was an emotion to be avoided (Hardy, Wolff & Goodell, 1952). Feelings of pain were said to be produced when violent wave forms travelled to the heart, the area identified as the central source of pain (Merskey & Spear, 1967).

Muller claimed that the state of the organism at the time of arousal and the method of arousal were responsible for the different sensations experienced by the body. This theory was not disputed until 1858 when Schiff identified pain as a separate and distinct sense transmitted by a specific nerve. This idea received further support from Blix and Goldscheider who independently located separate skin spots for warmth, cold, pressure and pain. Both reported that regardless of the stimuli presented to a given area it would consistently produce the designated quality of warmth, pain, pressure or cold (Dallenbach, 1939).

The findings reported by Schiff, Blix and Goldscheider contributed to the formation of the specificity theory of pain. This theory stated that specific pain receptors in the body transmitted noxious stimuli through a single pain pathway to a pain centre in the brain. However, this theory was opposed by individuals who supported the pattern theory of pain. Pattern theory proposed that pain was mediated by tactile nerves and resulted from the summation of their excitation (Dallenbach, 1939). In effect, every sensory stimulus was believed capable of

producing pain if it reached sufficient intensity. Between 1886 and 1896 a heated controversy arose among the individuals supporting the specificity, pattern and affective theories of pain. However, support shifted in favour of specificity theory when Von Frey discovered modality specific tactile receptors (Dallenbach, 1939). Specificity theory was subsequently presented in text books and taught in classrooms although the peripheral and central pathways involved in the transmission of pain had not been identified.

The Influence of Specificity Theory on Pain Management

General acceptance of the specificity theory influenced pain research and pain management. Prior to this time methods of pain relief had been based primarily on individual preference, intuition and superstition. Now the neurosurgical approach to pain control grew in popularity. Emphasis was placed upon removing the noxious stimulus or preventing its transmission to the brain by destroying peripheral nerves or central pathways. A review of some of these procedures illustrates how they provided information which did not support the specificity theory.

Rhizotomy and Chordotomy

A posterior rhizotomy, a procedure which interrupts the sensory nerve roots was used to relieve pain as early as 1896 (Dandy, 1929; Grant, 1941; Ray, 1941). Unfortunately its use did not always provide pain control and it caused the patient a widespread loss of sensation. The reported loss of sensation was largely overcome when pain fibres were localized in the anterior ascending columns. The surgical interruption of these fibres (a procedure known as

chordotomy) caused minimum sensation impairment (Beer, 1913; Frazier, 1918; Spiller & Martin, 1912). Chordotomy was initially used to control pain in the pelvis and lower extremities but as experience with the procedure increased and anatomical and physiological knowledge advanced it was also used to relieve pain in the upper body (Peet, Kahn & Allen, 1933; Stookey, 1931). However, as with rhizotomy, pain relief was not consistent after chordotomy (Sugar & Berry, 1951). These findings indicated that a single pain pathway could not account for the total pain experience.

Lobotomy

In 1946 Freeman and Watts presented data on 400 patients who underwent a prefrontal lobotomy for the treatment of a mental disorder. Clinical observations of these patients indicated that the surgery altered their perception of pain. Prior to surgery many of these patients had reported unbearable pain as their chief complaint. After surgery they continued to report pain, but they no longer appeared to be disturbed by it because the suffering and anguish were gone. Results of subsequent studies provided support for the use of lobotomy to relieve pain (Dynes & Pappen, 1949; Koskoff, Dennis, Lazovik & Wheeler, 1948). Even in instances where previous sectioning of the appropriate pain pathways had failed to provide pain relief, the lobotomy succeeded (Falconer, 1948). Unfortunately the lobotomy was not without side effects. Those patients who underwent the surgery experienced a change in personality because their emotional and intellectual ability was impaired. However, this surgical technique was influential in

demonstrating that pain perception involved a motivational-affective dimension which could not be explained fully by anatomical and physiological processes.

The Influence of World War II on Pain Research

Clinical observations of patients following rhizotomy, chordotomy and lobotomy all suggested that the specificity theory provided neither an accurate nor a complete description of the pain process. World War II was also influential in helping researchers to arrive at this conclusion. The incidence of pain attributed to phantom limbs, causalgia and neuralgia increased due to war injuries and these painful syndromes were often unrelieved by available methods of surgical pain control (Falconer, 1948). Causalgia produced a burning pain in the hands and feet and neuralgia was experienced as a sharp, spasm like pain along a nerve tract. Livingston (1947) was one researcher who recognized the inadequacy of the specificity theory and he studied the mechanisms of causalgia in an attempt to provide a more comprehensive explanation for the pain experience. He viewed pain as a sensory, subjective and individual event which could exceed its protective function to become destructive. Livingston suggested that changes within the central nervous system (CNS) caused pain by modifying the patterns of excitation which would register in the brain. He also proposed that chronic irritation, a somatic lesion for example, would produce organic changes in the higher centres of the brain and these changes could in turn promote physiologic and organic changes in body parts remote from the site of injury. If

the irritant was not removed at an early stage the cycle would continue and surgical attempts to relieve the pain would be unsuccessful.

Like Livingston, Noordenbos (1959) also noted that the specificity theory did not provide an accurate description of the pain experience. In order to gain a better understanding of the mechanisms of pain he studied common features of pain unrelieved by surgical measures. Noordenbos proposed that stimuli initiate complex impulse patterns within the CNS and an imbalance in fibre activity alters these patterns and produces pain. For example, if fast fibre activity is decreased the transmission of pain impulses is enhanced because the activity of the more slowly conducting pain fibres is increased. Noordenbos further suggested that a multi-synaptic afferent system with many interconnections exists in the CNS. This concept is contrary to the specificity theory which supports the presence of a single pain pathway.

The Psychological Component of Pain

The general acceptance of the specificty theory meant that the psychological aspects of pain received little attention. Individuals unable to demonstrate a physical cause for their pain obtained little satisfaction in their quest for pain relief. Although Freud and Breuer's work on hysteria suggested as early as 1895 that pain could be psychogenic in origin (Breuer & Freud, 1936) the general belief that pain had to be organic in nature prevented these data from contributing to the understanding of pain at that time (Engel, 1959). The possibility that pain involved a

psychological component was more recently emphasised by experiences from World War II. Clinical observations of soldiers and civilians supported the role of intellectual and emotional influences in pain perception (Beecher, 1956). Based on his own observations Beecher believed that the situation in which the injury occurs may influence the pain response.

In addition, contemporary psychiatrists began to support theories which recognized that pain was more than organic in nature (Engel, 1958; Szasz, 1957). Szasz believed that the ego perceives the body as an object and pain occurs as a consequence of the threatened loss of a body part or injury to the body. Engel believed that the psychic organization of the individual is responsible for the perception of pain and he defined characteristics of the pain prone person. Because of their characteristics, pain prone individuals experience pain which is disproportionate to all clincal evidence.

In summary, the above pain theories all share a common belief. Each theory suggests that pain mechanisms must be explained by more than a single pathway.

The Contribution of Laboratory Studies to Pain Research

Clinical observations of pain did not provide the only evidence that specificity theory could not accurately describe the mechanisms of pain. Laboratory studies, both animal and human, also contributed to our understanding of pain. Pavlov (1927) used dogs to demonstrate that the meaning associated with a painful stimulus could influence the pain response. The results of this

study indicated that the dogs evaluated the stimulus and modified their response before an instinctive pain response could be elicited.

Thompson and Melzack (1956) provided further evidence that situational factors can influence the perception of pain. They assessed the effect of early environment on pain perception and they reported that dogs raised in isolation for seven to ten weeks demonstrated abnormal pain avoidance responses. When tested, these dogs repeatedly placed their noses in a flaming match and did not appear to experience pain.

Studies on human subjects under controlled laboratory conditions also indicated that a painful stimulus could be modified en route to the brain. It was demonstrated that pain could be influenced by such factors as suggestion, distraction and hypnosis (Hardy et al., 1952), gender (Sherman, 1943), instruction (Blitz & Dinnerstein, 1968; Gelfand, 1964; Wolff, Krasnegor & Farr, 1965), level of education (Clausen & King, 1950), age (Chapman & Jones, 1944; Clark & Mehl, 1971; Schladerman & Zubek, 1966; Woodrow, Friedman, Siegelaub & Collen, 1972), and cultural background (Cloog, 1961; Mechanic, 1963; Sternbach & Tursky, 1965; Zborowski, 1969). All these findings, in conjunction with the animal studies previously discussed, suggested that the perception of pain required more than a single pathway between the periphery and the cortex.

The Gate-Control Theory of Pain

Clinical observation, human studies in the clinical and laboratory setting and animal research all suggested that the perception of pain was both a physiological and a psychological process which could not be explained adequately using existing pain theories. The gate-control theory was the first pain theory to incorporate both a physiological and a psychological component when describing the pain experience.

The Gate-Control Theory Defined

On the basis of anatomical and physiological evidence Melzack and Wall (1965) proposed that a gate control system exists in spinal cord which modifies the transmission of afferent nerve impulses before they evoke a pain response. The substantia gelatinosa in the dorsal horns of the spinal column is identified as the pain gate. The relative activity in large diameter A-beta and small diameter C fibres is thought to be one mechanism controlling the gate and increasing and/or decreasing the transmission of somatic input. The activity of the large, rapidly conducting A-beta fibres closes the gate and decreases the number of impulses reaching the CNS while activity in the small diameter, slowly conducting A-delta and C fibres opens the gate and facilitates the transmission of nerve impulses.

Melzack and Wall (1965) also proposed that afferent input received by the body is influenced by the ongoing activity which precedes the stimulus and the stimulus evoked activity. This suggests that a painful stimulus is received by an active nervous

system and influenced by such things as past experience, cultural learning, anxiety and the meaning attached to the pain experience. This cognitive process is thought to occur in the cerebral cortex which receives pain information from afferent sensory input via rapidly conducting, large fibre systems. The cortex evaluates this information and modulates the gating mechanism using descending fibres which terminate in the dorsal horns. Hence, these descending fibres permit cognitive processes to influence pain perception. When the integration of excitatory and inhibitory influences exceeds a critical level the individual will perceive and respond to pain. Pre and post synaptic influences have been suggested as possible mechanisms for the inhibitory and excitatory effects of the fibre activity described by the gate-control theory but the exact mechanisms are still unknown (Wall, 1980).

Melzack and Casey (1968) proposed that three major psychological dimensions of pain exist (sensory-discriminative, motivational-affective and cognitive-evaluative) and they incorporated these dimensions within the gate-control theory. Based on research they state that: (1)The rapidly conducting projection systems (neospinothalamic and spinocervical tracts) which terminate in the ventrobasal thalamus contribute to the sensory-discriminative dimension of pain and process information about the spatial, temporal and magnitude properties of the input. (2)The motivational-affective characteristics of pain are subserved by activity in the reticular formation and limbic systems. These brainstem structures have reciprocal interconnections which are

influenced primarily [redacted] slowly conducting spinal systems (spinoreticular and paleospinothalamic tracts in the anterolateral somatosensory pathway) and (3)Cognitive activities are subserved in part by cortical processes and the dorsal column and dorsolateral pathways are the rapidly conducting ascending systems which transmit sensory information to the cortex. Descending control mechanisms which originate in such brain structures as the raphe nuclei, reticular formation, cerebral cortex and hypothalamus descend in dorsolateral pathways and terminate in the substantia gelatinosa Melzack & Wall, 1984). Melzack and Casey suggest that these ascending and descending pathways interact with one another to integrate the perceptual, motivational and affective dimensions of pain for the purpose of influencing a particular individual's response to a given pain stimulus. In summary, the gate-control theory portrays pain as a dynamic process which incorporates the influences of complex ascending and descending systems.

An Evaluation of the Gate-Control Theory

It is generally agreed that a good theory should allow researchers to describe, explain, predict and control the phenomenon it represents (Ellis, 1968; Hardy, 1974; Kim, 1980). Overall, the gate-control theory meets these requirements. It describes pain as a physical and psychological phenomenon, it incorporates biological and behavioural pain observations and it suggests relationships between them. Incorporating these elements within the theory permits it to logically and reasonably explain such painful syndromes as phantom limb pain, referred pain,

causalgia and prolonged pain. It also permits the prediction of a pain response in the presence of a painful stimulus. Finally, the gate-control theory, as will be shown, has resulted in the introduction of powerful, multi-dimensional approaches for pain control.

Recognition of the three dimensions of pain has provided clinicians with new pain management techniques which can modify sensory input (sensory control) and/or influence motivational and cognitive factors (psychological control). It has also provided some older methods of pain control with a scientific rationale (manual and mechanical therapy, heat and cold, and electrotherapy). The action of these techniques can now be explained by the patterns of excitatory and inhibitory influences they produce and the feedback loops they activate between the spinal cord and the brain.

As stated previously, the gate-control theory is based on physiological evidence and assumptions drawn from psychological observations in the clinical setting. Although all facets of the theory have not been verified by physiological and anatomical evidence, research to date has only served to support, not refute the theory. For example, laminae 2 and 3 in the dorsal horns have been identified as the substantia gelatinosa and physiological evidence supports the role of the substantia gelatinosa as the gating mechanism (Wall, 1980). Namely laminae 2 and 3 receive all known types of peripheral afferents (skin, viscera and high threshold muscle afferents), they contain many pain related

substances (substance P, somatotensin, fluoride resistant acid phosphatase, enkephalins and GABA), and recordings from single cells in laminae 2 and 3 reveal unusual properties not seen in large dorsal horn cells (small receptive fields, prolonged response to a single stimulus, prolonged habituation and shifting receptive fields). It has also been noted that at least three descending brainstem systems terminate in the area of laminae 2 and 3 (Wall, 1980).

The operational adequacy of the psychological component of the gate-control theory is its weakest element. The psychological variables are difficult to identify and their exact mode of operation is unknown. However, this theory has contributed more to our understanding of pain than any other theory to date and it has suggested new approaches for pain management and new areas for pain research. Until future research can refute or improve upon the gate-control theory it appears to represent adequately and reasonably the mechanisms of pain. In particular, by recognizing the joint contribution of both physiological and psychological components to the pain experience the theory helps to explain why many factors can influence an individuals' perception of pain.

Factors Affecting the Perception of Pain

As documented, the gate-control theory supports the influence of both a physiological and a psychological component in the perception of pain and these influences can serve to either heighten or attenuate the experience of pain. Their joint

contribution makes an accurate pain diagnosis necessary because the basis of the pain has implications for effective pain management.

A hook hanging ritual in India demonstrates how emotional processes can diminish pain during a normal pain producing situation. This ritual, performed to bless the children and the crops, involves a man swinging freely, hanging only from hooks embedded deep in his back (Kosambi, 1967). During this ceremony the man appears to be in a state of exaltation, not one of pain.

However, fear, anxiety, anger and depression are some psychological mechanisms known to increase the amount of pain an individual may experience (Craig, 1984). The ability of these emotions to activate the autonomic, visceral and skeletal systems may account, in part, for their role in the pain experience (Craig, 1984). Relaxation, provision of information and advanced preparation, distraction, suggestion and imagery have all been successfully used as anxiety reducing and coping mechanisms. Individuals using effective coping mechanisms can be expected to report less pain than individuals who experience pain without the benefit of such mechanisms.

Age is another variable which is reported to influence pain perception. However, the data are not consistent. Studies which used radiant heat to measure cutaneous pain sensitivity have reported an increased pain threshold in the elderly (Chapman & Jones, 1944; Schluderman & Zubeck, 1966; Sherman & Robillard, 1960). This indicates that the elderly experience a loss of cutaneous pain sensitivity. However, it was not determined if

these changes reflected an age change in central nervous system processes responsible for pain perception and/or age related skin changes which could be caused by subclinical peripheral neuropathies secondary to disease or injury.

In contrast, other studies have reported an increase in pain sensitivity with age. Elderly subjects demonstrated (1)a decrease in pain threshold and pain tolerance when electrical shocks were delivered to the dorsal surface of the second and fourth fingers of the right hand. (Collins & Stone, 1965) and (2)a decrease in pain tolerance when mechanical pressure was applied to the Achilles tendon (Woodrow, Friedman, Siegelaub & Collen, 1972). Studies which have reported no age differences in pain sensitivity add a further dimension to the area of pain and aging. Pain threshold was not reported to differ with age when electrical stimulation was applied to the teeth (Harkins & Chapman, 1977) or radiant heat was applied to the skin (Hardy, Wolff & Goodell, 1943; Clark & Mehl, 1971). The results of the above studies indicate that the effect of age on pain sensitivity is an area which requires further investigation to permit the formulation of an accurate hypothesis. The method of stimulation, the area of stimulation and the circumstances surrounding the stimulation procedure may each have played a role in the reported results.

Gender is also reported to influence pain perception but, as is true with age, these data are controversial. Some researchers have reported there is no difference in pain threshold between the sexes (Hardy, Wolff & Goodell, 1943) and others have claimed

females have a lower pain tolerance than males (Sherman, 1943; Woodrow et al., 1972).

Physiological characteristics can also increase or diminish the amount of pain experienced. When surgical patients are considered increased pain can be expected under given circumstances. Thoracic and abdominal incisions, particularly upper abdominal incisions, are frequently associated with increased pain because of their proximity to the diaphragm and respiratory apparatus. Vertical or diagonal incisions may produce more pain than a horizontal incision because they involve greater muscle, nerve and fascia damage (Sweeney, 1980). Increased pain may also be expected following an extended period of anaesthesia. Two mechanisms have been proposed for this phenomenon: (1)pain threshold changes due to the adaptation or fatigue of involved neural circuits, and/or (2)prolonged exposure and retraction of tissues and organs enhances cellular lysis and injury (Sweeney, 1980).

Clearly, the pain reported by an individual must be assessed in light of a multitude of factors. One cannot define the pain of an appendectomy, a cholecystectomy or a bowel resection or assume that one procedure is associated with any more or less pain than another.

Management of Acute Pain

As a result of our increasing knowledge in the area of pain one could predict that the numbers of people suffering has decreased

over the past 20 years. However, present research does not support this. When 372 Canadian families were surveyed 36% reported that at least one family member had experienced pain within two weeks of the survey (Crook, Rideout & Browne, 1984). This situation does not improve when one looks at the incidence and severity of pain reported by surgical patients. Post-operative pain was described as the most neglected hospital state in 1956 (Keats, 1956) and in the 1980's this still appears to be true. Recent studies demonstrate that surgical patients experience inadequate pain relief during the post-operative period (Cohen, 1980; Donovan, 1983; Keeri-Szanto, 1979; Loan & Morrison, 1967; Wallace & Norris, 1975). Cohen (1980) reported that 75% of her surgical sample experienced moderate to severe pain post-operatively. Amazingly this consequence of surgery is tolerated by the health care system while a 75% incidence of wound infection or minor atelectasis would not be permitted. In practice, post-operative pain appears to be viewed as a necessary but temporary part of the healing process. Cohen (1980) reported that 39% of the nurses in her study did not consider maximum pain relief to be their primary goal and this could have important implications for patient recovery. Pain which remains moderate to severe in nature can contribute to pulmonary and circulatory dysfunctions and gastrointestinal disturbances (Benedetti, Bonica & Bellucci, 1984). It can also interfere with patterns of sleeping, eating and social behaviour when its presence occupies a large proportion of the individuals attention (Wall, 1979). In addition, the presence of pain can limit the effect of

therapeutic interventions. For example, it can hinder ambulation, deep breathing and coughing exercises and/or the adequate cleansing and packing of a surgical incision. All of these effects serve to increase patient discomfort during the post-operative period and support the need for adequate pain control. The knowledge that prolonged, acute pain may be a precursor for chronic pain (Bonica, 1985) provides further rationale for the effective control of surgical pain. At present narcotics are the conventional method of surgical pain control. The maximum amount of narcotic a patient can receive during a 24 hour period is stated by the physician but nurses are free to administer the drug, at their discretion, within this designated range. Researchers have demonstrated that analgesic requirements are influenced by diverse demographic and psychological variables (Taenzer, Melzack & Jeans, 1986). In addition, it has been shown that the amount of analgesic administered is influenced by characteristics of both the patient and the nurse. One major finding of these studies suggests that nurses equate degree of injury to an expected amount of pain when they assess the pain a patient is experiencing (Davitz & Pendleton, 1969; Dudley & Holm, 1984; Lenburg, Glass & Davitz, 1970; Mason, 1981; Seath & Rigney-Radford, 1984; Taylor, Skelton & Butcher, 1984).

Although the analgesic effects of narcotics cannot be denied when they are administered appropriately they have the potential to alter conciousness and to contribute to the incidence of patient confusion, gastrointestinal disturbances and, infrequently,

respiratory distress. Prolonged narcotic use is also associated with physical and psychological dependence. If present, these side effects have the ability to impede patient recovery, a compelling reason to implement, where feasible, additional methods of pain control. Research which evaluates the effectiveness of pain control techniques in the clinical setting has an important role to play in the area of pain management.

Methodological Issues

When evaluating the effectiveness of pain control techniques in the clinical setting the study design, control techniques and pain measurement tool(s) must be considered. Failure to analyze these factors can result in inappropriate pain management recommendations.

Design

The research design must permit a comparison of the treatment with either baseline data or an alternative pain relieving technique. Where possible, the presence of a placebo effect should also be assessed. Implementing a placebo makes it possible to determine how much of the treatment effect can be attributed to treatment specific factors and how much to placebo related factors. A double-blind should also be employed when feasible. The double-blind placebo model is one of the best techniques available to eliminate differential subject perceptions of the treatment and thereby enhance internal validity of the study (Christensen, 1985). When a double-blind is not feasible, a

partial blind should be implemented.

If applicable, the design should also include an adequate follow-up to determine if the treatment effects are long term or transient in nature. Due to the time characteristics of acute and chronic pain a follow-up is normally most appropriate in studies evaluating chronic pain relief.

Pain Measurement

Both objective and subjective pain measures have been employed in pain research. Von Frey introduced objective pain measures and Beecher was the first researcher to quantify clinical pain using a subjective patient response (Wolff, 1980). Objective measures may require pain assessment by an observer and this can introduce subject and/or observer bias into the study and weaken the internal validity. Research data has also indicated that discrepancies can exist between observer reports and patient self-reports of pain (Kremer & Block, 1981; Teske, Randall & Cleeland, 1983).

Pain measurement has been primarily subjective since the introduction of the gate-control theory (Finch & Melzack, 1982; Jensen, Karoly & Braver, 1986). Visual analogue, numerical rating and verbal description scales are subjective tools which measure pain intensity. These scales are reported to be reliable and sensitive pain measures which are useful to assess treatment effects (Craig & Prkachin, 1983; Huskisson, 1983; Jensen et al., 1986). The nature of the scale used (visual analogue, numerical or adjective) has not been found to influence reports of pain

intensity (Jensen et al., 1986; Kremer, Atkinson & Ignelzi, 1981).

The McGill Pain Questionnaire is a multidimensional subjective pain measure which is conceptually linked to the gate-control theory. It is designed to evaluate the sensory-discriminative, motivational-affective and cognitive-evaluative dimensions of pain and it is reported to be a valid, reliable and useful tool to measure pain (Melzack, 1983; Reading, 1983; Turk, Rudy & Salovey, 1985). It must be recognized however, that subjective measures can also be distorted. They can be influenced by subject, interviewer and experimenter bias. They can also be difficult for subjects to complete. Young subjects and subjects who are disabled mentally and/or physically may be unable to comprehend the instructions related to the use of the tool and their language skills may be inadequate to convey their thoughts and feelings (Craig & Prkachin, 1983).

When selecting an appropriate pain measure the researcher must consider (1)the type of pain to be measured, (2)the exact purpose and goals of the tool and (3)the definition of pain derived for the study in question (McGuire, 1984). Formulating an operational pain definition is important because at present there is no generally accepted definition of pain. When pain is defined according to the subjects' translation a method of self-report should be implemented. Sample characteristics, ease of administration, scoring of the tool and its reported reliability and validity must also be considered.

If the research includes an evaluation of post-operative pain

the variable distribution of surgical pain severity must be considered (Keats, 1956). As many as 20% of patients who undergo thoracic or abdominal surgery may not complain of any significant post-operative pain (Papper, Brodie & Rovenstine, 1952). Random assignment should be employed in studies which evaluate surgical pain for the purpose of dealing with this variable.

Nursing Management of Pain

Nurses are the health care professionals most readily available to the hospitalized patient therefore they have an essential role to play in providing adequate pain relief. For this reason it is important for nursing research to study the many factors which influence clinical pain and to look specifically at methods of pain control available to nurses.

Nursing research which looks specifically at methods of pain control is found sporadically in the literature. The use of moist heat (Halsell, 1967), and music (Locsin, 1981) have been reported to relieve post-operative pain. Approaches taken by nurses while caring for patients in pain and administering analgesics has also been investigated (Chambers & Price, 1967; Diers, Schmidt, McBride & Davis, 1972; McBride, 1967; Moss & Myer, 1966). Finally, the use of pre-operative teaching to decrease anxiety and subsequently decrease post-operative pain has been well-documented (Johnson, Fuller, Endress & Rice, 1978).

Witt (1984) states that any pain relieving measure should lie within the scope of the nurses' qualifications. The intervention

should be effective and portable and it should not require physician supervision or informed patient consent. In addition, it must not interfere with the patients medical regime. These guidelines suggest that distraction, relaxation, suggestion, imagery and cutaneous stimulation are methods of pain relief which could be used by nurses, at their discretion, in the clinical setting. However, the effectiveness of the above methods are poorly documented. Distraction, relaxation, suggestion and imagery are techniques designed to promote the psychological control of pain. Relaxation is used as a means to control tension and anxiety, factors known to increase pain (Craig, 1984). Similarly, distraction, suggestion and imagery are coping mechanisms which provide the individual with some sense of control over the painful experience. This sense of control can change the meaning of the painful situation and make it more tolerable.

A review of the literature related to pain management indicates that the use of cutaneous stimulation to relieve pain is receiving increased attention since the introduction of the gate-control theory. In the following section, transcutaneous electrical nerve stimulation (TENS) is described and the feasibility of using TENS as a method of post-operative pain control is discussed.

Transcutaneous Electrical Nerve Stimulation

The use of TENS was recorded as early as 46 A.D. when Greek and Roman physicians used the torpedo fish or electric ray to treat

such ailments as gout and headaches (Kane & Taub, 1975; Kellaway, 1946). Today, developments in the fields of electronics and Neurophysiology have permitted its safe and reliable use in the clinical setting (Tyler, Caldwell & Ghia, 1982).

The TENS mechanism can be explained using the gate-control theory. TENS is thought to stimulate the large diameter, myelinated A-beta fibres which have a low threshold for electrical stimulation. The increased activity in these fibres serves to decrease the transmission of painful stimuli through the small diameter A-delta and C fibres (Melzack & Wall, 1984). An alternate hypothesis proposes that TENS enhances the release of the bodies naturally occuring opiates (endorphins) which bind to receptors on the terminals of primary afferent pain fibres and prevent the transmission of painful stimuli (Tyler et al., 1982).

TENS was initially used to control chronic pain and more recently it has been employed to control surgical pain (Tyler et al., 1982). Eighty percent of patients in one study reported reduced pain when they used TENS post-operatively (Hymes, Raab, Yonehiro, Nelson & Printy, 1974). Since this time researchers have demonstrated that TENS is an effective technique for pain control in patients who have undergone a variety of surgical procedures. These include abdominal, thoracic, back and orthopaedic surgery (Ali, Yaffe & Serrette, 1981; Bussey & Jackson, 1981; Cooperman, Hall, Mikalacki, Hardy & Sadar, 1977; Harvie, 1979; Hymes, et al., 1974; Kurzbauer, 1981; Pike, 1978; Rosenburg, Curtis & Bourke, 1978; Schuster & Infante, 1980; Solomon, Viernstein & Long, 1980;

Stabile & Mallory, 1978; VanderArk & McGrath, 1975). Each study found TENS to be a simple, non-toxic and non-invasive procedure (Tyler et al., 1982). A local skin reaction at the sites of the electrodes was the only complication observed following the appropriate application of TENS (Harvie, 1979; Rosenberg et al., 1978; Schuster & Infante, 1980). It was also found to offer advantages over narcotic administration. Namely, TENS decreased or prevented the incidence of respiratory depression, sedation, confusion and gastrointestional disturbances. In addition, TENS did not promote physiologic or psychologic dependence (Tyler et al., 1982). Because of these many benefits TENS receives a high degree of patient acceptance and many people own and operate their own TENS unit at home. TENS can also be used by a vast majority of the population. Individuals who have demand cardiac pacemakers and women in their first trimester of pregnancy are the only people for whom the use of TENS is not recommended (Burton, 1976).

It is interesting to note that all of the TENS studies cited used the number of analgesics requested by the patient as the primary measure of post-operative pain control. Current research has indicated that this measure may not be the most valid because a low correlation has been reported between narcotic requests and subjective pain ratings (Taenzer, 1983). Research has also demonstrated that analgesic requests can be related to patient (Taenzer, Melzack & Jeans, 1986) and nurse variables. Notably, nurses' decisions to administer the drugs are influenced by (1)patient diagnosis (Davitz & Pendleton, 1969; Dudley & Holm,

1984; Lenberg, Glass & Davitz, 1970; Mason, 1981; Seath & Rigney-Radford, 1984; Taylor, Skelton & Butcher, 1984), (2)form of pain expression (Baer, Davitz & Lieb, 1970) and (3)patient socioeconomic status (Davitz & Davitz, 1975; Davitz & Pendleton, 1969). In addition, the gate-control theory indicates that subjective pain reports are the most valid measure of pain. In summary, the above research suggests that drug requests should not be used as the only outcome measure. TENS research which incorporates a subjective pain rating would permit a more adequate evaluation of the use of TENS for surgical pain control.

Specifically, one could ask if TENS has a role to play in providing pain relief during a single event which could be uncomfortable for the patient, an abdominal wound packing for example. After bowel surgery or when infection is present at the time of surgery or expected post-operatively, subcutaneous tissues may not be sutured and the wound is packed two to three times daily. The presence of the open wound can foster patient anxiety and thereby enhance the perception of pain (Benedetti et al., 1984; Craig, 1984). In addition, the formation of the incision causes tissue damage and promotes the production of pain producing substances, e.g., substance P, potassium, hydrogen ions, lactic acid and bradykinin. These substances decrease the pain threshold of nociceptors and sensitize damaged nerve endings (Benedetti et al., 1984). Because these physiological changes take place tension at the site of the incision can cause pain. Cleansing and packing the wound cavity involves movements which can create tension and

subsequently pain. If packing the wound becomes a painful experience for the patient nurses may be unable to execute the procedure effectively (Doherty, 1979). If inadequate wound care exists an increased incidence of wound infection can occur (Anderson, 1985). Clearly, adequate pain control during a surgical wound packing would serve to promote patient comfort and minimize the incidence of a wound infection. TENS is a method of pain control which could be employed easily and safely during a surgical wound packing.

Summary and Conclusions

Pain research and pain management in the Western world was influenced primarily by the specificity theory until the gate-control theory was introduced in 1965. This theory was the first pain theory to incorporate the influence of both physiological and psychological processes in the pain experience.

Although the gate-control theory increased our knowledge in the area of pain management it appears that surgical patients still continue to receive inadequate pain relief post-operatively. Because poor pain control can hinder patient recovery it is important to search for improved methods of pain management.

Narcotics are presently the primary method of surgical pain control but their use is associated with side effects and their delivery can be sporadic. Because nurses are the health care professionals most readily available to the hospitalized patient they play an essential role in providing adequate pain relief. To

enhance pain management during the post-operative period two major areas for research have been identified. First, it is necessary to document nurses' pain beliefs and theories and their current patterns of pain management to determine whether present nursing practices are based on a lack of knowledge about pain and available pain relieving measures or if they are influenced by a collection of false information. This information would identify areas of pain management which need to be clarified and it would provide guidelines for future nursing education at all levels. To provide patients with maximum pain control it is essential that nurses are aware of the many variables which can contribute to an individuals pain and to their responses to this pain. Second, limited nursing research on pain relieving measures indicates that further research is needed in this area. Nurses need to be aware of pain relieving techniques available to them but these techniques must first have been proven to provide effective pain control. In addition these techniques should be acceptable to, and practical for a majority of patients and they must be suitable for nurses to administer and incorporate easily into their daily practice. A review of the literature suggests that TENS is a method of pain control which meets these criteria. A study should be designed to determine if TENS will decrease the amount of pain adult surgical patients experience during an abdominal wound packing.

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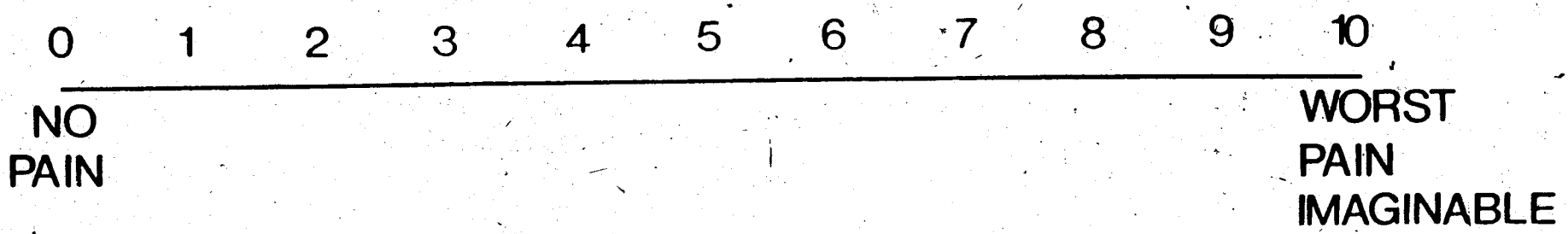
Appendix B

11-Point Self-Report Pain Scale

11-Point Self-Report Pain Rating Scale



Appendix C

Samples of Subject Consent Form and Study Summary

CONSENT FORM

Study: Use of TENS During Dressing Change.

Researcher: Ann Hargreaves
Master of Nursing Student
Faculty of Nursing
University of Alberta
Phone: 432-6251

This study will evaluate the use of TENS for any pain associated with routine wound packings.

1) You may withdraw from the study at any time with no consequences.

2) Your name and the information you provide will be kept confidential. Your name will not appear in any research reports.

3) You may be in a control group and you may not receive TENS.

4) Two sticky paper patches will be placed near your incision in preparation for the TENS treatment. You may experience a minor skin irritation at the sites of the patches but this is not common.

I agree to participate in the study titled "Use of TENS During Dressing Change".

_____ _____
(Signature) (Date)

_____
(Witness)

PATIENT INFORMATION SHEET

Study: Use of TENS During Dressing Change

Researcher: Ann Hargreaves R.N.
M.N. Student
Faculty of Nursing
University of Alberta
Phone: 432-6251

Supervisor: Dr. J. Ramsay
Faculty of Nursing
University of Alberta
Phone: 432-6317

1) I want to find out if TENS will help any pain you have at your incision during dressing change.

2) TENS is used by some people to help their long-term pain. We don't know the effect of TENS with pain like yours. TENS equipment looks much like a portable radio and it is often battery operated. The TENS equipment I use is a bit larger and it is plugged in.

3) People who use TENS place sticky paper patches near the incision site. These patches are attached to the TENS machine.

4) Some people will feel nothing and others will feel a tingling.

5) To be able to assess TENS, some people will get TENS for about 30 minutes and others won't get TENS. You may be randomly chosen for a control group and you will not receive TENS.

6) The study will be done about two days after surgery when you are having a regular dressing change. You will only take part in the study once. Whether or not you get TENS, I will ask you to tell me about any pain or sensations you have during your dressing change. I will also take some information from your chart about your age, why you had your surgery and when you last had a needle.

7) TENS has been used safely with most people. 1% to 2% of people who have TENS have skin irritations (such as redness) after the sticky paper patches. Otherwise there seem to be no problems. It is not used for people who have pacemakers or women in early pregnancy.

8) I want you to know that once the study has begun you can drop-out at any time or change your mind about being in the study. No one will hold that against you.
Your care during your stay here won't change if you are or aren't in this study. You will still receive pain medication as ordered by your doctor.

9) Your name and what you say and do will be confidential. Your nurses and doctors will not see or hear about your records from this study unless you, yourself, wish to speak with them about your experiences.

Appendix D

Protocol Used for Electrode Placement

Protocol Used for Electrode Placement