Transcutaneous Electrical Nerve Stimulation: An Overview

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ABSTRACT

Pain and its management hold a central place in health care. The pain associated with pregnancy and giving birth is unique in that it is a normal, physiologic phenomenon that is affected by cultural mores, personal experience, and internalized sensations. There are numerous nonpharmacologic tools available to treat discomfort during pregnancy and childbirth. Some methods of nonpharmacologic relief are underutilized, due to the lack of knowledge of the evidence. Childbirth educators, doulas, nurses, and midwives are a prime source of knowledge for birthing families to learn a variety of comfort techniques during pregnancy and labor. The purpose of this article is to discuss the use of transcutaneous electrical nerve stimulation (TENS) as a nonpharmacologic comfort technique.

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Pain and its management hold a central place in health care. It is estimated that people seeking care in an emergency department report having pain approximately 70% of the time. While 50% of inpatients of the hospital report pain, 35% of them rate the pain as severe (Johnson et al., 2019). Pregnant women experience a transformation in their bodies that can lead to alterations in their physical and emotional state, causing discomfort (Lothian & DeVries, 2017). The pain associated with giving birth is unique in many ways. It is a wholly normal, physiologic phenomenon that is affected by cultural mores, personal experience, and internalized sensations. Physiologically, this pain sensation is created by the stretching of the pelvic joints, cervix, vagina, and perineum. Likewise, the contractile forces of the uterus produce painful sensations that accompany the tissue stretching (Hilbers & Gennaro, 2017).

Pain management during pregnancy and birthing has experienced an evolution over time. Currently, there are numerous pharmacologic and nonpharmacologic tools available to women to treat pain and discomfort during pregnancy and childbirth. Nonpharmacologic strategies experience widespread usage, such as, relaxation, water immersion, and massage, while other methods are perhaps underutilized. This underutilization is often due to the lack of scientific evidence (DiTomasso, 2019), or lack of knowledge of the evidence. Childbirth educators, doulas, nurses, and midwives are a prime source of knowledge for birthing families to learn a variety of coping techniques during labor (Lothian & DeVries, 2017). The purpose of this article is to discuss the use of transcutaneous electrical nerve stimulation (TENS) as a nonpharmacologic comfort technique.

TRANSCUTANEOUS ELECTRICAL NERVE STIMULATION

The use of an electrical charge to relieve pain has its roots in ancient history. There are cave drawing artifacts showing an electric fish, and in 46 AD the first written account was documented of the use of a person standing on an electric fish to relieve pain (Johnson, 2014; Wright, 2012). Modern usage was

first documented by Wall and Sweet (1967) to relieve chronic neurogenic pain. TENS involves the use of an electrical current distributed by way of electrodes that are placed on the skin. TENS usage is a noninvasive, inexpensive, nonaddictive, source of pain relief that can be self-administered in many cases (Johnson, 2014; Santuzzi et al., 2013). The placement of the electrodes is critical for the success of the procedure. Generally, electrodes are placed over the major nerves near the location of the pain (Johnson, 2014). However, studies indicate that placement of the electrodes in areas away from the site of the pain also provides substantial relief of pain (Wright, 2012).

Gate-Control Theory of Pain

Melzack and Wall's (1965) gate-control theory of pain, which is well known to childbirth educators, is theorized to be the mechanism of action for pain relief from TENS. This theory put forth that impulses of pain travel to the central nervous system by way of small-diameter nerve fibers, while sensory impulses travel by way of large-diameter nerve fibers. Melzack and Wall postulated that a gating mechanism in the posterior horn of the spinal cord processes the incoming impulses. By interrupting the pain impulses with sensory impulses, the "gate" is closed to the incoming pain impulses, thus decreasing pain sensation (Melzack & Wall, 1965).

TENS functions to stimulate the A-beta nerve fibers in the skin with the electrical stimuli, thus, the signal of pain sensation being carried on the small-diameter nerve fibers is blocked. This process is called segmental inhibition (Samuel & Maiya, 2015; Wright, 2012). In addition, the stimulation of the small nerve fibers in muscle decreases the release of excitatory neurotransmitters and increases the release of inhibitory neurotransmitters, such as serotonin, and endogenous endorphins (Wright, 2012).

TENS Dosing Technique

There are typically three types of dosing regimens for TENS. These are low-frequency or acupuncture, high-frequency or conventional, and intermittent or burst frequency dosing. Low-frequency dosing has a frequency of approximately 2–10 hertz (Hz) (Quittan et al., 2016). It is low-frequency dosing that stimulates the body to release endorphins. Using low-frequency dosing takes a longer time to achieve pain relief sensation since it requires time for the release of endorphins. However, this pain relief sensation lasts longer owing to the chemical endorphins. Post dosing pain relief has been reported to last between 5 minutes and 18 hours, with some people reporting relief up to 24 hours post-dosing (Samuel & Maiya, 2015; Wright, 2012). As can be noted, there is wide variation in response from individuals, which is not well understood (Wright, 2012). Likewise, there are reports of cumulative effects on pain relief with repeat applications of TENS with the hypothesis that this is due to changes in the neuronal pathway (Samuel & Maiya, 2015).

High-frequency dosing occurs within the range of approximately 90 to 150 Hz. It is the high-frequency dosing that decreases the excitatory neurotransmitters and increases the inhibitory neurotransmitters, such as serotonin (Samuel & Maiya, 2015). High-frequency dosing often has a rapid onset of relief, while also losing effectiveness rapidly when TENS is discontinued (Wright, 2012). There is a tendency for patients to tolerate the high-frequency dosing better than low-frequency dosing; therefore, high-frequency dosing is often initiated first (Sluka et al., 2013).

Burst TENS is high-frequency dosing that has intermittent bursts of two to three episodes of low-frequency dosing. With burst dosing, the person experiences increased serotonin and endorphins release (Samuel & Maiya, 2015). With long-term use of TENS, the central nervous system becomes accustomed to the stimulus, thus decreasing the effectiveness of treatment. This is called habituation (Wright, 2012). Burst TENS is one means to overcome the effects of habituation (Sluka et al., 2013).

For therapy to be effective it is critical that the intensity be maintained at enough strength to generate decreased pain sensation. Initially, it is usual to have the intensity increased until the person feels an effective, but tolerable sensation, not provoking pain or muscle contractions (Johnson, 2014). As the person becomes habituated to the intensity, it is also common to gradually increase the intensity as the treatment progresses to maintain the same level of tolerable sensation (Sluka et al., 2013).

Precautions

Safe usage guidelines are available from both manufacturers and professional associations related to physiotherapy with the use of TENS. Some of these recommendations are based on medico-legal viewpoints rather than evidence-based literature.

For example, manufacturers often state that TENS units should not be used in the pregnant population, yet there is clinical research that points to use with this population if safeguards are in place (Johnson, 2014).

Generally, persons with implanted devices should be checked to ascertain that the electrical current emitted by the TENS unit does not interfere with the implanted medical devise. Consequently, TENS should not be used in anyone with a cardiac pacemaker if the programming cannot be overridden to avoid interference by the TENS. Likewise, anyone with an implantable cardioverter-defibrillator should not use the TENS unit as there is evidence that the electric current of the TENS would inhibit the functioning of the defibrillator. In these cases, a cardiologist should be consulted (Johnson, 2014).

Usually, the TENS electrodes should not be placed on the gravid abdomen. However, there are reports of the use of TENS to improve placental blood flow without ill effect to the fetus (Crothers et al., 2012; Johnson, 2014; Resnik, 2002). Also reported is that TENS electrodes should not be placed on the head of someone with epilepsy. Areas of skin should be avoided over open wounds, areas prone to bleeding, damaged skin, or skin with decreased sensation. Likewise, the electrodes should not be placed over sites of deep vein thromboses. There is limited knowledge about TENS use over sites of solid tumor carcinomas, as the effects on tumors are not known. However, TENS has been used in palliative, end-of-life care. Finally, TENS should not be used on the eyes or over the anterior neck at the carotid arteries (Johnson, 2014).

General Usage

TENS units and accessories are relatively inexpensive. The units are generally available for purchase at pharmacies as an over-the-counter product or accessible via the internet. Often the units are powered by 9-volt batteries. TENs units can be used as a stand-alone therapy or in conjunction with pharmaceuticals (Banerjee & Johnson, 2013).

A qualitative research study of reported chronic back pain in England found both direct benefits of TENS units, such as decreased pain sensation, as well as indirect benefits, such as decreased usage of medications and enhanced ability to rest (Gladwell et al., 2015). A quantitative study from Egypt reported improvement in back pain measurement, flexion, and extension range of motion with TENS therapy and exercise as compared to exercise alone (Elserty et al., 2016). In a study from India, TENS was used to augment medications in post-abdominal surgery patients in both emergent and planned surgical procedures. The authors of this study found that continuous TENS application provided the best pain relief after surgery. In addition, these authors found decreased post-surgical complications from paralytic ileus and atelectasis (Verma & Gupta, 2018). Thus, the benefits of TENS therapy are noted in both medical and surgical applications. Likewise, there are benefits as perceived by patients and quantified by physical outcomes.

TENS USAGE IN PREGNANCY

Low Back Pain

Approximately half of all pregnant women experience some type of back pain (Brown & Johnston, 2013; Carvalho et al., 2017; Kurup et al., 2012). A recent multinational study found the prevalence of back pain in pregnancy to be 70%–86% with the highest reports from the United States and the lowest reports from Norway. Of interest, this study stated that the greatest intensity of low back pain was described by women of the United Kingdom (Gutke et al., 2018). The pain is most often described as an intermittent, burning sensation (Carvalho et al., 2017). In comparison, approximately 40% of non-pregnant women complain of low back pain (Hughes et al., 2018; Thorell & Kristiansson, 2012).

Of women who complain of low back pain, 20% complain specifically of pelvic pain (Liddle & Pennick, 2015; Sinclair et al., 2014). However, many times back and pelvic pain are considered together as often women have difficulty articulating a difference in the pain sensations (Hughes et al., 2018). While there are definitions for the specific locations of low back pain and pelvic pain (Gutke et al., 2018), it is often difficult clinically to differentiate pain from these two locations, since women often describe them together (Hughes et al., 2018). Symphysis pubis pain does not occur often in gravid women; however, it is more incapacitating when it does occur (Diaz & Rivera, 2012). Most women report that low back pain regresses by 6 months after giving birth (Thorell & Kristiansson, 2012).

Commonly, women first report low back pain during the second trimester and usually describe it as more painful at night than during the day

(Carvalho et al., 2017). In a study by Brown and Johnston (2013), women in the United Kingdom were more likely to complain of greater low back pain using a visual analog scale (VAS) in the third trimester when they perceived that the fetus was in a suboptimal position. In comparison, women who described the fetus as being in an optimal position reported lower intensity of low back pain using a VAS (Brown & Johnston, 2013).

The exact cause of back pain in pregnancy is unknown (Hughes et al., 2018) but is generally considered to be of musculoskeletal origins, rather than gynecologic (Gutke et al., 2018). Biomechanically, the center of gravity moves forward as the breasts, fetus, and uterus grow, thus increasing weight distribution (Carvalho et al., 2017; Hughes et al., 2018). Added to this, is water retention owing to the effects of progesterone activation. In turn, this leads to changes in posture, decreased plantar arches, hyperextension of the knee joints, forward tilting of the pelvis, and lumbar lordosis. Relaxin, which is released from the corpus luteum, relaxes all joints, not simply the ones of the pelvic girdle (Carvalho et al., 2017). With the growing utero-fetal structure, the abdominal wall musculature stretches, thus decreasing the structural support (Kurup et al., 2012). All these factors in concert lead to lower back pain and pelvic pain (Hughes et al., 2018). Of interest, spinal disc disease is not more prevalent in pregnancy (Diaz & Rivera, 2012).

Risk factors associated with the development of lower back pain are a previous history of low back pain, and/or a history of low back pain occurring only during the menstrual cycle (Carvalho et al., 2017). According to a study by Kurup et al. (2012) low back pain is more likely to occur with women of advanced maternal age; short stature, less than 5 feet 3 inches or 160 cm; higher parity; and late gestational age, that is, at the end of pregnancy (Kurup et al., 2012). There is no difference in prevalence between women who are identified as having either low-risk or high-risk pregnancies (Carvalho et al., 2017).

Physiologic and psychologic disturbances due to low back pain lead to poor quality of sleep and rest. In turn, this leads to interference with activities of daily living, as well as household and recreational activities. Low back pain issues can translate into an economic deficiency with poor work performance and/or absences from work (Carvalho et al., 2017).

TENS Therapy for Low Back Pain

Approximately 20%–25% of women with low back or pelvic pain seek treatment for this condition (Gutke et al., 2018; Sinclair et al., 2014). Women seek treatment from a variety of health-care disciplines and with a variety of methods (Sinclair et al., 2014). However, physiotherapy or physical therapy is the most sought discipline for treatment (Gutke et al., 2018; Hughes et al., 2018; Sinclair et al., 2014). Physical therapy includes complementary and alternative treatment measures, such as TENS (Sinclair et al., 2014).

While studies have identified that no single treatment is completely successful in removing all pain (Diaz & Rivera, 2012), a systematic review by Gutke et al. (2015) found that there was a significantly greater decrease in low back pain and a greater increase in functioning with TENS treatment. TENS therapy is considered safe in all three trimesters of pregnancy with no differences in maternal or neonatal outcomes (Keskin et al., 2012; Shah et al., 2015).

Four electrodes measuring from 5 cm by 5 cm to 5 cm by 9 cm in size should be used. Sites for electrode placement should avoid acupressure points utilized for induction of labor (Diaz & Rivera, 2012). These sites include LI4, the dorsal aspect of the thumb webbing, and SP6, bladder 60 and 67, on the lower half of the leg and ankle. Some include avoiding the gallbladder 21, the middle of the trapezius muscle, which is often used to alleviate shoulder pain. Generally, for low back and pelvic pain, electrode sites on either side of the spine are most appropriate. It is suggested that depending on the gestational age, TENS therapy should be discontinued if uterine contractions develop during treatment (Crothers et al., 2012).

Recommendations for TENS usage in pregnancy are to keep the current density low (Crothers et al., 2012). The TENS unit should produce a tingly sensation two to three times the sensory threshold (Galfat & Mishra, 2019). Recommendations based on Austrian guidelines show the sensitivity threshold to be near 5–8 milliamps. Quittan et al. (2016), recommends high-frequency TENS of 80–120 Hz, continuous therapy, with a pulse duration of 0.1–0.2 milliseconds. Therapy should occur a minimum of one 30-minute session per day (Quittan et al., 2016). However, Galfat and Mishra (2019) describe a therapeutic regimen with treatment occurring twice a week for 3 weeks with improvement in both

VAS and disability questionnaire scores (Galfat & Mishra, 2019).

Neuropathic Pain Relief With TENS

There is a case report in the literature of a 33-year old woman with neurofibromatosis type 1, and a T12-L13 meningocele, with cauda equina distortion, which caused her significant pain at the S1–S4 nerve roots. She was being treated with opioid analgesics; however, she presented with the desire to have a child and to stop her opioids. She reportedly stopped her opioids on her own when she learned she was pregnant and had withdrawal symptoms, for which she was referred to a pain clinic. Of interest, chorionic villi sampling determined that the embryo did not carry the neurofibromatosis gene (Silva & Afonso, 2019).

At 15 weeks gestation, the woman was prescribed a TENS unit with a preset frequency of 125 Hz and a pulse duration of 100 microseconds. She was advised of the risks of TENS therapy, particularly the lack of evidence for the use of TENS for this indication in pregnancy. She consented to proceed with this treatment for 30 minutes per session, for four times per day. She initially presented to the pain clinic with a VAS of 8 out of 10, but throughout the remainder of her pregnancy, she reported pain on a VAS of 2–4.5 out of 10 (Silva & Afonso, 2019).

Throughout her pregnancy, she did not experience any side effects of TENS therapy, and ultrasound surveillance of the fetus remained normal. She gave birth at full term and continued the use of the TENS unit for 6 months postpartum while she breastfed. At 6 months postpartum, she elected to return to pharmacologic treatment with gabapentin for her chronic pain, as her end of day pain rose to the level of 7 out of 10 on a VAS. Both mother and child were followed for 24 months after birth. The child exhibited normal growth and development, with no evidence of neurologic or psychomotor deviations (Silva & Afonso, 2019).

TENS Usage During Labor

In 2009 the *Cochrane Database of Systematic Reviews* released an evaluation of research on the use of TENS as a pain management therapy during labor. The result of their findings was that there was no consistent evidence to support the benefit of TENS in labor, as some studies showed a benefit, while others did not. However, the authors went on to say that there were no known risks to mother or baby from the use of TENS during labor. Finally, their conclusion was that it was appropriate to recommend the option of TENS therapy, alone or as an adjunct to other treatment, at any stage of labor (Dowswell et al., 2009).

A study by Mucuk et al. (2013), compared VAS, along with adrenocorticotropic hormone (ACTH) and cortisol levels of women in labor both with and without TENS therapy. In the intervention group, women who were between 3.5 and 5 cm of cervical dilatation were given a 20-minute TENS session. The current density was low at no greater than 0.6 milliamps, frequency was low at 5–10 Hz with a pulse duration of 2.5 milliseconds. The control group did not have a TENS session, but instead had a nurse sit constantly at the bedside for 20-minutes. At the end of both 20-minute sessions, blood specimens were drawn and pain level was assessed with a VAS. Results showed that in the TENS intervention group there was a clinical decrease in VAS levels of pain, and both ACTH and cortisol levels; however, the results did not reach statistically significant levels (Mucuk et al., 2013). This leads to a conclusion that both pain and stress levels appeared to clinically decrease with TENS therapy.

Baez-Suarez et al. (2018) reported on a research study to explore the effect of TENS therapy during labor and to find a more effective dosage. The study was a randomized controlled trial that included a placebo. There were three study groups, two active TENS intervention groups and a non-TENS placebo control group. In both TENS groups, women experienced clinically significant decreases in pain; however, only the group with dosages of high frequencies (80–100 Hz), and a high-pulse duration (350 microseconds) were statistically significant. There were no significant differences in any of the groups with respect to neonatal outcomes, such as Apgar scores, birth weight, or head circumference. A secondary outcome was that women in both TENS groups reported greater satisfaction with their birth experience 24 hours after giving birth than the non-TENS group (Baez-Suarez et al., 2018).

A study investigating TENS usage in the first stage of labor with a sample of primigravid women was reported in 2020 by Lilly. In this study, there was a control group with no treatment and an intervention group with TENS therapy. All women were 38–40 weeks gestational age. All women were at 3–7

cm of cervical dilatation when they were enrolled in the study. Outcomes collected during the study were both pain levels from a VAS and behavioral assessments from observational checklists. The observational checklists were tested for reliability and interrater reliability prior to the beginning of the study. The dosing parameters of the TENS therapy was not described; however, it was reported that the unit was given to the women with explanations of usage, so that the women were in control of turning the unit on or off. Since the women were in control of the unit, perhaps they were able to change the dosing frequency to achieve their own satisfaction level, yet this is not reported. Findings were reported as statistically significant for lower VAS in the women with TENS therapy, as compared to those without TENS. Likewise, there was a statistically significant difference reported between the behavioral responses to pain between the group with TENS therapy and the group without TENS therapy (Lilly, 2020).

IMPLICATIONS FOR PRACTICE

Education of Childbirth Educators, Nurses, Doulas, and Midwives

As previously stated in a review published in the *Cochrane Database of Systematic Reviews* (2009), the authors present the conclusion that because TENS therapy does not cause harm and could provide benefits, women in labor should be offered TENS therapy at any stage of labor when the birthing woman believes it to be helpful (Dowswell et al., 2009). A study by Boateng et al. (2019) seemed to indicate that maternity nurses and midwives were not aware of TENS therapy as a nonpharmacologic comfort measure; therefore, when studying their experiences with nonpharmacologic interventions during labor, the nurses and midwives in this study did not report its usage. Consequently, childbirth educators, doulas, nurses, and midwives should be educationally prepared and knowledgeable to educate on TENS therapy should their clients present with questions.

Childbirth educators have the responsibility to bring knowledge, and thus enlightenment, to prepare expectant families for the birthing period and beyond (Waller-Wise, 2013). It is important for childbirth educators to be well-informed on the use of the TENS unit. Some research seems to indicate that TENS is more beneficial when the user is moving. Therefore, childbirth educators could discuss the use of TENS therapy as they include movement in their classes (Ondeck, 2019; Sluka et al., 2013). Or this topic could be taught along with comfort measures of pregnancy (Terreri, 2013).

In addition, childbirth educators, doulas, midwives, and nurses should add TENS therapy to their arsenal of comfort techniques taught and used during pregnancy. Bedside nurses dramatically impact the care that women obtain in the hospital setting. For nurses to change bedside practice, hospital and nursing administration needs to support practice change (Waller-Wise et al., 2020). Policy, either at the administrative or unit level, should be written to allow TENS therapy within the hospital or antenatal setting for pregnant women with low back pain of pregnancy.

National Associations of Physiotherapy or Physical Therapy

The Association of Charted Physiotherapists in Women's Health from the United Kingdom has guidelines for the usage of TENS therapy during pregnancy. However, these guidelines do not offer specific recommendations for dosages of therapy (Crothers et al., 2012). Likewise, the Austrian Society of Physical Medicine and Rehabilitation and the Austrian Pain Society established guidelines for TENS usage in pregnancy for musculoskeletal pain (Quittan et al., 2016). More national associations of physical therapists and/or physiotherapists need to publish guidelines for usage along with specific information on dosing. These guidelines need to be updated frequently as evidence evolves.

Patient Teaching

As can be seen from this review of TENS therapy, several different dosing regimens have been used in research. A good starting point for the education of expectant families is the Austrian guidelines. Electrodes should be placed alongside the spinal column at L3 and in the area of the sacroiliac joints. The frequency should be in the range of 80–120 Hz, a pulse duration of 0.1–0.2 milliseconds, and a sensitivity threshold in the vicinity of 5–8 milliamps, as tolerated without causing distress, added pain, or muscle spasm (Quittan et al., 2016) Therapy can continue as long as it provides relief, but the pregnant women are to be in control of the TENS unit (Lilly, 2020). If habituation occurs, the unit can be discontinued or can be switched to a different dosing regimen (Wright, 2012). There are choices for dosage for

pregnant women, as can be seen in the various dosing routines reported from research in this article. For example, the dosing procedure of Baez-Suarez et al. (2018) of high frequencies (80–100 Hz), and high pulse duration (350 microseconds), which was previously discussed provided greater pain relief (Baez-Suarez et al., 2018).

Research

Next, research needs to continue to include applications for TENS use in pregnancy and its effectiveness (Hughes et al., 2018). Research should include further investigation into the experience of musculoskeletal pain during pregnancy (Brown & Johnston, 2013). In addition, descriptive studies can address the frequency of education of TENS therapy in childbirth education classes, the frequency of usage in both pregnancy and/or labor, and the frequency of usage based on birthing location and/or care provider. While TENS units are now more readily available to expectant women, studies of the frequency of purchase, type unit, cost, and so on would be useful information to know (Dowswell et al., 2009). Finally, outcomes for women and newborns should continue to affirm the safe usage of TENS therapy through pregnancy, labor, should it be used, and lactation.

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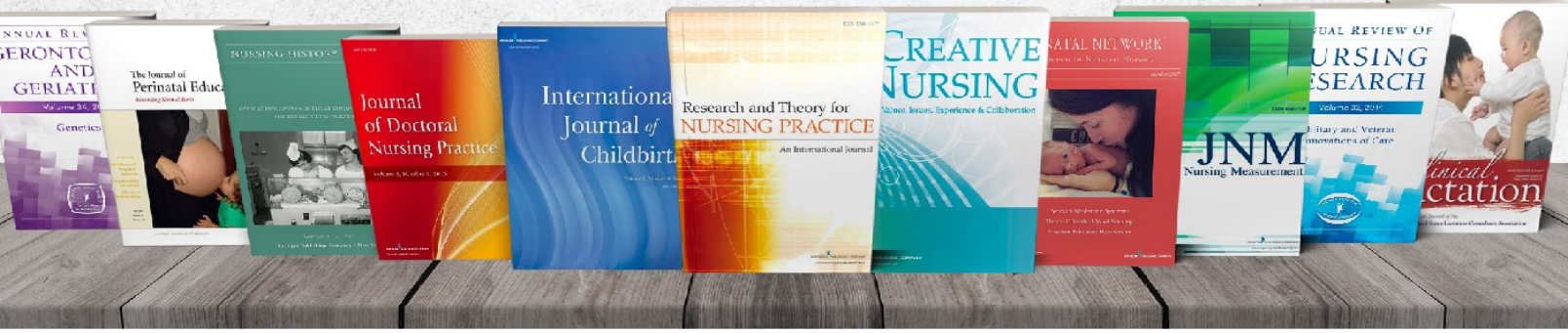

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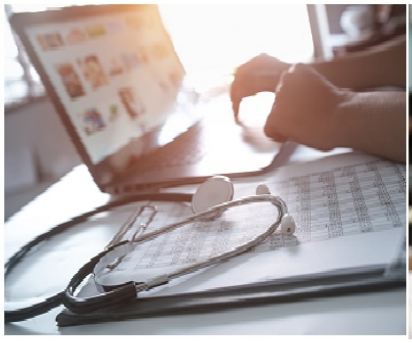

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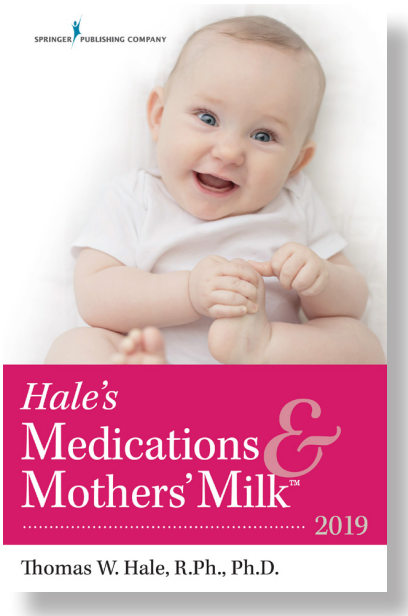

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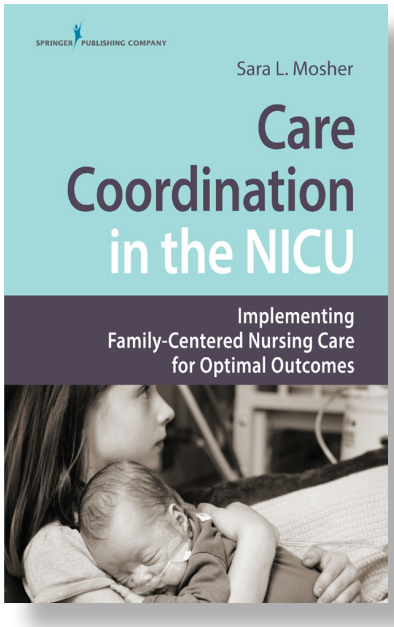

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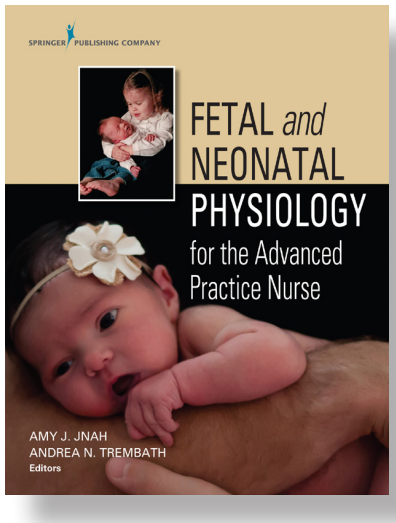

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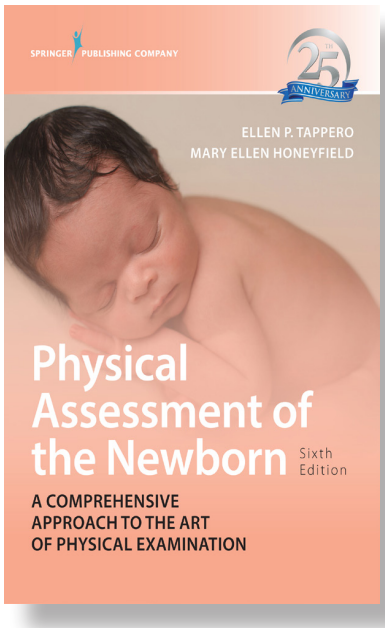

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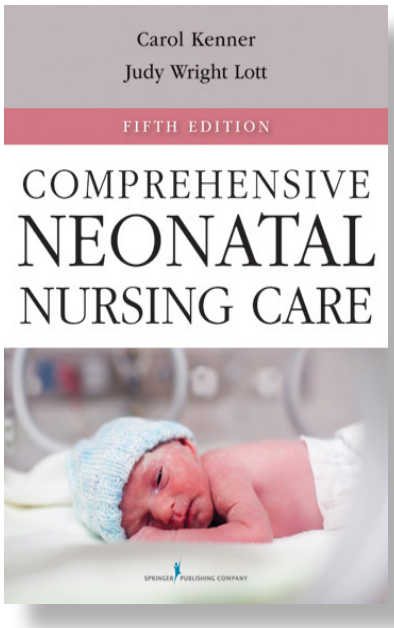

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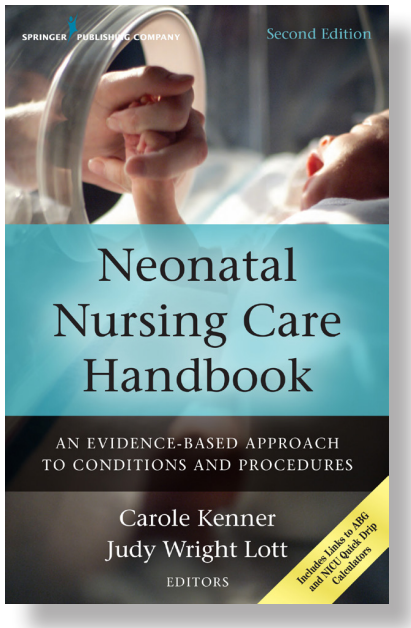

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