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Cardiac Surgery**

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COLD THERAPY FOR THE MANAGEMENT OF PAIN
ASSOCIATED WITH DEEP BREATHING AND
COUGHING POST CARDIAC SURGERY

By
Myrienne Chailier, RN, BScN
3897199

Thesis submitted to the Faculty of Graduate and Postdoctoral Studies in partial fulfillment of the requirements for the degree of Master of Science in Nursing

Faculty of Health Sciences
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Legend

CABG – Coronary Artery Bypass Graft

CINAHL – Cumulative Index to Nursing & Allied Health Literature

cm – centimetres

DB & C – Deep Breathing and Coughing

ICU – Intensive Care Unit

LIMA/LITA – Left Internal Mammary (Thoracic) Artery

min – minutes

mg – milligrams

mm – millimetres

N/A – Not Applicable

NRS – Numerical Rating Scale

OR – Operating Room

PAU – Pre-Admission Unit

PEDro – Physiotherapy Evidenced Based

PO – Per Os (by mouth)

PRN – As needed

RIMA/RITA – Right Internal Mammary (Thoracic) Artery

RM-ANOVA – Repeated Measure Analysis of Variance

SVG – Saphenous Vein Graft

VAS – Visual Analogue Scale

Abstract

Incisional, chest and sternal pain is prevalent in patients after cardiac surgery. If pain is not properly managed it may prevent patients from performing activities such as deep breathing and coughing (DB & C) which are important for preventing postoperative respiratory complications. There is a scarcity of research about the nonpharmacologic modalities for treating post cardiac incisional and sternal pain. Of these modalities, cold therapy is a strategy that has been used effectively over many decades in a number of areas including orthopedic surgery. The beneficial effects of cold therapy for pain management have been widely documented and the side effects are minimal, yet its use is limited in post-surgical cardiac patients. Nurses can have an active role in relieving patients' surgical pain with cold therapy. Presently, there are no studies in the literature that specifically address cold therapy for sternotomy pain management following coronary artery bypass graft (CABG) surgery.

The objectives of this study were: 1) to evaluate the effects of cold therapy on pain associated with DB & C post cardiac surgery; 2) to identify sensations from the patients' perspective when cold in the form of a gel pack is applied to the median sternotomy chest incision before DB & C; 3) to identify patients' preferences for gel or no gel pack application.

A crossover research design was utilized and each patient served as their own control. Participants underwent four sessions of DB & C every two hours on postoperative day two. Two sessions were preceded by cold application and two sessions were without cold application. At the end of the four sessions of DB & C, patients were asked about their preferences for gel or no gel pack application.

Pain scores associated with DB & C were significantly decreased with the application of cold therapy ($F=28.69$, $p<.001$). Most participants preferred using the gel pack before performing the DB & C exercises ($n=22$; 69%) and there were 2 (6%) participants who preferred DB & C without the gel pack, the other participants ($n=8$) had no preference. The sensations experienced were similar among all participants, most described coolness ($n=9$; 28%) or cold ($n=23$, 72%).

In conclusion, this study demonstrates that cold therapy is useful for managing patients' pain associated with DB & C following CABG surgery. Cold therapy is low risk, low cost and can be easily integrated into nursing practice since cold packs are easily accessible in most hospitals. With nurses' initial supervision, cold therapy is a safe and effective pain management modality that gives patients an active role in pain management. Further research is recommended on the application of other cold modalities such as the use of ice chips as the cold source before DB & C as well as performing the intervention earlier after the surgery on postoperative day one.

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CHAPTER ONE - Clinical Issue

Cardiovascular diseases remain the number one cause of death in North America (American Heart Association, 2007; Heart & Stroke Foundation, 2002). A variety of cardiovascular problems are treated with cardiac surgery. As the population ages, the number of cardiac surgeries will continue to increase (Government of Canada, 2005). Incisional, chest and sternal pain is prevalent in many patients following open heart cardiac surgery such as coronary artery bypass grafts (CABG). CABG is a surgical procedure that is performed for the treatment of restricted or blocked heart arteries (Gardner, 2004). The pain is due to the trauma (cutaneous, deep somatic and visceral) associated with the surgery (Kruger & McRae, 1999; Reimer-Kent, 2003; Watt-Watson & Stevens, 1998). If this pain is not properly managed it may prevent patients from performing activities such as deep breathing and coughing (DB & C) which are important for preventing postoperative respiratory complications (Henke & Eigsti, 2003; Patton & Schaerf, 1995; Pierce & Robertson, 1977; Westerdahl, Lindmark, Eriksson, Hedenstierna, & Tenling, 2003). Many hospitals' postoperative standard of care, including the University of Ottawa Heart Institute, encourages patients to DB & C after cardiac surgery at least every two hours while they are awake. Incisional pain can be treated with both pharmacologic and nonpharmacologic therapies. There is a scarcity of research about the nonpharmacologic modalities, also known as non-drug therapies, for treating post-cardiac incisional sternal pain. Of these modalities, cold therapy is a pain management strategy that is used effectively in areas such as orthopedic surgery and sports medicine (Algaflly & George, 2007; American Academy of Orthopaedic Surgery, 2008; Australian Physiotherapy Association, 2008; Knight, 1995). The beneficial effects

of cold therapy for pain management have been widely documented and the side effects are minimal, yet its use remains limited in post-surgical cardiac patients.

Statistics from the Cardiac Care Network of Ontario (2007) indicate that there are approximately 10,512 cardiac surgeries in Ontario per year. To minimize postoperative complications and maintain health care budgets, it is essential to provide optimal pain management to this significant number of cardiac surgical patients. Poorly managed pain remains a problem for postoperative patients across many surgical specialties and conditions. There have been tremendous improvements in pain management in the last decade but challenges remain (Canadian Pain Society, 2005; McCaffery & Pasero, 1999). Unrelieved pain can lead to a number of post surgical complications including atelectasis, pulmonary infection and hypertension (McCaffery & Pasero; Puntillo & Weiss, 1994).

Soon after cardiac surgery, patients recover from anesthesia and they are encouraged to perform activities such as DB & C to maximize their recovery and to prevent pulmonary complications such as atelectasis and infections (Black & Hawks, 2005; Fanning, 2004; Patton & Schaerf, 1995; Pierce & Robertson, 1977; Westerdahl et al., 2003). Patients who do not perform DB & C due to unrelieved pain are at an increased risk for inadequate lung expansion, retention of secretions due to ineffective coughing and immobility which leads to atelectasis and pneumonia (Matthay & Wiener-Kronish, 1989). Since nurses are present with patients around the clock, they have an important role to play in reinforcing DB & C exercises every one to two hours when patients are awake and in the management of pain.

DB & C is typically associated with incisional pain. This relates to the fact that most patients having CABG surgery undergo a procedure termed sternotomy. In this

procedure, the sternum is cut open medially to provide access to the heart (Gardner, 2004). At the end of the surgery, the sternum is wired back together and the skin is sutured creating an incision line on the sternum. DB & C creates stress and pain on the incision line over the sternum as the thoracic cage expands and puts pressure on the wound. Coughing has been identified as the most painful experience post cardiac surgery (Milgrom, Brooks, Qi, Bunnell, Wuestefeld, & Beckman, 2004). The discomfort associated with DB & C can prevent patients from performing these activities (Davies, MacLeod, & Ogilvie, 1990; Fanning, 2004).

Current Practice

Presently, cold therapy is not used to alleviate sternotomy incisional pain experienced when DB & C. There are no studies in the literature that specifically address cold therapy for sternotomy pain management. The current practice to control postoperative cardiac pain is typically restricted to pharmacological measures. Acetaminophen and morphine or hydromorphone are the pharmacological modalities most often used to alleviate cardiac post-surgical pain at the University of Ottawa Heart Institute. These medications can lessen pain to a certain level but increased dosages for greater pain relief can have negative side effects such as sedation, nausea, and constipation that are problematic for some patients (Benyamin et al., 2008; Harris, 2008). Further, medications may not control the increased pain that is associated with DB & C. In this study, cold therapy was explored as a strategy to alleviate this typically short episode of amplified pain.

Study Objectives

The objectives of this study were: 1) to evaluate the effects of cold therapy on pain associated with DB & C; 2) to identify sensations from the patients' perspective when cold in the form of a gel pack is applied to the median sternotomy chest incision before DB & C; 3) to identify patients' preferences for gel pack or no gel pack application prior to DB & C. These objectives were met with three research questions. 1) Does cold therapy for CABG patients with sternal incisions reduce pain related to DB & C? 2) What sensations do CABG patients describe when applying cold therapy for sternal pain management associated with DB & C? 3) Do CABG patients prefer the application of cold therapy before DB & C?

Organization of the Thesis

This thesis is article-based and it contains five chapters. There is one article in chapter four and the other chapters provide supporting information related to the article. Chapter one is an introduction to the study and a description of the clinical problem. Chapter two is a review of the literature on pain, cold therapy and cardiac surgery. In addition, the neuromatrix theory of pain and the study measures are presented. Chapter three is a detailed description of the study methods and findings. Chapter four is a complete description of the research in abbreviated form appropriate for submission to a peer-reviewed journal and it fits the criteria for submission to the Canadian Journal of Cardiovascular Nursing. Chapter five contains the discussion including recommendations for nursing practice related to the results of the study. Each chapter contains related references, figures and tables.

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CHAPTER TWO - Literature Review

The literature review was conducted using key words on topics related to cold therapy for the management of postoperative sternotomy pain in cardiac patients. Key words searched in MEDLINE, CINAHL (Cumulative Index to Nursing & Allied Health Literature), PEDro (Physiotherapy Evidenced Based) and Cochrane library databases were: pain, cardiac surgery, incision pain, deep breathing and coughing, postoperative respiratory exercises, nonpharmacologic therapy, ice, cryotherapy, cold and analgesia. Details of the databases searched are presented in Appendix A. The concepts of pain, cardiac surgery, deep breathing and coughing, nonpharmacologic pain management and cold therapy are explored in this literature review.

Pain

Definitions

Two popular definitions of pain have been explored in the literature. Pain has been defined as an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms such as damage (International Association for the Study of Pain, 1994). This definition originated from the Gate Control Theory of Pain by Melzack and Wall initially published in 1965. This theory will be described in more detail at the end of this chapter. McCaffery & Pasero (1999) define pain as "whatever the experiencing person says it is, existing whenever he/she says it does" (p. 17). Pain is unique and subjective and it varies from one person to the next (McCaffery & Pasero). Patients are the experts of their pain experience. Since nurses, physicians, or family members cannot feel and experience patients' pain, it should be assessed and

treated on an individual basis with a range of pharmacologic and nonpharmacologic modalities.

Breakthrough Pain

Pain can be intensified at various times with specific activities such as movement. Breakthrough pain is defined as a transitory exacerbation of pain experienced by the patient who has relatively stable and adequately controlled baseline pain (Portenoy, 1990). McCaffery and Pasero (1999) and Svendsen et al. (2005) support this definition by affirming that breakthrough pain occurs either spontaneously without warning or as a result of an identifiable event such as coughing. Caraceni, Martini, Zecca, and Portenoy (2004) identified that breakthrough pain in cancer patients was associated with higher pain scores and greater interference with activities of daily living. It typically occurs rapidly and is short-lived (Zeppetella & Ribeiro, 2003; 2006). Breakthrough pain can also be termed 'incident pain' which is defined by Cousins (1994) as "pain occurring other than at rest, such as during deep breathing and coughing or during ambulation" (p. 377). This type of pain can be treated with quick-acting analgesics of short duration (McCaffery & Pasero).

After cardiac surgery, patients need to perform certain activities to optimize their recovery. One of these activities that can create incident pain is deep breathing and coughing (DB & C). Since the sternum is cut open for the surgery, the movement of the rib cage during DB & C typically increases pain, creating breakthrough pain (El-Ansary, Waddington, & Adams, 2007).

Unrelieved Pain

Patients with unrelieved pain are less likely to breath deeply, cough, or move around in bed after surgery (Banks, 2007). This relative immobility is related to slower recovery time (Schurr, Gorson, Pellino, & Scanlon, 2004). Unrelieved pain can also produce a number of complications in the cardiovascular and pulmonary system. Key cardiac adverse effects that are associated with unrelieved pain include tachycardia, hypertension, increased stroke volume and cardiac work which increase myocardial oxygen consumption thereby preventing the heart from resting and healing after surgery (Martin & Turkelson, 2006; Watt-Watson & Stevens, 1998). Unrelieved pain post CABG can impair breathing patterns leading to pulmonary complications (Martin & Turkelson). Examples of pulmonary complications related to unrelieved pain include atelectasis, pneumonia, hypoxemia and retention of secretions (Middleton, 2003; Reimer-Kent, 2004; Schuller & Morrow, 2000). Unrelieved pain is a significant source of negative patient outcomes that lead to increased cost and length of hospital stay (Ersek & Poe, 2004; Fortner, Okon, & Portenoy, 2002; Puntillo & Weiss, 1994; Reimer-Kent, 2003). On the other hand, Reimer-Kent found that proactive pain management in patients undergoing cardiac surgery using a combination of opioids and non opioids administered around the clock, decreased the negative side-effects related to opioids such as nausea, psychosis, confusion, delirium and constipation which may increase cost and length of hospital stay.

Post Surgical Cardiac Pain

Coronary artery bypass graft (CABG) is a surgical procedure that is performed for the treatment of restricted or blocked coronary arteries. The sternum is cut open from just below the jugular notch to below the xiphoid process to expose the heart (Gardner, 2004).

The sternum is held open with retractors during the surgery in order to have access to the heart. The heart is either stopped and a bypass (heart/lung) machine is utilised to replace the heart's function or the surgery is performed while the heart is still beating using stabilizers to immobilize the area where the surgery is performed (Behny, 2006; Briffa, 2008; Hannan et al., 2007; Hyett, 2004). One or many blood vessels are taken from elsewhere in the body, most often from the leg veins, radial artery and/or internal chest mammary arteries, and are connected above and below the blocked heart artery to create a new route for blood circulation bypassing the blockage (Gardner; Underwood, & Cooper, 2003). Over 95% of CABG surgeries performed at the Ottawa Heart Institute use either the left internal mammary (thoracic) artery (LIMA, LITA) or the right internal mammary (thoracic) artery (RIMA, RITA; A. Stolarik, personal communication, October 10, 2008). It is typical practice to use the LIMA for a blockage of the left anterior descending artery of the heart (Mesana, 2007). Yorke, Wallis, and McLean (2004) compared pain intensity scores in cardiac surgical patients having internal mammary artery (IMA) grafts versus patients having grafts using the radial artery or the saphenous vein. They reported that patients with an IMA graft had more pain on average (5.1/10) as compared to patients without an IMA graft (4.0/10).

The location of cardiac post-surgical pain is typically on the sternal incision (Mueller et al., 2000; Woodend, 1999). In order to close the sternum, wires are used to suture the sternum and to stabilize the chest wall (Woo & Gardner, 2003). Pain after CABG is described by patients as sharp, sore, aching, tender and tiring on postoperative day two and three (Pozehl, Barnason, Zimmernan, Nieveen, & Crutchfield, 1995). Similarly, Yorke et al. (2004) indicated that patients undergoing cardiac surgery

described their pain in order of importance as tender, sharp, aching and stabbing. In addition, tiring and exhaustive sensations were the affective descriptors most often identified by these patients.

Kuperberg and Grubbs (1997) reported that 67% of the 20 participants following CABG rated their worst pain above 5 on a 10 point scale on postoperative day two. On postoperative day four, 54% of patients rated their pain above 5 on a 10 point scale and 60% of patients complained of undesirable side-effects from their pain medications.

Yorke et al. (2004) reported that pain after cardiac surgery, at the time of discharge from the cardiothoracic step-down unit, averaged 4.7 on a 10-point scale. In 1999, Woodend explored the University of Ottawa Heart Institute in-hospital patients' pain intensity for the previous 24 hours. The 38 patients on the surgical unit averaged a maximum pain intensity of 4.2 on a 10 point scale in the previous 24 hours. The location of the pain was mostly around the xiphoid process which is the lower area of the sternum. To alleviate pain, patients were given a number of medications but cold therapy was not utilized for incisional pain management.

Pain intensity scores following cardiac surgery are generally higher on the first postoperative day and gradually decrease over the next several days (Kshetry, Carole, Henly, Sendelbach, & Kummer, 2006; Madan et al., 2006; Milgrom et al., 2004). In 705 patients interviewed regarding pain scores post cardiac surgery, coughing scored highest with an average of 6.5 on a 10 point scale on postoperative day one (Milgrom et al.). The scores decreased on subsequent days to 5.4 on postoperative day two and 5.1 on postoperative day three. Deep breathing also scored as high as 5.3 on postoperative day one and 4.4 on postoperative day two. Overall, activities causing the most pain, in order

of severity, were coughing, moving and turning in bed, getting out of bed and deep breathing (Milgrom et al.). Lahtinen, Kokki, and Hynynen (2006) found that coughing caused the worst pain in 78% of the 213 patients after cardiac surgery. Similarly, Yorke et al. (2004) reported that 95% of the 102 patients reported coughing as the most painful activity post cardiac surgery. Women reported having more pain (average of 5.7/10) as compared to men (4.4/10). Four months after CABG surgery, coughing was still identified as the most painful activity but the pain scores had decreased to less than 1 on 10 (Westerdahl, Lindmark, Bryngelsson, & Tenling, 2003). Postoperative cardiac pain was not shown to vary with age. Pain intensity does not appear to differ between older and middle-aged adults after CABG surgery (Redeker, 1993). Both age groups affirmed that pain was the most prevalent symptom during hospitalization.

Deep Breathing and Coughing

Decreased respiratory function after chest wall surgery can be explained by many factors such as altered chest mechanics, reduced rib cage expansion, and uncoordinated chest wall motion which may persist longer than four months post surgery (Westerdahl, Lindmark, Bryngelsson et al., 2003). To increase lung expansion, there are many techniques utilised including deep breathing and coughing (DB & C). Alternatives to DB & C such as incentive spirometry, positive expiratory pressure and inspiratory resistance have been shown to be as effective as DB & C (Davies et al., 1990; Fanning, 2004; Westerdahl, Lindmark, Almgren, & Tenling, 2001; Westerdahl, Lindmark, Eriksson, Hedenstierna, & Tenling, 2003).

Generally, DB & C is encouraged after surgery in order to prevent pulmonary complications (Black & Hawks, 2005; Henke & Eigsti, 2003; Westerdahl, Lindmark,

Eriksson et al., 2003). Surgical nursing textbooks encourage DB & C to be performed at least once every hour while the patient is awake (Black & Hawks; Ignatavicius & Workman, 2006). Patients should be sitting in an upright position to enhance lung expansion when DB & C with the rib cage supported by placing the patients' hands across their chest. Patients take a deep breath through their nose and exhale through pursed lips and after the third breath, coughing is encouraged while a pillow is held against the incision (splinting) to help manage pain (El-Ansary et al., 2007; Ignatavicius & Workman; Martin, & Turkelson, 2006). When secretions are present in the lungs, coughing may be provoked as a reflex to clear the lungs after taking only one deep breath (Mazzone, 2004). Proper pain control allows patients to increase their inspiratory lung volume when breathing which in turn prevents respiratory complications (Edelen & Perlow, 2002; Westerdahl, Lindmark, Eriksson et al., 2003).

Pain experienced when performing respiratory exercises post cardiothoracic surgery may prevent patients from achieving maximum lung volumes which in turn creates pulmonary complications (Edelen & Perlow, 2002). Puntillo and Weiss (1994) reported that patients with higher pain scores on three consecutive days following cardiac surgery had significantly more atelectasis than patients having less pain. Since patients have an active role in initiating DB & C every hour, their understanding of these exercises as well as their cooperation is essential in ensuring that DB & C is conducted on a regular basis. It is important that patients are reasonably comfortable because they are less likely to engage in their DB & C exercises if they are in a significant amount of pain.

Nonpharmacological Therapies

In addition to pharmacological therapies, nonpharmacological therapies are increasingly being used for the treatment of pain (Gaydos, 2001). Examples of nonpharmacologic therapies include heat, cold, massage, relaxation, and imagery. Kshetry et al. (2006) found that the combination of therapeutic touch, massage and music therapy were effective strategies to decrease pain and tension for cardiac post-surgical patients. On postoperative day one, pain decreased significantly from 4.1 on a 10 point scale to 2.4 and on postoperative day two, pain decreased significantly from 3.8 to 1.3. These strategies were accepted by the majority of the participants.

Some nurses prefer nonpharmacological techniques since they are low risk and they also give patients an active role in relieving their own pain (Frisch, 2001; Sparber, 2001). However, nonpharmacological pain management strategies are seldom integrated into standard postoperative pain management practices in North American hospitals (Shojania, Duncan, McDonald, & Wachter, 2001; Tracy, Dufault, Kogut, Martin, & Rossi, 2006). In oncology, a study on 90 patients' charts revealed that during their course of treatment, only 10% of patients had undergone a nonpharmacological pain relief therapy such as heat, massage and positioning to alleviate pain (McMillan, Tittle, Hagan, & Laughlin, 2000). Limited access to certain types of nonpharmacologic interventions is a barrier to implementation (Ferrell, 2004). For example, lack of equipment such as a cold or heat pack, makes its application harder to implement. Lack of time was also identified as a barrier by Gagner-Tjellesen, Yurkovich, & Gragert (2001) and Helmrich et al. (2001).

Education, as well as an optimal practice environment with support from administration and nurses' positive beliefs predicted the use of nonpharmacological strategies in nurses working in oncology (Kwekkeboom, Bumpus, Wanta, & Serlin, 2008). Lack of knowledge has been identified as a barrier to the use of nonpharmacological modalities. Many authors believe nurses need more education about how to use nonpharmacological modalities (Coyne et al., 1999; Gaydos, 2001; Plaisance & Logan, 2006; Snyder & Wieland, 2003).

Nonpharmacologic interventions are useful for patients who may benefit from a reduction in drug therapies as well as those who are likely to experience pain and have incomplete analgesia from pharmacologic interventions (Winn & Dentino, 2004). A number of sources indicate that nonpharmacologic interventions combined with pharmacological interventions may provide the most effective pain management (Banks, 2007; Canadian Pain Society, 2005; Ferrell, 2004; Herr, 2002; Rakel & Barr, 2003; Registered Nurses' Association of Ontario, 2002; Snyder & Wieland, 2003; Winn & Dentino, 2004). Anderson and Cutshall (2007) encourage massage therapy post cardiac surgery to help reduce pain as well as anxiety and tension.

Cold Therapy

Reports of cold application for pain management have been described in the literature for over 50 years. Cold has been used to decrease both post-surgical and medically associated pain (Airaksinen et al., 2003; Chou & Liu, 2008; Cohn, Draeger, & Jackson, 1989; Collins, 2008; Hochberg, 2001; McCaffery, 1990; Rakel & Barr, 2003; Saliba, Saliba, & Denegar, 2006). There are also many sources affirming that cold decreases swelling associated with an injury or trauma and bleeding (Coté, Prentice,

Hooker, & Shields, 1988; Deal, Tipton, Rosencrance, Curl, & Smith, 2002; Hecht, Bachmann, Booth, & Rothman, 1983; Lehmann, Warren, & Scham, 1974; Saliba et al.). Some studies have identified that nerve conduction which leads to the perception of pain is slowed with cold application (Algafly & George, 2007; De Jesus, Hausmanowa-Petrusewicz, & Barchi, 1973; Lee, Warren, & Mason, 1978). In addition, cold decreases muscle spasms from musculoskeletal trauma (Haines 1967; Newton & Lehmkuhl, 1965), and recovery time from injuries (Knight, 1995).

Cold is used to manage pain in a number of clinical situations. For example, cold has analgesic properties on post-surgical and procedural pain. Koç, Tez, Yoldas, Dizen, and Göçmen (2006) identified a significant decrease in postoperative hernia pain with the application of ice for 20 minutes over the hernia surgical dressings. Using the visual analogue scale (VAS) from 0 to 10; scores at two, six and 24 hours postoperative, all clients in the experimental group demonstrated better pain management than their control group counterparts. The mean pain score after 24 hours in the control group was 3.6 whereas the experimental group scored 2.4 on a 10 point scale. In a study by Akan, Misirlioglu, Yildirim, Çakir, Taylan, and Aköz (2003), ice was also shown to be safely used to decrease pain in skin graft donor sites on postoperative day four and five.

Applying ice before a painful procedure has also been shown to decrease the pain associated with this procedure. Needle-stick puncture pain has been tested with ice and without ice (Hayward, Landorf, & Redmond, 2006). With a VAS of 100 millimetres (mm), participants that used ice before the needle-stick puncture averaged a pain score of 23.3 mm versus 53.5 mm in the control group, without ice. Ice applied on the skin before needle-stick punctures decreased pain by 56%. Since the effectiveness of ice depends on

many factors such as duration of cold application, location of treatment, mode of cold therapy used and use of skin barriers, many of these factors will be explored below.

Mechanism of Action for Cold Therapy

Time of Application

Domhall (2001) indicates that health related textbooks still recommend varied durations and frequencies for cold application and many of these textbooks lack sufficient background and procedural information. Based on many authors, it is recommended to apply cold for 20-30 minutes every two hours especially in the first 12 to 72 hours after trauma, until swelling, when present, has stabilized (Baxter & Barlas, 2002; Hochberg, 2001; Knight, 1995; Lee, Itoh, William Yang, & Eason, 1990; McConnell, 1998; Miller, 2004; Saliba et al., 2006). Most authors also recommend the use of a skin barrier when applying cold to an injury (Baxter & Barlas; Hochberg; McConnell; Miller).

Skin Barriers

A skin barrier is an item placed between the skin and the cold source. It can be a dry or damp washcloth, or an elastic bandage. However, skin barriers can alter skin temperature and effectiveness of cold therapy (see Appendix B for the list of studies on cold therapy since 1946). LaVelle and Snyder (1985) examined the differences in temperature on ankles with a dry washcloth, no barrier, damp cloth and an elastic bandage. A dry wash cloth decreased the skin temperature to about 19 °C (degrees Celsius); demonstrating a drop of about 10C⁰ after 20 minutes. Frostbite did not occur in any patients but some discomfort was verbalized by the no barrier and damp washcloth groups. Janwantanakul (2004) also found no adverse reactions when ice was applied with no skin barriers for 20 minutes on the thighs of healthy females.

Stevens and D'Angelo (1978) as well as Knight (1995) warn patients to be careful of frostbite with gel packs. When they are removed from the freezer, they remain below freezing temperatures which can cause frostbite. Therefore, it is recommended to use a skin barrier for gel packs (Knight). Gel packs remain cold up to 30 minutes after removal from the freezer (Lee et al., 1990). Surgical dressings can be used as skin barriers but the thickness needs to be taken into consideration because the beneficial effects of cold diminish when dressings are too thick. According to Omer and Brobeck (1971), skin temperature decreased under a bulky surgical dressing with 9 to 13 gauze thickness applied to the forearm but the temperature changes were not significant when comparing ice versus no ice application. The thickness of the dressing may have been too thick to significantly lower the skin temperature. On the other hand, Creager and Knight (1991) found ice to be effective over two gauze thickness dressings. There was no frostbite identified in either study. In fact, frostbite is seen very rarely regardless of skin barriers when applied for 30 minutes or less (Knight, 1995).

Temperature

Cold therapy application decreases the skin temperature. Safe temperature ranges have been identified by Domhnall (2001) as 10 to 15 C⁰. In laboratory studies, Bugaj (1975) was among the first authors to identify that analgesia was attained when the skin temperature was at about 13.6⁰C and that the analgesic effects disappeared post treatment as the temperature went back up to 15.6⁰C. The superficial skin is colder than deeper tissue layers upon cold application (Merrick, Jutte, & Smith, 2003). Merrick et al. found that at one centimetre (cm) depth beneath the skin, ice bags were more effective in decreasing tissue temperature than gel packs but at two cm, there were no significant

differences. Enwemeka et al. (2002) recorded skin temperatures of the quadriceps muscle in young healthy adults at 1, 2 and 3 cm depths after 20 minutes of cold pack application with a dry towel skin barrier. There was a decrease in skin temperature at the 1 cm depth after 8 minutes of ice application. When the ice was removed, 2 and 3 cm tissue levels continued to decrease in temperature for up to 40 minutes whereas the 1 cm depth started to warm immediately.

Wound Healing

Continuous hypothermia causes non-stop vasoconstriction and can therefore depress wound healing as evidenced by Knight (1995). However, there are no studies indicating that a 20 minute application of cold therapy to a wound will impede healing. Cold therapy did not affect wound healing following the application of ice on the jaw after molar surgery (Filho, Silva, Camargo, & Gouveia, 2005; Van Der Westhijzen, Becker, Morkel, & Roelse, 2005). Similarly, Akan et al. (2003) found no differences in the skin graft donor sites' wound healing for patients with burns between the control and experimental groups with cold pack application for maximum 60 minutes (until the pain subsided) over five postoperative days. In the literature, there were no adverse effects related to depressed wound healing when ice was applied over surgical wounds even when the ice was applied longer than 30 minutes.

Vascular Changes

After tissue injuries, such as a surgical intervention, vasodilation occurs. This results in rising hydrostatic pressure which increases serous fluid extravasation leading to swelling at the site of injury (Knight, 1995). In addition, capillary rupture occurs due to the surgical incision (Svendson et al., 2005). When cold is applied after a surgical

procedure, the body attempts to preserve core heat by constricting superficial cutaneous vessels, which leads to decreased capillary permeability and decreased risk of hemorrhage (Knight, 1995). Cooling lowers the metabolic activity and oxygen demand of cells. There are two theories about the effects of cold on blood vessels. Some believe that local vasoconstriction occurs mostly in superficial tissues through reflex mechanisms, whereas deep tissues vasoconstrict mostly due to decreased metabolic activity (Saliba et al., 2006). Upon cold application, other authors observed a vasodilation of deep vessels which increases blood supply (Daanen, 2003; Keatinge, 1961; Knight, Bryan, & Halvorsen, 1981). The constriction in the surface vessels produces a reflex vasodilation in the deep vessels which supplies the wound with more healing nutrients.

Nerve Conduction

Cold was shown to affect nerve conduction by slowing it. In laboratory studies, De Jesus et al. (1973) identified that nerve velocity decreases as the temperature drops below 18⁰C on fingers. Lee et al. (1978) also found similar results on the wrist (ulnar nerve) and elbow nerve conduction. Nerve velocity dropped by, on average, 11.6% after 24 minutes of ice application on the wrist and 29.4% after 20 minutes on the elbow. Algafly and George (2007) examined nerve conduction velocity when the skin temperature was reduced to 10⁰C with superficial ice over the ankle. One ankle acted as the control and the other as the experimental condition. Compared to the control, ice reduced nerve conduction velocity by 32.8%. The reduced nerve conduction led to an increase in pain threshold and tolerance.

Cold Sensations

Hocutt (1981) described patients' responses to cold therapy. Within three minutes, cold was felt; between 2-7 minutes, descriptors were burning and aching sensations, and local numbness and analgesia was felt between 5-12 minutes. During the first few minutes of application, cold discomfort is documented in the literature as being a barrier to its application (McCaffery, 1990). Cold therapy may be more acceptable if the cold source is covered with a skin barrier, making the initial sensation feel mildly cool.

In summary, DB & C causes intensified pain in post cardiac surgical patients with a median sternotomy incision. Increased pain experienced when DB & C must be properly managed by nurses to facilitate patients' ability to DB & C, an activity critical to recovery. Local application of cold has been shown to be beneficial in other areas of practice such as orthopedic surgery and sport medicine. Its application on median sternotomy before DB & C could be a safe and effective way to alleviate the breakthrough pain that is experienced when conducting DB & C exercises.

Theoretical Framework

Melzack's neuromatrix theory of pain is an expansion of the gate control theory put forward by Ronald Melzack and Patrick Wall in 1965 and revised by the same authors in 1983. This theory provides a theoretical basis for cold application in pain management. The gate control theory describes pain perception as being modulated by interactions between neurons (A & C fibres; Melzack & Wall, 1996). According to Melzack and Wall (1996), there is a gating mechanism in the spinal cord that controls the flow of sensory impulses. The gate opens with increased activity of small diameter nerve fibres and alternatively closes inhibiting pain transmission with increased activity of large

diameter nerve fibres. Michlovitz (1990) identified that ice applied over peripheral nerves increases pain threshold and elicits a spinal cord reflex to close the gate. Further, Lehmann and DeLateur (1990) identified that cold reduces pain by slowing nerve conduction and synaptic activity of small unmyelinated nerve fibres that conduct pain impulses from the periphery to ascending pathways up to the brain.

The Gate Control Theory was recently expanded by Melzack to include a more multidimensional pain experience (Melzack, 2005). The neuromatrix theory of pain includes memories and past experiences. Pain is activated by a neural network in the brain rather than sensory inputs solely received from the injury. After an injury, the body-self neuromatrix activates perceptual, homeostasis, and behavioural patterns. In other words, it activates the awareness, physiological equilibrium and reactions to the stimuli causing pain. The neural network consists of feedback loops between the thalamus and cortex as well as feedback loops between the cortex and limbic system. Pain perception is generated from three networks: sensory-discriminative (somatosensory components), affective-motivational (limbic system components), and evaluative-cognitive (thalamocortical components) (Melzack). The processing and synthesis of nerve impulses results in a neurosignature unique to each human being because it is genetically determined and modified with sensory experiences. There are four components of the multidimensional nervous system: 1) the body-self neuromatrix; 2) the cyclical processing and the synthesis in which the neurosignature is produced; 3) the sentient neural hub which converts the flow of neurosignatures into the flow of awareness, and; 4) the activation of an action neuromatrix to provide the pattern of movements to bring

about the desired goal (Melzack). The neuromatrix theory expands pain assessment by including cognitive, emotional, social and cultural aspects of pain.

According to Trout (2004), the neuromatrix theory of pain explains the efficacy of music therapy in reducing pain perception. Culture and past experiences with selected music might affect the "parallel processing of multiple inputs" (p. 9) in the brain creating a decrease in pain perception. This is important to this study because pain is unique to every patient and the feeling of cold can be felt and accepted differently depending on past experiences or culture. Since sensory A-beta fibres transmit impulses more quickly than C fibres; by stimulating the A-beta fibres through a frozen gel pack, the transmission of C pain fibres is reduced (Algaflly & George, 2007; Lehmann & De Lateur, 1990; Trout).

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Appendix A

Literature Search Strategies

A literature review was conducted in MEDLINE, CINAHL (Cumulative Index to Nursing & Allied Health Literature), PEDro (Physiotherapy Evidenced Based) and Cochrane library databases. Dates and languages were not restricted. Many articles dated from over 10 years ago. The Registered Nurses' Association of Ontario website was also consulted for pain assessment and management best practice guidelines in the PDF format. In addition, the American Heart Association, American Pain Society, Canadian Pain Society, Government of Canada, Heart and Stroke Foundation, International Association for the Study of Pain, New Zealand Dermatological Society and the American Academy of Orthopaedic Surgery websites were consulted. Key words searched were: pain, cardiac surgery, incision pain, deep breathing and coughing, postoperative respiratory exercises, nonpharmacologic therapy, ice, cryotherapy, cold and analgesia.

Appendix B

Research Studies on Cold Therapy

Authors	Method/ Use of Skin Barrier	Body Part	Application Time (min)	Skin Temperature (⁰C)	Efficacy
Schaubel (1946)	Ice bag No barriers	All orthopedic surgery	2880 (48 hrs)	Surface within 3 hrs: 4.88	Yes: decrease in narcotics used
Wolf & Basmajian (1973)	Thermo- electric cooling device	Left medial calf	5	Surface: 9.98 (-20.42) Intramuscular: 33.99 (-1.2)	N/A
Lowdon & Moore (1975)	Ice massage No barriers	Bicep	5,10 & 15	IM: 4cm: 5 min: (-15.9) 10 min: (-18.36) 15 min: (-20.36) *thicker skinfold requires longer time of application	N/A
Bugaj (1975)	Ice massage No barriers	Lower extremities	10	5.7 (-26.6) Back to pre-treatment temperature after about 90 min. Analgesia up to 30 min. after ice application	Yes, if Tempe- rature is below 13.6 ⁰ C
Lee, Warren & Mason (1978)	Ice bag No barriers	elbow	20	15.5 (-13.1) After 30 min post- treatment: temperature still 1.4 lower than pre- application	N/A
Knight (1981) (in Knight 1995)	Ice pack No barriers	Forearm	45	Average: 13 (-18)	N/A

Authors	Method/ Use of Skin Barrier	Body Part	Application Time (min)	Skin Temperature (°C)	Efficacy
DeCrosta (1984)	Ice Massage No barriers	Arthritis, cramps, lower back, stump, cancer pain, abdomen, perineal, rectum, acute trauma, bone marrow aspiration	10	N/A	Yes: Less pain
LaVelle & Snyder (1985)	Ice bag Different barriers	Right Ankle	30	No barriers: 11 (-18.6) 20 min: 12 Dry washcloth: 10 (-11.3) 20 min: 11 Damp washcloth: 10 (-18.7) 20 min: 11 (No difference)	N/A
Cohn, Draeger & Jackson (1989)	Ice thermal blanket No barriers	Knee	Conti- nuously	N/A	Yes: decreased Demoral use by 53%
Taber, Contryman, Fahrenbruc h, LaCount & Cornwall (1992)	Gel pack Dry barrier	Right Ankle	20	13.5	N/A
Oosterveld, Rasker, Jacobs & Overmars (1992)	Ice bag No barriers	Anterior Knee	30	Surface: 11.5 (-16.4) Intra-articular: 22.5 (-9.4)	N/A
Logan (1993)	Ice massage No barriers	Abdomen: Before injections	5-10	N/A	Yes: Preference with ice

Authors	Method/ Use of Skin Barrier	Body Part	Application Time (min)	Skin Temperature (°C)	Efficacy
Finan, Roberts, Hoffman, Fiorica, Cavanagh & Dudney (1993)	Thermal blanket One gauze	Perineum (laparotomy gynecology patients)	continuous	N/A	Not Significant
Myrer, Measom & Fellingham (1998)	Ice bag Ice bath No barriers	Left calf	20	Intramuscular (IM): Ice bag: 27.8 (-7.1) Ice bath: 28.2 (-5.1) Subcutaneous (S/Q): Ice bag: 13.8 (-17) Ice bath: 19 (-13.8)	N/A
Richman, Singer, Flanagan & Thode (1999)	Ice bag No Barriers	Antecubital fossa (forearm)	10	N/A Most patients (17 on 28) not completely anesthetized.	On 100mm VAS: with ice: 27.0 Without ice: 34.5 75% of women preferred ice treatment & 75% of men preferred without ice
Hochberg (2001)	Cooling blanket & Ice pack Surgical dressing as a barrier	Wrist	720= 12hrs continuous (blanket) & 20 (ice pack)	N/A Cold applied over dressing (<3mm)	Yes: cooling blanket greater reduction of pain, edema & narcotic use

Authors	Method/ Use of Skin Barrier	Body Part	Application Time (min)	Skin Temperature (°C)	Efficacy
Myrer, Myrer, Measom, Fellingham & Evers (2001)	Ice bag No barriers	Calf: different thickness: less than 8mm, 10- 18mm & over 20mm	20	IM: 8mm: 1cm: 19.97 (-15.27) 8mm: 3cm: 26.16 <u>(-9.08)</u> 10-18mm: 1cm: 24.92 (-10.62) 10-18mm: 3cm: <u>29.31 (-.23)</u> 20mm: 1cm: 29.41 (-6.13) 20mm: 3cm: N/A	N/A Pain scores not analysed
Sauls (2002)	Ice pack 4x4 dressing barrier	Thorax: chest tube insertion	10	N/A	Not signifi- cant
Chesterton, Foster & Ross (2002)	Frozen peas & Gel Pack Damp cotton barrier	Anterior Thigh	20	Peas: 12.3 (-19.8) Gel Pack: 14.5 (-15.9)	N/A
Otte, Merrick, Ingersoll & Cordova (2002)	Ice bag No barriers	Anterior Thigh	20	Subcutaneous: 0- 10mm skin fold: lessened 7 degrees within 8 min. Intramuscular: 11-20mm: -5.23 21-30mm: -3.97 31-40mm: -1.79	N/A
Enwemeka, Allen, Avila, Bina, Konrade & Munns (2002)	Cold pack Dry Barrier	Quadriceps Muscle	20	Surface: -3.8 1cm: -2.49 2cm: 0 3cm: 0	N/A

Authors	Method/ Use of Skin Barrier	Body Part	Application Time (min)	Skin Temperature (°C)	Efficacy
Merrick, Jutte & Smith (2003)	Ice bag No barriers Ice Pack Gel pack	Thigh	30	Surface: 6.47 1cm S/Q: 27.27 <u>2 cm S/Q:31.82</u> Surface: 6.24 1cm S/Q: 27.21 <u>2cm S/Q: 30.59</u> Surface: 9.86 1cm S/Q: 29.46 2cm S/Q: 32.07	N/A
Akan, Misirlioglu, Yildirim, Çakir, Taylan & Aköz (2003)	Ice pack No Barriers	Skin graft: postero- lateral thigh	Up to 60 min until pain sub- sided	N/A	Lower pain scores during the first 3 days with ice. No differences on day 4-5
Janwantana kul (2004)	Ice bag With and without a damp towel	Thigh	20	Wrapped Ice: 10.5 (damp towel) Unwrapped Ice: 6.3 (on skin)	N/A
Filho, Silva, Camargo & Gouveia (2005)	Ice packs With Barrier	Jaw	30 every 1.5 hour	N/A	Yes: lower pain values
Van der Westhuij- zen, Becker, Morkel, & Roelse (2005)	Ice Pack With Barrier	Jaw	Continuous for 24 hrs	N/A	Not significant
Hayward, Landorf & Redmond (2006)	Ice cube With Barrier	Foot (toe)	6	N/A	Yes: with the VAS: from 53.5mm no ice to 23.3mm with ice

Authors	Method/ Use of Skin Barrier	Body Part	Application Time (min)	Skin Temperature (°C)	Efficacy
Koç, Tez, Yoldas, Dizen & Göçmen (2006)	Ice bag Surgical dressing as a barrier	Inguinal Part	20	N/A	Less pain at 2, 3, 24 hours post- operative
Algafly & George (2007)	Crushed ice in a bag without a barrier	Ankle	varied	Temperature aimed at the surface of the skin was: 15-10	Reduced nerve velocity which increased pain threshold and tolerance
Chou & Liu (2008)	Ice towel and ice pack	Face	30	N/A	Both ice towel and ice pack groups reported reduced discomfort

CHAPTER THREE - Methods and Findings

This randomised controlled crossover trial tested the effects of a cold pack on pain associated with DB & C in patients post CABG surgery. This chapter will review the methodology and findings in greater detail than could be described in the article due to page length restrictions. Topics in this chapter include: the methods, materials and measures, sample demographics as well as sample size calculation, data collection, pilot of the procedures, data collection record, effects of narcotics, sensations and preferences and treatment. The findings on sensations and preferences and pain scores will also be explored in this chapter.

Methods

Design

A randomised crossover design was used and each patient served as his/her own control. Data was collected on post-surgical day two between 7:30 am and 6 pm. Participants underwent four episodes of DB & C, two with the gel pack and two without the gel pack. The sequence of gel pack application was randomized and half the participants started with the gel pack and half started without the gel pack. Randomization was done through a coin toss (see Appendix C for participant randomization).

Materials and Measures

Gel Packs

The gel packs that were used as the cold source for the study were manufactured by Gelpax Inc., weighed 270 grams and measured six inches by ten inches (see Figure 1). They were made of non-toxic, biodegradable gel held in a flexible plastic contour. The

gel packs were kept in the freezer on the patient service unit where the participant was located at the time of data collection. The gel packs need approximately one hour of freezing before the temperature is low enough to be suitable for use (S. Scott, personal communications, CEO and President of GelPax inc., March 29, 2007). The gel packs were applied over the surgical dressing covering the sternal incision.

Pain Intensity Scale

Participants used a numerical rating scale (NRS) to rate their pain from 0 (no pain) to 10 (worst possible pain; see Figure 2). Reliability and validity of the NRS has been previously established by many authors in postoperative patients, cancer, chronic pain and patients with rheumatoid arthritis (DeLoach, Higgins, Caplan, & Stiff, 1998; Downie et al., 1978; Kremer, Atkinson, & Ignelzi, 1981; Wilkie, Lovejoy, Dodd, & Tesler, 1990). The NRS is currently used at the study hospital for pain assessment and is well accepted and understood by patients.

Sample Demographics

There were 32 participants (25 males, 7 females) in this study and there were no dropouts or complications related to the gel pack. All of the eligible patients approached agreed to take part in the study. Participants ranged in age from 46 to 81 years with an average age of 66 (SD = 7.17) years. Eight (25%) participants were recruited via the Pre-Admission Unit (PAU) and 24 (75%) participants were considered 'urgent' and were recruited throughout the hospital. The number of coronary artery grafts of the participants were as follows: 5 participants (16%) had 4 grafts, 16 participants (50%) had 3 grafts, 7 participants (22%) had 2 grafts, 4 participants (13%) had one graft. Of the grafts utilised, 25 (78%) grafts were the left mammary artery, 3 (9%) grafts were the right mammary

artery and 24 (75%) grafts were the leg veins. Thirty one participants (97%) had an admission diagnosis of coronary artery disease and one participant had aortic stenosis. There were 19 (59%) participants who had previously used cold therapy for a previous injury.

Sample Size Calculation

Power is the capacity to detect differences that exist in the population (Burns & Grove, 2005). The minimum power acceptable for a study is typically .80. Effect size, type of study, number of dependent and independent variables, and sensitivity of the tools or measures must be taken into consideration when calculating sample size (Burns & Grove). Effect size is the presence of an effect or phenomenon caused by the treatment researched. Based on the literature reviewed, a decrease of one point on the pain scale from 0 to 10 was expected to be both statistically and clinically significant with the application of cold. This is used in the determination of effect size and subsequent sample size. When using a crossover research design, the sample size requirement is smaller because each participant serves as their own control. Therefore, each participant performed DB & C with and without cold therapy. The sample size calculation based on a two-tailed t-test revealed that 32 participants was sufficient assuming that $\alpha=0.05$ and $\beta=0.20$.

Data Collection Procedures

At the beginning of every DB & C session participants rated their baseline pain from 0 to 10 on the Numerical Rating Scale (NRS). If the session involved the gel pack, the investigator brought the gel pack from the freezer to the participants' bedside and the participants applied the gel pack over the dressing covering their chest incision. A timer

was activated for 20 minutes. The investigator remained with the participants for the 20 minutes that the gel pack was in place. During those 20 minutes, participants were asked to describe the sensations they felt related to the gel pack. After 20 minutes, the gel pack was removed and the head of the bed was elevated between 45⁰ and 90⁰ in preparation for DB & C. If the session did not involve the gel pack the investigator prepared the participant for DB & C in the same manner as with the gel pack. A pillow or folded sheet was provided to participants for splinting purposes and DB & C was initiated. Three cycles of three deep breaths were performed followed by an episode of coughing. Rest and normal respirations were encouraged in between the three cycles. Participants were asked to rate their pain from 0 to 10 on the NRS at the completion of the third cycle. At the end of the last session, all participants were asked if they preferred the gel pack prior to DB & C.

Pilot of the Procedures

Prior to data collection in the clinical setting, the procedures were trialed in the nursing laboratory at the University of Ottawa, School of Nursing. The thesis supervisor, the principle investigator and another master's student role played the data collection procedures and scripts to ensure consistency and accuracy of data collection. The first participant in the study was also considered to be a pilot case and, as such, data collected from this participant was not included in final analysis. No changes were made to the study methods or procedures following the laboratory practice or following the pilot case.

Data Collection Record

All data collected from the participants and from the participants' medical records was recorded on a data collection record developed for this study (see Appendix D for the

data collection record). Variables included participant age, sex, admission diagnosis, area of admission, type of surgery, allergies and previous use of cold for a physical injury, such as a sprained ankle. Data collected on the record also included narcotics administered for pain control, pain scores at baseline and post DB & C, participants' description of the sensations experienced while the gel pack was in place and preferences for DB & C with or without the gel pack. Participants' records were reviewed prior to and after the collection of pain scores to gather demographic data and narcotics administered.

Effects of Narcotics

The narcotics administered to the participants, on an as needed (PRN) basis, were noted on the data collection record with respect to drug, dosage and time of administration. The two drugs administered to the participants were either morphine or hydromorphone. The analgesic effects of morphine and hydromorphone, taken by mouth, last from 30 minutes to four hours (Hopfer Deglin & Hazard Vallerand, 1999; Tatro, 2007). Fewer than 6 of the 32 participants were under the influence of narcotics during each of the DB & C sessions. This number was too small to permit comparisons between the effects of cold therapy in participants with and without narcotics.

Sensations and Preferences

Participants were asked to describe the sensations that they experienced during the time the gel pack was in place. They were prompted every five minutes to provide a description. At the end of the four sessions, participants were also asked if they preferred DB & C with or without the gel pack and why they had this preference. Responses were recorded on the data collection record. The text from the sensations and preferences questions was transcribed from the data collection record into a word document for

analysis. Each line of text was examined to identify commonalities and differences among the descriptions provided by the participants. For the most part, participants used short phrases or descriptive words to describe their experiences and no participant provided more than five lines of text as transcribed into the Word document. Typically, participants used words related to temperature such as 'cold' or 'cool' to describe the sensations they were experiencing. A small number of patients used words such as 'comforting', 'reassuring', 'relaxing' and 'easing pain'. The first question on preferences was a yes or no question and the majority of the participants preferred DB & C with the application of cold therapy. The participants who preferred DB & C with the gel pack explained that cold is 'comforting' and it helps to 'manage pain'.

Treatment Effects

Carryover Effect

A carryover effect occurs when a previous treatment affects the treatments that follow (Burns & Grove, 2005). For example, the analgesic effects of the first treatment using drug A may persist during the second treatment using drug B and measuring the effects of solely drug B would be erroneous because drug A still provides analgesia. In this study, the potential for a carryover (or residual) effect was minimized by applying the gel pack to the participant's chest every four hours and allowing a washout period of two hours between DB & C sessions. This time period was deemed acceptable based on the work of Chesterton, Foster, and Ross (2002). These authors indicated that the temperature of the skin surface reaches its maximum coolness after 10 minutes of gel pack application on the anterior thigh using a damp cotton towel as a skin barrier and it starts to warm up after 20 minutes of application (Chesterton et al.). Furthermore, other

authors found that following 20 minutes of cold application the skin over the quadriceps muscle became warm 48 minutes after the cold pack was removed (Enwemeka et al., 2002).

In our study, once the gel pack was taken off the chest and DB & C was performed, most participants would rest in bed with blankets covering their chest which had the effect of warming the area. The warm air in the hospital also helped to warm patients after the gel pack was removed. Hence, the two hours intervals between the DB & C sessions were sufficient to avoid the carryover effect. No participants stated that their skin, at the level of their chest incision, was still cold or under the influence of the analgesic effects of cold therapy in the sessions following the cold application.

Controlling for the Effects of Order

Participants were randomly assigned to either begin the DB & C sessions with the gel pack or without the gel pack. Participants then alternated with respect to the gel pack. Therefore, if session one was with the gel pack, session two was without the gel pack, session three was with the gel pack, and session four was without the gel pack. Randomisation of the participants to begin the trial with or without the gel pack controlled for the effects of order. Average pain scores between the group that started with the gel pack ($M= 3.1$, $SD = 2.5$) and the group that started without the gel pack ($M=3.8$, $SD=2.8$) were not significantly different ($t=0.74$ (30), $p>.05$).

Pain Scores

RM-ANOVA

Mauchly's test for sphericity is used to test the assumption of equality of difference variances between study conditions in repeated measures ANOVA (Page,

Braver, & MacKinnon, 2003). Variances for each set of differences should be equal to be spherical and if the results are not spherical, the within-subjects F tests cannot be trusted. In our study, the chi-square score was .000, $df = 0$ and there was no associated p value which indicates that the assumption for sphericity was met.

A 2 (treatment) X 2 (session) X 2 (time) within subjects RM-ANOVA was conducted on pain intensity scores at baseline and post DB & C with postoperative patients following a CABG procedure. The three independent variables were treatment with two levels (gel pack and no gel pack) session with two levels (am and pm), and time with two levels (baseline and post DB & C). The dependent variable was pain intensity measured on a scale of 0-10. The three way interaction between session, treatment and time was non significant, $F(1, 31) = 1.17, p = .29$. The two way interaction between session and treatment was non significant, $F(1, 31) = 1.06, p = .31$, as was the two way interaction between session and time, $F = .44, p = .51$ (see Table 1). The interaction between treatment and time was significant, $F(1, 31) = 28.69, p < .001$ and indicated that the changes in pain scores from baseline to post DB & C differed between the treatment and control group such that the application of the gel pack lowered pain scores. Mean pain scores are shown in Table 2, and Figure 3 is a graphic of the interaction effect between pain scores at baseline and post DB & C with and without the gel pack.

Table 1

Interaction Effects for Treatment, Session and Time from RM-ANOVA

	F	P	Effect size (partial eta-squared)
Three way interaction:			
Am-pm + Gel pack- no gel pack application + Baseline-post DB & C scores	1.17	0.29 (NS)	0.04
Two way interaction:			
Am-pm + Gel pack-no gel pack application	1.06	.31 (NS)	0.01
Two way interaction:			
Am-pm + Baseline-post DB & C scores	0.44	0.51 (NS)	0.03
Two way interaction:			
Gel pack-no gel pack + Baseline-post DB & C scores	28.69	<.001	0.48

Table 2

Means and Standard Deviations of Pain Intensity Scores at Baseline and Post DB & C

Treatment	Session			
	AM		PM	
	Baseline M(SD)	Post M(SD)	Baseline M(SD)	Post M(SD)
Gel pack	2.97 (2.58)	2.72 (2.23)	2.84 (2.55)	2.56 (2.84)
No Gel pack	3.19 (2.53)	3.84 (2.54)	2.31 (2.32)	3.44 (2.68)

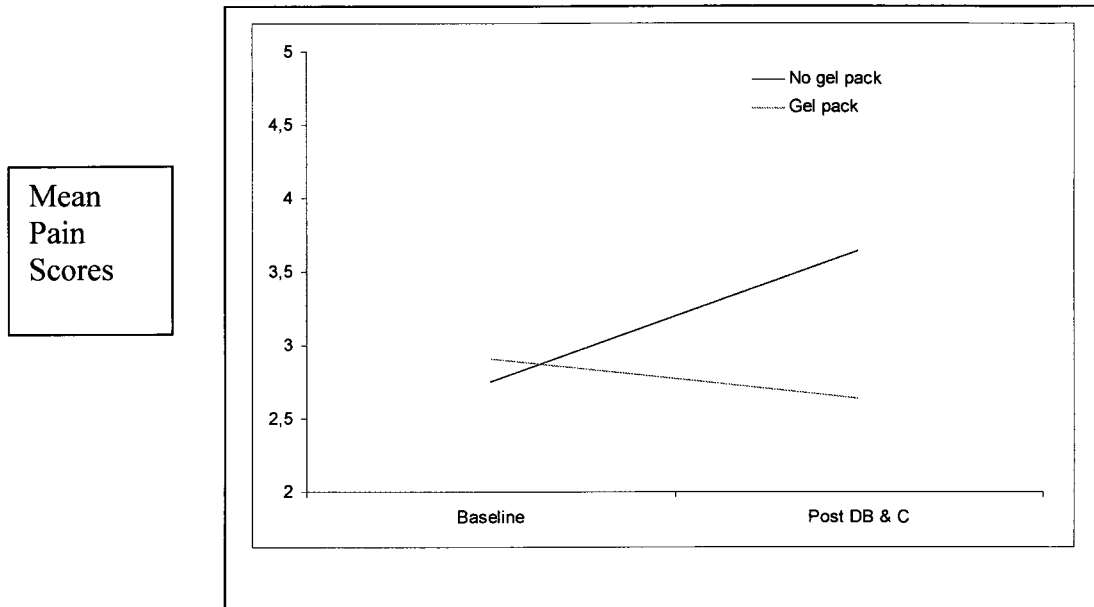


Figure 3. Interaction effect between pain scores at baseline and post DB & C with and without the gel pack.

Effect Size

Eta-squared (η^2) is a measure of effect size for ANOVAs (Norman & Streiner, 2008). Eta-squared ranges from 0 to 1 and indicates how much of the variance of the dependent variable can be accounted for by each independent variable. According to Stevens (2001), an eta-squared of 0.01 is considered a small effect size, 0.06 is a moderate effect size and a score of 0.14 would be considered a large effect size. In our study, the eta-squared for the treatment (gel pack and no gel pack) by time (baseline and post DB & C) interaction was 0.34 and the partial eta-squared was 0.48 which are both considered large. This indicates that 34% of the variability in the dependent variable (pain scores) can be explained or accounted for by the independent variable (treatment and time).

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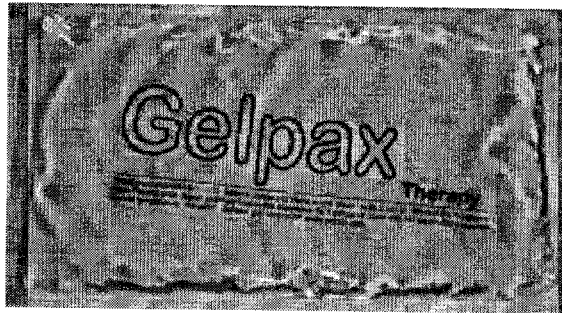


Figure 1. Image of Gel Pack used as cold source.



Figure 2. Pain Scale: Numerical Pain Scale 0-10.

Appendix C
Participants Randomization

Flip of coin: Heads was the first group starting with cold application and tails was the second group starting without cold application.

Participant study number: group

1)	2	17)	1
2)	1	18)	2
3)	2	19)	2
4)	1	20)	2
5)	2	21)	2
6)	1	22)	1
7)	2	23)	1
8)	2	24)	2
9)	1	25)	2
10)	1	26)	1
11)	2	27)	2
12)	2	28)	1
13)	1	29)	2
14)	2	30)	1
15)	1	31)	1
16)	1	32)	1

Total number of participants in group one: 16

Total number of participants in group two: 16

Appendix D

Data Collection Record

Study Title: Superficial Cold Therapy for Pain Management Associated with Deep Breathing and Coughing Post Cardiac Surgery

Name: _____ Study # _____

Age: _____ Sex: Male: _____ Female: _____

Attendance to the PAU: Yes: _____ No: _____

Urgent Surgery: Yes: _____ No: _____

Diagnosis: _____

Type of Surgery: _____

Narcotics taken on postoperative day 2:

	Time	Dose	Route
Morphine			
Hydromorphone			

Allergies: _____

Study group 1: _____ Study group 2: _____

Pain scores 0-10: time 1: pre DB&C: _____ post DB&C: _____ Position: gel: _____
 time 2: pre DB&C: _____ post DB&C: _____ Position: gel: _____
 time 3: pre DB&C: _____ post DB&C: _____ Position: gel: _____
 time 4: pre DB&C: _____ post DB&C: _____ Position: gel: _____

Sensations:

-What sensations related to the gel pack do you feel? (questioned q 5 min. with gel pack application) _____

Gel pack 1:

Gel pack 2:

Preferences:

-Do you prefer to do the DB&C with or without the gel pack?

With: _____ Without: _____

Why: _____

-Would you use this method again? Yes: _____ No: _____

Why: _____

Previous use of cold: Yes: _____ No: _____

Comments: _____

CHAPTER FOUR - Manuscript

Running head: COLD THERAPY FOR PAIN MANAGEMENT

Cold Therapy for the Management of Pain Associated with
Deep Breathing and Coughing Post Cardiac Surgery

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Keywords: postoperative pain, cardiac surgery, cold, deep breathing and coughing

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Abstract

Background: Coughing has been identified as the most painful experience post cardiac surgery. The intensified pain associated with deep breathing and coughing (DB & C) is not usually managed with any nonpharmacological modalities. Cold pack application is a pain management strategy that is used effectively in areas such as orthopedic surgery. **Methods:** Participants, in a randomised crossover trial, applied a frozen gel pack to their sternal incision dressing on postoperative day two before performing DB & C exercises. Pain scores from 0 to 10 at rest were compared with pain scores post DB & C with and without the gel pack. Participants were also asked to describe their sensations with the frozen gel pack as well as their preferences for gel pack or no gel pack application before DB & C. **Results:** The RM-ANOVA revealed a significant reduction in pain scores between pre and post with the application of the gel pack ($F=28.69$, $p<.001$). There were nine (28%) participants who reported feeling coolness and not cold. The other 23 (72%) participants felt cold rather than coolness in at least one of the two gel pack sessions. There were 22 (69%) participants who preferred the application of the gel pack versus no gel pack. All 32 (100%) participants would reapply the gel pack in the future for another injury or surgery. **Conclusion:** This study demonstrates that cold therapy can be utilised to manage sternal incisional pain when DB & C.

Introduction

Cardiovascular diseases remain the number one cause of death in North America (American Heart Association, 2007; Heart & Stroke Foundation, 2002; Statistics Canada, 2004). Narrowing and blockage of the arteries supplying the heart muscle often requires a surgical intervention termed coronary artery bypass graft (CABG). A vessel is taken from somewhere else in the body, typically from the mammary or radial artery, or the leg veins and it is connected above and below the blocked artery. Incisional, chest and sternal pain is prevalent in patients immediately after cardiac surgery and if this pain is not properly managed it may prevent patients from performing activities such as deep breathing and coughing (DB & C) which are important for preventing postoperative respiratory complications (Henke & Eigsti, 2003; Patton & Schaerf, 1995; Pierce & Robertson, 1977; Westerdahl, Lindmark, Eriksson, Hedenstierna, & Tenling, 2003). Many hospitals have postoperative standards of care that encourage patients to DB & C after cardiac surgery at least every two hours while they are awake (Alberta Health Services, 2009; Holloway, 2004; Westerdahl, Lindmark, Eriksson, Hedenstierna, & Tenling, 2005).

DB & C is typically associated with incisional pain because most cardiac surgical patients undergo a sternotomy. In this procedure, the sternum is cut medially from just below the jugular notch to below the xiphoid process to gain access to the heart (Gardner, 2004). At the end of the surgery, the sternum is wired back together and the skin is sutured which creates an incision line over the sternum. DB & C creates stress on the incision line as the thoracic cage expands and puts pressure on the wound. Coughing was identified as the most painful experience post cardiac surgery (Milgrom, Brooks, Qi, Bunnell, Wuestefeld, & Beckman, 2004). The discomfort associated with DB & C can

prevent patients from performing these activities (Davies, MacLoed, & Ogilvie, 1990; Fanning, 2004). Patients following cardiac surgery are encouraged to perform DB & C as soon as they awaken from the anaesthetic to maximize recovery and prevent pulmonary atelectasis and pneumonia (Black & Hawks, 2005; Fanning, 2004; Patton & Schaerf, 1995; Pierce & Robertson, 1977; Westerdahl et al., 2003). Pain experienced when performing respiratory exercises post cardiothoracic surgery may prevent patients from achieving maximum lung volumes which in turn places the patient at risk for pulmonary complications (Edelen & Perlow, 2002). Since nurses are present with post-surgical patients around the clock, they have an important role in reinforcing DB & C and in pain management.

There have been improvements in pain management in the last decade but challenges remain (Canadian Pain Society, 2005; McCaffery & Pasero, 1999). Pain after CABG is described by patients as sharp, sore, aching, tender, and tiring on postoperative day two (Pozehl, Barnason, Zimmernan, Nieveen, & Crutchfield, 1995) and it is well localised on the sternum (Mueller, Tinguely, Tevaeairai, Revelly, Chiolero, & Von Segesser, 2000; Woodend, 1999). According to Woodend, a sample of 38 post cardiac surgical patients averaged a maximum pain intensity of 4 on a 10 point scale in the previous 24 hours. Milgrom et al. (2004) interviewed 705 cardiac postoperative patients regarding pain scores and coughing scored highest with a mean pain score of 6.5 on 10 on postoperative day one. The scores decreased to 5.4 and 5.1 on postoperative days two and three. Deep breathing also scored as high as 5.3 on postoperative day one and 4.4 on postoperative day two (Milgrom et al.). Overall, activities causing the most pain, in order, were: coughing, moving and turning in bed, getting out of bed and deep breathing

(Milgrom et al.). Similarly, Yorke, Wallis, and McLean (2004) reported that 95% of 102 patients reported coughing as the most painful activity post cardiac surgery. Lahtinen, Kokki, and Hynynen (2006) found that coughing caused the worst pain in 78% of the 213 patients surveyed after cardiac surgery. Edelen and Perlow (2002) noted the importance of pain control when performing respiratory exercises after cardiothoracic surgery. Proper pain control enabled patients to increase their inspiratory lung volume during deep breathing, which prevented respiratory complications.

Incisional pain can be managed with both pharmacologic and nonpharmacologic therapies. However, there is a scarcity of research about the nonpharmacologic modalities, also known as nondrug therapies, for treating post cardiac incisional sternal pain. Of these modalities, cold therapy is a pain management strategy that is used effectively in areas such as orthopedic surgery and sports medicine (Algaflly & George, 2007; American Academy of Orthopaedic Surgery, 2008; Australian Physiotherapy Association, 2008; Knight, 1995). The beneficial effects of cold therapy for pain management have been widely documented and the side effects are minimal, yet its use remains limited in patients post cardiac surgery. The American Academy of Orthopaedic Surgery recommends cold application for 20 minutes every 1 to 2 hours.

Cold therapy has analgesic properties that have been used to manage post-surgical and procedural pain. Koç, Tez, Yoldas, Dizen, and Göçmen (2006) identified a significant decrease in postoperative hernia pain with the application of an ice pack for 20 minutes. Postoperative pain scores at two, six and 24 hours were significantly lower in the treatment group as compared to the control group. In a study by Akan Misirlioglu,

Yildirim, Çakir, Taylan, and Aköz, (2003), ice packs were safely used to decrease pain in skin graft donor sites on postoperative day four and five.

Current Practice

Cold therapy is not presently used to alleviate sternotomy incisional pain experienced when DB & C. There are no studies in the literature that specifically address cold therapy for sternotomy pain management. The current practice to control postoperative cardiac pain at the hospital where the study took place is typically restricted to medications such as acetaminophen and morphine or hydromorphone. These medications are effective for background pain but the increased dosages needed for the breakthrough pain associated with activity such as DB & C can have negative systemic side effects such as nausea and sedation that are unwanted by patients (Benyamin et al., 2008; Harris, 2008; McCaffery & Pasero, 1999). The application of cold therapy to alleviate the breakthrough pain associated with DB & C was explored in this study.

Research Questions

The research questions were as follows: 1) Does cold therapy for CABG patients with sternal incisions reduce pain related to DB & C? 2) What sensations do CABG patients describe when applying cold therapy for sternal pain management associated with DB & C? 3) Do CABG patients prefer cold therapy prior to DB & C?

Methods

Design

A repeated measure, crossover design was used and each patient served as his/her own control. Data was collected on post-surgical day two between 7:30 am and 6 pm. Participants underwent four episodes of DB & C, two with the gel pack and two without

the gel pack. The sequence of gel pack application was randomized and half the participants started with the gel pack and half started without the gel pack.

Randomization was done through a coin toss.

Setting

The study took place in a tertiary care teaching hospital in Eastern Ontario that specializes in cardiac care. There are 116 in-patient beds as well as ambulatory and rehabilitation services. The postoperative unit contains 30 beds to provide care for approximately 30 cardiac surgeries per week.

Inclusion and Exclusion Criteria.

Participants were included if they were: 1) male or female patients scheduled to undergo CABG surgery with or without a valve replacement using a median sternotomy; 2) able to speak and understand French or English; 3) over 21 years of age; 4) willing to participate. Participants were excluded if they: 1) were allergic or sensitive to cold; 2) had been diagnosed with Raynaud's disease, cryoglobulinemia (clumping of plasma proteins) or cold hemoglobinuria (red blood cells breakdown and have the inability to combine with blood proteins); 3) had cognitive impairments such that they could not understand the use of a pain scale; 4) had a chest tube at the time of data collection; 5) had a minimally invasive CABG surgery without a median sternotomy; 6) developed postoperative complications such as infection, bleeding, uncontrolled atrial fibrillation or wound dehiscence ; 7) were diabetic; 8) had a bilateral mammary harvest.

Materials and Measures

Gel Packs

The gel packs that were used as the cold source for the study were manufactured by Gelpax Inc., weighed 270 grams and measured six inches by ten inches. They were made of non-toxic, biodegradable gel held in a flexible plastic contour. The gel packs were kept in the freezer on the patient service unit where the participant was located at the time of data collection. The gel packs need approximately one hour of freezing before the temperature is low enough to be suitable for use (S. Scott, personal communications, CEO and President of GelPax inc., March 29, 2007). The gel packs were applied over the surgical dressing covering the sternal incision.

Pain Intensity Scale

Participants used a numerical rating scale (NRS) to rate their pain from 0 (no pain) to 10 (worst possible pain). Reliability and validity of the NRS has been previously established by many authors in postoperative patients, cancer, chronic pain and patients with rheumatoid arthritis (DeLoach, Higgins, Caplan, & Stiff, 1998; Downie et al., 1978; Kremer, Atkinson, & Ignelzi, 1981; Wilkie, Lovejoy, Dodd, & Tesler, 1990). The NRS is currently used at this hospital for pain assessment and is well accepted and understood by patients.

Perception of Cold Therapy

Open ended questions were posed to study participants to assess sensations and preferences related to cold therapy. When patients had the gel pack on their chest, the following questions were asked: How does the gel pack feel on your chest? Can you describe the sensations to me? To assess preferences, the following questions were asked

at the end of the 4th session of DB & C: Do you prefer cold therapy prior to DB & C? Why? Would you use this method again? Why or why not? The answers were recorded on paper at the participants' bedside. Demographic data obtained from each patient record included age, sex, attendance at the Pre-Admission Unit (PAU), diagnosis, type of surgery, previous use of cold therapy and type and amount of opioids taken on a PRN basis.

Record Audit

All data collected from the participants and from the participants' medical records were recorded on a data collection form developed for this study. The form included participants' demographics, narcotics administered as needed, pain intensity scores, sensations and preferences. Participants' records were reviewed prior to the four sessions of DB & C to gather demographic data. The Medicine Administration record (MAR) was also reviewed at the end of the study to identify the narcotics administered. Participants' descriptions of their sensations and preferences were transcribed from the data collection form verbatim into word document.

Procedures

Recruitment

Prior to recruiting patients, ethical approval was obtained from the hospital's ethical review board. Two methods were used to recruit participants. The first method consisted of recruiting patients planned and pre-scheduled for CABG in the Pre-Admission Unit (PAU). A poster in both French and English was posted in the waiting room of the PAU. As part of the routine admission process, all patients are asked by nurses if they would like to be involved in any type of study that is ongoing in the

hospital. If they agree, patients then sign a form indicating this and it is placed in their medical chart. Only the patients that agreed to be in a study and met the eligibility criteria for this study were approached by the principle investigator. The second recruiting method targeted patients that were considered 'urgent' and were typically scheduled to undergo surgery within four days. These patients did not go through the PAU. The eligibility of patients was reviewed by the advanced practice nurse in cardiac surgery and the principle investigator. If the patients had signed the form indicating they wanted to be approached to be involved in a study as described above, they were approached by the principle investigator for this study and the consent form was signed.

Data Collection Protocol

The investigator entered the participant's room, introduced herself and reminded the participants of the study aims. The investigator reviewed the numerical rating scale (NRS) and techniques for DB & C with participants prior to starting data collection. In addition, participants were asked if they had previously used cold therapy for another injury. At the beginning of every DB & C session participants rated their baseline pain from 0 to 10 on the NRS. If the session involved the gel pack, the investigator brought the gel pack from the freezer to the participants' bedside and the participants applied the gel pack over the dressing covering their chest incision. A timer was activated for 20 minutes. The investigator remained with the participants for the 20 minutes that the gel pack was in place. During those 20 minutes, participants were asked to describe the sensations they felt related to the gel pack. After 20 minutes, the gel pack was removed and the head of the bed was elevated between 45⁰ and 90⁰ in preparation for DB & C.

If the session did not involve the gel pack the investigator prepared the participant for DB & C in the same manner as with the gel pack. A pillow or folded sheet was provided to participants for splinting purposes and DB & C was initiated. Three cycles of three deep breaths were performed followed by an episode of coughing. Rest and normal respirations were encouraged in between the three cycles. Participants were asked to rate their pain from 0 to 10 on the NRS at the completion of the third cycle. The gel pack was disinfected with an anti-bacterial wipe and placed back into the freezer. At the end of the last session, all participants were asked if they preferred the gel pack prior to DB & C.

Results

Sample

Demographic data was analysed using means, standard deviations and percentages. There were 32 participants (25 males, 7 females) in this study and there were no dropouts or complications related to the gel pack. All of the eligible patients approached agreed to take part in the study. Participants ranged in age from 46 to 81 years with an average age of 66 (SD = 7.17) years. Eight (25%) participants were recruited via the PAU and 24 (75%) were considered 'urgent' and were recruited in the hospital. The number of coronary artery grafts were as follows: 5 participants (16%) had 4 grafts; 16 participants (50%) had 3 grafts; 7 participants (22%) had 2 grafts; 4 participants (13%) had one graft; and of the grafts utilised, 25 (78%) were the left mammary artery. Thirty one participants (97%) had an admission diagnosis of coronary artery disease and one participant had aortic stenosis. There were 19 (59%) participants who had previously used cold therapy for a previous injury.

Pain Intensity Scores

Participants were randomly assigned to either begin the DB & C sessions with the gel pack or without the gel pack. Participants then alternated with respect to the gel pack. Therefore, if session one was with the gel pack, session two was without the gel pack, session three was with the gel pack, and session four was without the gel pack. Randomisation of the participants to begin the trial with or without the gel pack controlled for the effects of order. Average pain scores between the group that started with the gel pack ($M= 3.1$, $SD = 2.5$) and the group that started without the gel pack ($M=3.8$, $SD=2.8$) were not significantly different ($t=0.74$ (30), $p>.05$).

A 2 (treatment) X 2 (session) X 2 (time) within subjects repeated measures analysis of variance (RM-ANOVA) was conducted on pain intensity scores at baseline and post DB & C with patients that underwent a CABG procedure. The three independent variables were treatment with two levels (gel pack and no gel pack) session with two levels (am and pm), and time with two levels (baseline and post DB & C). The dependent variable was pain intensity. The interaction between treatment and time was significant, $F(1, 31) = 28.69$, $p < .001$ (see Table 1) and indicated that pain scores post DB & C were significantly lower when participants used the gel back. The means and standard deviations for pain intensity scores are presented in Table 2.

Table 1

Interaction Effects for Treatment, Session and Time from RM-ANOVA

	F	P	Effect size (partial eta-squared)
Three way interaction:			
Am-pm + Gel pack- no gel pack application + Baseline-post DB & C scores	1.17	0.29 (NS)	0.04
Two way interaction:			
Am-pm + Gel pack-no gel pack application	1.06	.31 (NS)	0.01
Two way interaction:			
Am-pm + Baseline-post DB & C scores	0.44	0.51 (NS)	0.03
Two way interaction:			
Gel pack-no gel pack + Baseline-post DB & C scores	28.69	<.001	0.48

Table 2

Means and Standard Deviations of Pain Intensity Scores at Baseline and Post DB & C

Treatment	Session			
	AM		PM	
	Baseline *M (SD)	Post M (SD)	Baseline M (SD)	Post M (SD)
Gel pack	2.97 (2.58)	2.72 (2.23)	2.84 (2.55)	2.56 (2.84)
No Gel pack	3.19 (2.53)	3.84 (2.54)	2.31 (2.32)	3.44 (2.68)

* Scale 0-10

Sensations and Preferences

A word count on the transcribed text was performed to identify the words most frequently used to identify the sensations and preferences perceived by the participants. There were nine (28%) participants who reported feeling coolness and not cold. The other 23 (72%) participants felt cold rather than coolness in at least one of the two gel pack sessions. Only three (9%) participants experienced numbness and no one experienced

tingling. One participant did not like the experience of cold and experienced discomfort at the end of the 20 minute application. This participant's discomfort resolved once the gel pack was taken off his chest. One participant (3%) initially felt discomfort when the gel pack was applied but this resolved within less than a minute. Twelve participants (38%) reported that the sensation of cold peaked after 10 minutes. Three (9%) participants stated the temperature under the dressing never got cold enough.

There were five (16%) participants who mentioned that breathing was easier with the cold application. Four (13%) participants indicated the lung secretions were looser when the gel pack was applied. One participant said: "cold helped to get rid of the phlegm [...] it is easier to cough". In addition, one participant stated that "the coolness adds reassurance" when applied on the chest incision.

Twenty-two participants (69%) preferred DB & C with the gel pack and two participants (6%) preferred to do the DB & C without the gel pack. One participant mentioned it was too cold and she did not like being cold, the other participant did not notice a difference in pain intensity. Eight participants (25%) had no preference. All the participants (100%) would apply a gel pack again for pain management. The two participants who preferred DB & C without the gel pack stated they would reapply ice in the future if it helped to manage pain or if it was recommended by the health care team.

Discussion

Pain with DB & C post cardiac surgery remains an issue for patients and health care providers. While nurses administer pain medication such as acetaminophen and morphine that work on background pain, breakthrough pain caused by DB & C is not well managed. Patients may avoid DB & C if it intensifies pain. Cold therapy has been

studied for many years with various injuries or procedures, yet it has never been studied with patients following cardiac surgery. In this study, a gel pack was applied to participants' sternums in order to manage the pain associated with DB & C. Each participant did four sessions of DB & C and two sessions were preceded by 20 minutes of gel pack application on the dressing covering the wound.

Pain Reduction

Pain was significantly reduced with the use of the gel pack. Pain scores post DB & C were on average 3.5/10 without the gel pack compared to 2.6/10 with the gel pack. In all four sessions, pain scores post DB & C with the gel pack were lower than the scores without the gel pack, a reduction of about one point on the 10 point scale. The results of this study support the use of cold therapy for sternal incisional pain management associated with DB & C post cardiac surgery. A similar reduction in pain scores with cold therapy was identified for a variety of surgical procedures such as facial, jaw and abdominal surgery (Chou & Liu, 2008; Filho, Silva, Camargo, & Gouveia, 2005; Koç, Tez, Yoldas, Dizen, & Göçmen, 2006). In addition, cold therapy is also effectively used for pain management with orthopaedic injuries and postoperatively (Chou & Liu; Saliba, Saliba, & Denegar, 2006).

According to the World Health Organization (WHO) analgesic ladder (1996), pain scores from 0 to 3 on a 10 point scale are considered to be mild pain and scores above 3 to 6 moderate pain. Patients in this study experienced mild pain ($M = 2.6$) when using the gel pack as compared to moderate pain ($M = 3.5$) without the gel pack. The decrease in one point on the ten point pain intensity scale is both statistically and clinically significant. Well controlled pain allows patients to perform activities such as

DB & C which prevent pulmonary complications such as pneumonia and atelectasis. According to Jakobsson (2000), an acceptable pain score postoperatively is considered to be below 2 to 3 on 10. When pain scores are above 3 to 4 on 10, pain management must be addressed by nurses because pain interferes with activities such as mobility, eating and DB & C. This is also supported by McCaffery and Pasero (1999) who suggest that a pain score greater than 3 requires a review and adjustment of the pain treatment plan. In this study, participants using the gel pack had an acceptable pain score which was below 3 on 10 but participants without the gel pack had a pain score above 3 on 10 which is considered unacceptable and in need of intervention. DB & C is a key activity in the prevention of respiratory complications and patients are unlikely to do it if they are not comfortable or do not have strategies to manage the breakthrough pain. The decrease of one point on the pain scale is clinically significant because with less pain, patients are more comfortable when performing DB & C exercises which prevent complications and lead to recovery.

Sensations and Preferences

The frozen gel packs were designed to decrease the skin temperature thus it is not surprising that the sensation most often reported by participants (72%) during the application of the gel pack was a feeling of cold. The remainder of the participants stated they felt a coolness that never reached a feeling of cold. There were no participants that described the negative sensations of aching, stinging, harsh, unbearable and burning when applying the gel pack. There are no studies in the literature that describe patients' perception of cold as it impacts the effectiveness of cold therapy for pain reduction. In

our study, participants perceived less pain post DB & C without experiencing numbness from the gel pack; coolness and cold sensations were sufficient to decrease pain.

The majority of the participants (n = 22, 69%) preferred using the gel pack before DB & C and all the participants stated they would reapply cold in the future. Participants found the cold pack application acceptable and no one refused the treatment the second time it was offered. This is not surprising considering the coldness decreased pain. This is reflected in the participants' comments in response to the open ended questions that were asked about their sensations and preferences. For example, some participants mentioned they felt the cold sensation provided reassurance, they could breathe easier and their secretions were looser. The perception that cold therapy helped participants to breath easier and expectorate more freely was unexpected and an interesting finding. This could be examined in a follow up study to investigate the effects of cold therapy on lung function.

Since cold therapy is an effective and low risk pain management strategy it is encouraging to note that the majority of participants accepted and preferred DB & C with cold therapy and all the participants would reapply cold therapy in the future. Overall, the gel packs were generally acceptable to participants and were perceived as being effective for pain reduction.

Implications for Nursing Practice

DB & C is important for recovery but remains one of the most painful activities post cardiac surgery. Treating breakthrough pain caused by DB & C with additional opioids can lead to undesired side effects. Cold therapy is a low cost, low risk and practical pain management strategy that effectively controls the breakthrough pain of DB

& C. Nurses can assist patients to take an active role in pain management during DB & C with the use of a gel pack. However, before applying cold, nurses should assess patients' previous experience with cold to detect any allergic reactions such as hives. In addition, during the application, nurses should monitor the patient for any signs of excessive pain or discomfort. One of the first signs of frostbite is blanching of the skin. Frostbite can occur with any type of cold modality such as a gel pack or ice chips. To prevent frostbite, nurses should use a skin barrier such as a thin towel or a flannel covering the wound dressing. Nurses should inform patients to remove the cold source if discomfort occurs or the wound dressing becomes damp. The application should not exceed 20 to 30 minutes and it can be reapplied every one to two hours (Knight, 1995).

In order to reduce variability among participants, cold therapy was applied on postoperative day two when they were alert, oriented and their chest tubes had been removed. However, in practice, it would be acceptable to use cold therapy on day one after surgery when pain is most severe. The chest tubes will not interfere with the cold pack application since they are located distal to the midline sternum. DB & C is initiated as soon as patients are awake after the surgery. It is an important activity that is repeated throughout the hospital stay in order to help with recovery. Therefore, it is essential to manage pain with every episode of DB & C.

Gel Pack versus Ice

Gel packs were used in this study but if they are not available, ice chips in a glove or plastic bag could be used instead. If ice chips are used, nurses must ensure the plastic bag or glove is leak proof to prevent the thawing ice from soaking the dressing. This can be accomplished by using two bags and placing the bag on the patient's chest with the

opening facing up. Nurses should caution the patient to remove the ice if the bag is leaking.

Strengths and Limitations of the Study

The within subjects research design was a strength of this study in that individual differences were controlled because every participant served as their own control. A within subjects design increases power to detect a difference in the treatment versus no treatment groups and reduces the error variance due to individual differences (Burns & Grove, 2005). A crossover research design provides an unbiased estimate of the differences between the treatment and no treatment conditions.

A limitation of this study was the small sample size with respect to women (n=7) as compared to men (n=25). However, this is representative of the population undergoing CABG surgery where about a third of the CABG surgeries in both Canada and the United States are women (Canadian Institute for Health Information, 2006; Cleveland Clinic, 2008). It was therefore not possible to compare men and women separately with respect to pain reduction with and without the gel pack. This limits the generalizability of the study results to women.

Future Research

The same study with ice chips in a glove or bag could be performed to see if it is equally effective and acceptable as the gel pack. Ice chips are easily accessible in a hospital and in patients' homes. Future studies could also focus on the application of gel packs earlier after surgery when pain is likely more intense. The decrease in pain scores using cold therapy when DB & C could be greater on postoperative day one even if chest

tubes are still present. To increase generalizability of study results to women, other studies could be performed with more women.

Conclusion

Cold therapy for DB & C is effective for decreasing pain post cardiac surgery. This modality is low cost, low risk, and can easily be integrated into nursing practice since cold packs are easily accessible in most hospitals. With nurses' initial supervision, cold therapy is a safe and effective pain management modality for patients following cardiac surgery.

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CHAPTER FIVE - Conclusion

Discussion

Pain post cardiac surgery is often present when performing DB & C exercises. However, these exercises are important for recovery as they prevent respiratory complications. To date, cold therapy has not been explored for patients following cardiac surgery although it has been used in other areas of practice for many years. This study explored the effects of a frozen gel pack for pain management prior to DB & C exercises.

This chapter will review in greater detail participants' demographics, exclusion criteria, postoperative pain in patients following cardiac surgery, pain associated with DB & C, pain management and nonpharmacological modalities, sensations and preferences, safety concerns related to cold therapy, study strengths and limitations, implications for nursing practice and future research.

Demographics

In this study, the proportion of males to females and the average age of the study participants was comparable to what is reported in the literature for cardiac surgical patients and comparable to what was reported in 2007 from the study hospital. There were 32 participants, 25 males (78%), and 7 females (22%) in this study. The disproportionate number of males to females is similar to what was reported at this hospital for 2007, where it was reported that 77% of patients having cardiac surgery were males and 23 % were females (University of Ottawa Heart Institute, 2007). In Milgrom et al. (2004), females represented 31% of the 705 cardiac surgical patients in a U. S. hospital. Similarly, 24.5% of the 102 Australian cardiac surgical patients were females in a study by Yorke et al. (2004). In Switzerland, Westerdahl et al. (2003) studied 61

cardiac surgical patients and 20% of the sample was female. In our study, the ratio of male to female participants was similar to what is described in the cardiac surgical literature.

In 2007, the average age of the patients following CABG surgery at the study hospital was 64 years of age (UOHI, 2007) and in this study, the average age was 66 years of age which is comparable. In other studies in the U. S., Australia and Switzerland, the average age of patients undergoing cardiac surgery ranged from 61 to 65 years old (Milgrom et al., 2004; Westerdahl et al., 2003; Yorke et al., 2004). Overall, the participants in this study were comparable in age and sex distribution to what is reported in the literature related to the cardiac surgical population.

Exclusion Criteria

Patients with diabetes represent about 35% of the population having a CABG procedure at the hospital where this study took place (UOHI, 2007). However, they were excluded from this study as a request by the surgeons because of the potential for complications related to diminished peripheral circulation and peripheral neuropathies. However, patients with diabetes could potentially benefit from cold therapy. Patients with diabetes were included in many other studies on cold therapy applied to other body areas and no side effects were reported (Akan et al., 2003; Algalfy et al., 2007; Knight, 1995; Koç et al., 2006; Waters & Raisler, 2003). For patients with diabetes, neuropathy is generally present in the extremities such as the hands and feet and generally not in the chest area (American Diabetes Association, 2009). With appropriate care and concern for safety, patients following cardiac surgery with diabetes could be involved in future studies using cold therapy for pain management.

Patients that had a bilateral mammary harvest represent about 5% of the population that underwent a CABG procedure at the hospital where this study took place (A. Stolarik, personal communication, October 10, 2008). This population may have diminished vascularisation in the chest cavity because both their mammary arteries were cut to be grafted on the heart. They were excluded from this study because there was a concern related to the effects of vasoconstriction caused by cold therapy. The concern was unfounded because the effects of cold are superficial and do not penetrate as deep as the mammary arteries (Merrick et al., 2003). Cold therapy could be studied on bilateral mammary harvest CABG patients. Pain is generally more intense in bilateral mammary harvest patients (Yorke et al., 2004) and the potential for cold therapy to provide pain relief is significant.

Postoperative Pain in Cardiac Surgical Patients

When participants in my study were at rest, baseline pain scores remained, on average, below 3 (2.8) on a scale of 0-10. Milgrom et al. (2004) reported the same mean pain scores at rest (2.8) on day two in a study of 705 patients that underwent cardiac surgery. Typically, pain intensity scores below 3/10 are considered to be mild pain and acceptable for post surgical patients (Jakobsson, 2000; WHO, 1996). Patients with mild pain or an intensity score of 3/10 are typically able to ambulate, eat and perform other activities of daily living (McCaffery & Pasero, 1999). Pain at rest should remain under 3/10 but with DB & C, pain intensity often increases into the moderate or severe range which prevents patients from doing activities essential for recovery. DB & C is a key activity in the prevention of respiratory complications and patients are unlikely to do it if

they are not comfortable or do not have strategies to manage the breakthrough pain. Cold therapy is simple to use and provides adequate analgesia for DB & C.

At this hospital, Woodend (1999) did a pain prevalence study and sampled all in-hospital patients, including patients on the surgical unit where we collected our data. Patients from postoperative day two until discharge were asked to rate their pain from 0 to 10 once during the day of data collection. Woodend reported a mean pain intensity score at rest of 4/10 as compared to our at rest scores which were on average 2.8/10. Based on the relatively high pain intensity scores obtained by Woodend in 1999, the surgical service initiated changes to the postoperative pain management protocol. They instituted around-the-clock administration of morphine or hydromorphone and acetaminophen during the first 24 hours postoperative. The new pain protocol is clearly beneficial since the average pain score decreased by over one point on the 10 point scale and pain scores went from moderate (over 3/10) to mild (3/10 and less) pain (Jakobsson, 2000).

Pain Associated with Deep Breathing & Coughing

Pain intensity increases in most patients with DB & C. Yorke et al. (2004) reported that 95% of the 102 patients surveyed identified coughing as the most painful activity post cardiac surgery. Lahtinen et al. (2006) reported that coughing caused the worst pain in 78% of 213 patients after cardiac surgery. Four months after CABG surgery, coughing was still identified as the most painful activity but the pain scores had decreased to less than 1/10 (Westerdahl et al., 2003). Poorly managed breakthrough pain associated with DB & C is a significant problem and this study was undertaken to develop strategies to better manage pain associated with DB & C. Cold therapy is a pain

management modality that effectively decreased pain associated with DB & C. Cold can be integrated into nursing practice to help patients diminish their pain as much as possible.

Milgrom et al. (2004) did a prevalence study on patients' post cardiac surgical pain scores post DB & C and the average pain scores were above 4 on 10 on postoperative day two compared to 2.8 at rest. In our study, participants' average pain scores were similar to Milgrom et al.'s work since pain scores post DB & C without cold therapy were on average 3.5/10. This represents moderate pain intensity compared to the baseline pain score 2.8 which is mild pain. Interestingly, participants' pain intensity scores post DB & C were on average 2.6/10 with the cold pack which indicates that pain scores with cold therapy were on average lower than participants' initial mean baseline pain scores (2.8).

Moderate pain prevents patients from mobilizing, eating, socializing and performing other activities essential in preparation for discharge (McCaffery & Pasero, 1999). In my study, DB & C pain scores without cold therapy were on average above 3/10 which indicates moderate pain. Generally, when pain scores are above 3 on 10, patients' pain needs to be better managed (Hallenbeck, 2003; Jakobsson, 2000). Following cardiac surgery, patients have a painful chest incision and are unlikely to do DB & C if their pain is not well managed. Maximal pain control when DB & C is essential because the exercises prevent complications and lead to recovery (Edelen & Perlow, 2002). With less pain, patients are able to perform DB & C exercises more efficiently as they take deeper breaths and cough more effectively (Edelen & Perlow; Westerdahl et al., 2003). In this study, patients successfully managed their pain with the

cold pack and their pain intensity scores, on average, decreased from the moderate to the mild pain range which in turn may have facilitated their ability to perform DB & C exercises.

Pain Management and Nonpharmacological Modalities

Although postoperative pain is typically managed with pharmacological therapy both pharmacological and nonpharmacological modalities can be used to decrease pain. A number of studies have described the use of guided imagery, music therapy and light massage or gentle touch, relaxation as well as superficial ice application to manage surgical pain. Studies on pharmacological modalities such as ropivacaine and Non-Steroidal Anti-Inflammatory Drugs (NSAID) have similar beneficial effects as cold therapy for pain management but the pharmacological modalities may have unwanted side effects. The studies on nonpharmacological and pharmacological pain management modalities will be explained in more details below.

The amount of pain reduction reported in the literature that results from the use of a nonpharmacological pain management modality varies, but typically ranges from a decrement of 0.5 to 2.5 points on a 10 point scale. For example, Kshetry et al. (2006) reported cardiac surgical patients' pain and tension was reduced on average 2.5 points on a 10 point scale using a combination of three nonpharmacological modalities: guided imagery, music therapy and light massage or gentle touch throughout postoperative day two. Although effective, in actual practice it would be prohibitively time consuming to perform the combination of the three interventions repeatedly over the course of the day. Good, Anderson, Ahn, Cong, and Stanton-Hicks (2005) analysed relaxation and music therapy effects on pain following intestinal surgery. They used the VAS from 0-100 to

measure pain intensity on postoperative day one and two. Following ambulation on postoperative day one, relaxation decreased pain scores by, on average, 11 points and music therapy decreased pain scores by, on average, 10 points compared to the control group. The diminished pain intensity of 10 points on 100 can be converted to 1 point on 10, which is comparable to what we found in this study. The authors recommend the integration of both relaxation and music therapy into practice because the reduction of the equivalent of 1 point on a 10 point scale was considered significant pain relief. In our study, pain reduction was also close to 1 point on a 10 point scale with the application of cold therapy and the results also support the integration of cold therapy into practice.

Ice cubes applied for six minutes on adults' skin before a digital nerve block needle-stick reduced pain by 30 points on the 100 point VAS compared to the no ice group (Hayward et al., 2006). The majority of the 20 participants preferred ice application compared to none. Only four participants had no preferences and none indicated they preferred without ice. A reduction of 30 points on 100 is significant and since most participants preferred ice, the application was recommended for practice. Similarly, in our study, the gel pack significantly reduced pain associated with DB & C and the majority of the participants preferred cold therapy compared to none. Koç et al. (2006) reported that 24 hours after hernia surgery, ice chips in a plastic bag applied for 20 minutes diminished pain 1.2 points on a 10 point scale between the experimental and control group. There was a greater decrease in pain scores at two hours, 1.6 points on 10, and six hours, 1.3 points on 10, after surgery. In our study, applying cold therapy earlier after CABG surgery as Koç et al. did in patients following hernia surgery could also generate a greater decrease in pain intensity. This could be further explored in future

studies. Based on the magnitude of pain reduction reported in the studies using nonpharmacological pain management modalities, we expected our pain intensity scores on postoperative day two to decrease one point on the 10 point pain scale which in fact they did. A decrease of one point on ten, from moderate to mild pain intensity for a nonpharmacological pain management modality can make an important difference in patients' pain enabling maximal comfort to perform activities leading to recovery.

Pharmacological pain management modalities can provide an important decrease in pain scores but may have undesired side effects. Dowling et al. (2003) found a decrease of one point on the 10 point scale (1.6 compared to 2.6/10) using the additional treatment of continuous ropivacaine percutaneously over the sternal incision in 40 patients with CABG. Cold therapy is less invasive and less expensive than percutaneous ropivacaine and it provides a similar pain relief. In addition, cold therapy can be used repeatedly without fear of drug toxicity (Reimer-Kent, 2003).

Kulik et al. (2004) added a NSAID (naproxen) to the normal pain management regimen in cardiac postoperative patients. Pain scores after chest physiotherapy over four postoperative days were lower in the naproxen group as compared to the control group and pain scores decreased by 1.7 points. Participants in our study showed a similar pain intensity decrease with cold therapy. The addition of naproxen to cold therapy could potentially have a greater effect than either alone. This could be a focus of future research.

Reimer-Kent (2003) found that pain management in cardiac surgical patients using a combination of opioids and non opioids administered around the clock, decreased the negative side-effects related to opioids such as nausea, psychosis, confusion, delirium

and constipation which may increase cost and length of hospital stay. An advantage of nonpharmacological therapy is that it does not have any of the side effects such as psychosis and nausea produced by narcotic administration. It is therefore advantageous to integrate nonpharmacological pain management modalities such as cold therapy in cardiac postoperative patients which may have the effect of decreasing the need for large doses of narcotics to control breakthrough pain.

Cold is used in addition to pharmacological modalities in other clinical populations. For example, cold after childbirth applied to the perineal area was shown to be beneficial in decreasing pain (East, Begg, Henshall, Marchant, & Wallace, 2008). Cold has also been used to diminish postoperative pain in patients with hernia surgery and orthopedic surgery (Koç et al., 2006; Knight, 1995). Cold therapy is low risk, low cost and nurses and patients can access ice or cold packs in the hospital and at home.

Sensations and Preferences

A word count was performed on the transcripts to identify the words most frequently used to identify the sensations perceived by the participants. As expected, the words most frequently used were coolness and/or cold. There were no words used by the participants that were negative such as aching, stinging, harsh, unbearable and burning when applying the gel pack. One participant experienced discomfort at the end of the 20 minute application which resolved immediately after taking the gel pack off the chest. Unbearable coldness was not described by any participants. One participant stated that "the gel pack is not excessively cold" which indicated that the temperature of the gel pack was acceptable to this patient. This is important because when we were planning the study, there was some concern that older patients (e.g. > 65 years) would not want to

apply cold on their chest. Typically, older adults have less subcutaneous fat as compared to younger adults which could potentially have the effect of making them more sensitive to cold temperatures (Eliopoulos, 2001). In addition, older adults' normal body temperatures, on average, are slightly lower than younger adults, ranging from 36.1 to 36.8 degrees Celsius (Eliopoulos). In our study, all the patients that were approached about the study agreed to participate and no patients refused to place the gel pack on their chest. Based on their descriptions experienced, all participants found the cold pack to be acceptable.

Many participants described a positive experience when applying the gel pack to their chest before deep breathing and coughing (DB & C). Five participants stated they could breathe easier when the gel pack was applied. One participant affirmed that "it is easier to cough with the ice and it helps to get rid of the phlegm". A participant stated that "cold takes away the pain from breathing and it feels good" and another participant stated that "cold eases the incision". Edelen and Perlow (2002) noted that cardiothoracic surgical patients with less pain can increase their inspiratory lung volume which prevents respiratory complications. In our study, participants' experiences and feedback with cold therapy were positive and many participants stated they could breathe better with cold applied before DB & C. Although we did not specifically evaluate the efficacy of their coughing and deep breathing efforts with and without the gel pack, it is hypothesized that it would improve and, similar to Edelen and Perlow's work, there would be an increase in inspiratory lung volume. This would be an important question for future research since cold therapy has the potential to improve breathing capacities.

Participants found the cold pack application acceptable and no one refused the treatment the second time it was offered. The majority of the participants stated that they preferred using the gel pack before DB & C and all the participants stated they would reapply cold in the future. Only two participants stated they preferred DB & C without the gel pack, but overall, cold therapy was an acceptable treatment for decreasing pain post DB & C for this group of participants. Since cold therapy is an effective and low risk pain management strategy it is encouraging to note that participants accepted and preferred DB & C with cold therapy. One participant stated "with ice, you prepare yourself for the whole DB & C". In this case, cold therapy served as a reminder or a cuing device to help the participant prepare for the increase pain that accompanies DB & C. Another participant started DB & C with the gel pack during session one and when he performed DB & C without cold therapy during the second session, he mentioned he was looking forward to doing DB & C with the cold application. This participant preferred performing all his DB & C exercises with the application of the gel pack.

Safety Concerns of Cold Therapy

The effects of cold on coronary grafts were a concern before undertaking the study. For example, it was suggested that cold could potentially cause vasoconstriction of the surgical grafts. Four of the eight cardiac surgeons were questioned by the principle investigator about their opinions on the safety of superficial cold therapy and they all believed that the application of the gel pack would have no effect on the surgical grafts. In addition, there is no literature to indicate that cold therapy is contraindicated for patients post cardiac surgery. In fact, no participants experienced any adverse events associated with the cold pack therapy.

Strengths

The crossover research design was a strength of this study. The design enabled each participant to experience both study conditions, DB & C with the gel pack and without the gel pack. In a between subjects design, participants vary by many known and unknown factors such as age, educational level, socioeconomic status, coping style to name a few. Because participants in the treatment and control group are the same individual, differences are controlled and every participant serves as their own control. A within subjects design consequently increases power to detect a difference in the treatment versus no treatment groups and reduces the error variance due to individual differences (Burns & Grove, 2005). A crossover research design can provide an unbiased estimate of the differences between the treatment and no treatment conditions.

Limitations

One limitation of this study is the small sample size with respect to women [$n = 7$, (22%)] which consequently limits generalizability of the results to women. There were more males as they represented 78% ($n=25$) of the sample. The literature indicates that pain is generally higher in females (Watt-Watson et al., 2004; Yorke et al., 2004). In a study by Yorke et al. on 102 patients following cardiac surgery, women ($n=25$) reported having more pain (average of 5.7/10) as compared to men ($n=77$) (4.4/10). Women also report more pain-related activity interference such as walking after cardiac surgery (Watt-Watson et al.). Women not only have incisional pain but they also may have breast discomfort described as aching and sharp pain than can last up to twelve months after surgery (King, Parry, Southern, Faris, & Tsuyuki, 2008). In our study, pain scores between men and women could not be reliably compared due to the small sample size

(n=7) with respect to women. The increased pain experienced by women as described in the literature should be examined in more detail in future studies in order to be able to understand the effects of cold therapy for pain management specifically for women.

Women may indeed benefit more from this simple pain management strategy than men as they experience pain more intensely and have breast discomfort in addition to incisional pain.

Implications for Nursing Practice

Nurses play an active role in relieving patients' pain. They are at the bedside 24 hours per day and they are continually assessing, treating and evaluating the efficacy of pain treatments. Based on the results of this study, cold is an effective and relatively simple pain management strategy for controlling the breakthrough pain of DB & C and it could be easily integrated into the patient care regimen. In addition, participants in this study found cold therapy to be acceptable and in some cases a comforting treatment. Nurses typically do not need a medical order to apply cold therapy (Chou & Liu, 2008; McDowell, McFarland, & Nalli, 1994; Sauls, 2002). However, for the sake of consistency and standardization of care it would be important to have a policy and procedure that clearly describes the indications for use, application and disinfection of the cold pack. Standardized procedures are helpful in that they enable nurses to provide consistent and accurate care to patients, which promotes positive outcomes and rapid recovery (Dirckx, 2001). Examples of procedures for the use of cold might include the type of patient that might maximally benefit, the amount of minutes of application, the use of a skin barrier and the type of cold therapy to use. The RNAO nursing best practice guideline on pain assessment and management support the use of both pharmacological

and nonpharmacological modalities to treat pain but it does not specifically address cold therapy in cardiac surgical patients (RNAO, 2002). After more extensive research describing the benefits of cold therapy, this modality could potentially be integrated into a nursing best practice guideline for surgical patients.

Cold packs are a safe and effective adjunct to pain medications and the application of cold packs on patients' chest before DB & C provides a good reminder to both nurses and patients to perform DB & C frequently during the day. Patients often avoid coughing since it is painful and nurses do not always have the time to remind patients to do DB & C every one to two hours. Applying the gel pack on their chest before DB & C is a treatment in which patients can play an active role in their care. Participants mentioned that applying the gel pack on their chest was reassuring and it helped them to breathe deeper. One participant said: "cold helped to get ride of the phlegm [...] it is easier to cough". Applying the gel pack on their own chest gave patients an active role in relieving their pain and performing their DB & C exercises which prevents complications that impede recovery. Providing patients a sense of control with respect to strategies they can use for pain management can help them control their pain more effectively (McCaffery & Pasero, 1999). Alp, Kanat, and Yurtkuran (2007) found that a self management program for 50 women with osteoporosis that included strategies for pain management improved their pain perception and quality of life.

Cold therapy can be easily integrated into the care plan in the immediate postoperative period and potentially at home to promote patient confidence with self care and increase their comfort when DB & C. Cold packs or ice cubes in a bag are easily accessible for both nurses within the hospital and patients at home. It is important for

nurses to integrate cold therapy as an additional pain management strategy in order to provide maximum pain relief when DB & C and potentially increase comfort.

The nurse educator can play a role in helping nurses to integrate cold therapy into their postoperative care regimens. She can gather the proper literature and teach nurses how and when to apply cold therapy in their practice setting. Textbooks and articles are a good source of information, and many nursing medical-surgical textbooks have guidelines to follow for cold application. The nursing policy and procedures for cold application after orthopedic surgery can be used as a guide for the application of cold after cardiac surgery.

Patient teaching is important to consider when using cold for the first time. Nurses should monitor the initial cold application for any reactions to cold such as cold allergies, frostbite and evidence of vascular effects (McConnell, 1998; Miller, 2004). Cold therapy is contraindicated in patients with cold allergies and vascular disorders such as Raynaud's disease. People living in Northern regions are exposed to cold temperatures thus the participants in this study would have already known if they were allergic to cold. A cold allergy is rare but it is characterised by urticaria, redness, itching and swelling and it is more prevalent in young adults and women (Claudy, 2001). Frostbite is also rare when cold therapy is used properly. There are no studies reporting frostbite with the application of cold for only 20-30 minutes repeated every one to two hours (Knight, 1995) but the application for more than 30 minutes increases the risks of frostbite (McDowell et al., 1994). A skin barrier such as a towel or gauze will help to prevent frostbite. The initial sign of frostbite named frostnip is characterised by pain, itching and blanching of the skin

and it typically occurs in extremities (Arford, 2008; Medline Plus, 2008). Overall, cold therapy remains a safe pain management strategy.

Future Research

Since this was the first study analysing the application of superficial cold therapy with cardiac patients, further studies need to explore the topic. Replication of the study with a balanced sample size for men and women would reinforce the efficacy of cold on sternal wounds for pain management and could facilitate a change in nursing practice. To increase generalizability of study results to women and other types of chest surgery, other studies could be performed with more women and surgeries requiring a sternotomy. For example, the efficacy of cold therapy can be explored in patients having valve surgery with a sternotomy. Cold therapy should be explored on diabetics because when cold is applied for less than 30 minutes with a skin barrier, there are no side effects reported in the literature and neuropathy should not be a concern.

The same study with ice chips in a glove or bag could be performed to see if it is equally effective and acceptable as the gel pack. Ice chips are easily accessible in a hospital and in patients' homes. Many studies on cold therapy have explored ice chips in a bag but none explored it with cardiac surgical patients.

Our study was performed on postoperative day two to ensure consistency in patient mental alertness and to make sure all the participants had their chest tubes removed. However, cold therapy could be applied when patients have their chest tubes in place. Patients are still expected to do DB & C exercises with the chest tubes in place and the chest tubes add to the discomfort. Future studies could also focus on the application of gel packs earlier after surgery such as after awakening from anesthesia. Pain relief

with cold therapy when DB & C could potentially be greater on postoperative day one because pain is generally more intense right after surgery. Patients' self application of cold therapy once discharged home could also be studied in order to identify pain management with cold before DB & C and to explore the acceptability of cold therapy at home.

Summary and Conclusion

The utilisation of cold therapy is an acceptable and effective way to help manage pain associated with DB & C after cardiac surgery. Participants experienced significantly less pain with the application of cold therapy before DB & C. This modality is low cost and low risk and can easily be integrated into nursing practice since cold packs are accessible in most hospitals. With nurses' initial supervision, cold therapy is a safe and effective pain management modality that gives patients an active role in pain management. Overall, cold therapy was well accepted by the participants involved in this study since most preferred DB & C with the application of the gel pack and they would all reapply cold therapy in the future. Nurses can integrate cold therapy as an additional pain management treatment in combination with the current pharmacological pain management protocol.

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