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A comprehensive literature review on hypothermia and early extubation following coronary artery bypass surgery

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ABSTRACT

Purpose: The purpose of this study was to comprehensively review the literature addressing the physiological effects of hypothermia and its association with the appropriate core body temperature for extubation following coronary artery bypass surgery.
Methods: The electronic databases MEDLINE, CINAHL and Web of Science via OVID were used to identify studies for the literature review. Search words used included 'core temperature', 'arrhythmia', 'cardiac', 'cardiac surgery', 'hypothermia', 'extubation', 'temperature', 'rewarming', and 'shivering'.
Results: The literature search yielded 55 articles that met our inclusion criteria. No studies specifically identified the benefit of extubation at 36.5 ° C. Although temperatures varied, arrhythmias resulting from hypothermia were not reported until core body temperature dropped below 33 ° C.
Conclusion: This comprehensive literature review suggests extubation at lower temperatures (between 34 ° C and 36 ° C) may be viable if shivering and other factors known to contribute to myocardial stress can be controlled. These findings offer the possibility of earlier extubation which may promote beneficial health outcomes.

1. Background

Cardiovascular disease remains one of the leading causes of death in Canada despite a 33% decrease in mortality from 2000 to 2009 (Heart & Stroke Foundation, 2012; Statistics Canada, 2012). Research, drug therapy, prevention efforts, and surgeries such as coronary artery bypass grafting (CABG) have all contributed to this decline. CABG surgery is one of the most expensive surgical procedures in North America with heart disease and stroke costing the Canadian economy more than $20.9 billion every year in physician services, hospital costs, lost wages and decreased productivity (Heart & Stroke Foundation, 2012). The Public Health Agency of Canada (2009) reports that 56.7% of these costs are related to hospital and physician care of ischemic heart disease including heart attack. To reduce the rising cost of cardiac operations, researchers have studied early extubation as a means to shorten intensive care unit (ICU) length of stay (LOS) and favorably influence patients' health outcomes. In the process various nursing ICU protocols have been developed to facilitate the expedient tracheal extubation of patients, taking into account hemodynamic status, mediastinal drainage, urine output, patient temperature (rewarming from induced hypothermia), and other factors (Pezawas, Rajek, & Plochl, 2007; Pezawas, Rajek, Skolka, Schneider, & Plochl, 2004).

Hypothermia is commonly used during cardiopulmonary bypass (CPB) on patients undergoing CABG surgery to decrease their metabolic rate. Decreased metabolism reduces oxygen demand by the body and increases tolerance of ischemic episodes (Campos & Paniagua, 2008). However, hypothermia is associated with many physiological effects which increase the risk for post-operative shivering, cardiac morbidity, coagulopathy, post-operative wound infections, and cardiac arrhythmias (Esnaola & Cole, 2011; Nathan & Polis, 1995). The additional stress hypothermia may have on the myocardium following CABG is of specific concern as patients may already have depressed myocardial function secondary to surgical events such as bleeding, hemodilution, and left-shifted oxyhemoglobin dissociation curve (Insler, O'Connor, Leventhal, Nelson, & Starr, 2000). As a result nursing protocols and checklists have been developed for the post-operative care of patients emerging from CABG surgery in a hypothermic state. This includes keeping patients sedated until such time as their temperatures reach normal, (37 ° C) at which point a nurse practitioner can proceed with extubation. While it is generally accepted that extubation should not be performed during shivering or while the patient remains severely hypothermic (32 °C) (Pezawas et al., 2004; Pezawas et al., 2007), the safety implications of extubation just below normothermic temperatures has not been established. The purpose of this study was to comprehensively

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review the literature addressing the potential physiological effects of hypothermia on the myocardium and the association between hypothermia and the timing of extubation following CABG surgery.

2. Methods

The following inclusion criteria that reflected the integrative review purpose were used to obtain articles:

Inclusion criteria
- All English manuscripts (both research and non-research) published between 1992–2012 related to:
  - The effect of hypothermia on the heart and other body systems
  - The use of therapeutic hypothermia or normothermia in cardiac surgery
  - Tracheal extubation following cardiac surgery

Exclusion Criteria
- Non-English publication
- Research not conducted on a human sample

2.1. Search for relevant studies

A thorough literature search was completed using the documented criteria. The electronic databases MEDLINE, CINAHL and Web of Science via OVID were used to identify studies. Search words used included 'core temperature', 'arrhythmia', 'cardiac', 'cardiac surgery', 'hypothermia', 'extubation', 'temperature', 'rewarming', and 'shivering'. Article abstracts were obtained and assessed for relevancy and full text was obtained for articles that met the inclusion criteria. Using the 'matrix method', each of these articles was evaluated using structured abstracting under the headings: journal identification, purpose, number of subjects, subject characteristics, design, sampling, findings and conclusions.

3. Study characteristics

The initial electronic database search produced 236 citations. The abstracts of these manuscripts were reviewed for relevancy based on the inclusion and exclusion criteria (see Flow Diagram). Thirty-six studies were retrieved for full text review. Twelve additional manuscripts were acquired through ancestry search and/or references from original 36 retrieved as relevant to the review. Seven additional articles were obtained via ancestry search. A total of 55 studies met the inclusion criterion focusing on the effect of hypothermia on the heart, core temperature during cardiac surgery, and extubation related to cardiac surgery, and were included in this comprehensive review.

3.1. Study settings

Of the 55 studies, the vast majority were single-site experimental and cohort studies (Cheng et al., 1996; de Souza et al., 2007; Durakovic, Misigoj-Durakovic, Corovic, Cubrilo-Turek, & Turek, 1999; Emslie-Smith, Sladden, & Stirling, 1959; Fleming & Muir, 1956; Frank et al., 1997; Hicks, McCord, & Blount, 1956; Insler et al., 2000; Janke, Pilkington, & Smith, 1996; Mowery, Morris, Jenkins, Ozdas, & Norris, 2011; Nathan & Polis, 1995; Okada, 1984; Ovrum, Tangen, Schiott, & Dragsund, 2000; Pezawas et al., 2004; Pezawas et al., 2007; Phillips, 1997; Ranucci, Bellucci, Conti, Cazzaniga, & Maugeri, 2007; Spaniol, Bond, Brengelmann, Savage, & Pozos, 1994; Storm et al., 2011; Tiainen et al., 2009; Vassallo, Delaney, Hoffman, Slater, & Goldfrank, 1999; Waibel et al., 2009; Wong et al., 1999), one included 8 sites (Graham, McNaughton, & Wyatt, 2001), another included 27 sites (Hannan et al., 2010), and one multisite study including 100 sites (Karalapillai et al., 2011). The remaining manuscripts were either review articles (Aslam, Aslam, Vasavada, & Khan, 2006; Campos & Paniagua, 2008; Creswell et al., 2005; Danzl & Pozos, 1994; Davis, 2012; De Witte & Sessler, 2002; Esnaola & Cole, 2011; Gardner & Glauser, 2009; Gussak, Bjerregaard, Egan, & Chaitman, 1995; Hermann, Weingart, Decker, Gallagher, & Stewart, 2003; Insler & Sessler, 2006; Kelly & Nolan, 2010; Kupchik, 2009; Lee-Chiong & Stitt, 1996; Leslie & Sessler, 1998; Osguthorpe, 1993; Pande, Nader, Donias, D'Ancona, & Karamanoukian, 2003; Polderman, 2009; Polderman & Herold, 2009; Slovis & Jenkins, 2002; Weinberg, 1993; Wittmers, 2001; Wong, 1983) or case studies (Barto, 2010; Khan, Prasad, & Glancy, 2010; Mattu, Brady, & Perron, 2002; Nolan & Soar, 2005; Trevino, Razi, & Beller, 1971). Nine studies were conducted in the United States of America (Frank et al., 1997; Hannan et al., 2010; Hicks et al., 1956; Insler et al., 2000; Mowery et al., 2011; Phillips, 1997; Spaniol et al., 1994; Vassallo et al., 1999; Waibel et al., 2009), four in the United Kingdom (Fleming & Muir, 1956; Graham et al., 2001; Janke et al., 1996; Rankin & Rae, 1984), and three in Canada (Cheng et al., 1996; Nathan & Polis, 1995; Wong et al., 1999). Two studies were conducted in both Australia (Emslie-Smith et al., 1959; Karalapillai et al., 2011) and Austria (Pezawas et al., 2007, 2004) and single studies were completed in Croatia (Durakovic et al., 1999), Japan (Okada, 1984), Italy (Ranucci et al., 2007), Norway (Ovrum et al., 2000), Finland (Tiainen et al., 2009), Brazil (de Souza et al., 2007), and Germany (Storm et al., 2011).

3.2. Sample sizes

The study by Karalapillai et al. (2011) had the largest sample size which included 43,158 participants. Five studies had between 2294–9482 participants (Hannan et al., 2010; Insler et al., 2000; Ovrum et al., 2000; Ranucci et al., 2007; Waibel et al., 2009), four had between 120–885 participants (Cheng et al., 1996; Frank et al., 1997; Mowery et al., 2011; Wong et al., 1999), and seventeen had less than 100 participants (de Souza et al., 2007; Durakovic et al., 1999; Emslie-Smith et al., 1959; Fleming & Muir, 1956; Graham et al., 2001; Hicks et al., 1956; Janke et al., 1996; Nathan & Polis, 1995; Okada, 1984; Pezawas et al., 2007, 2004; Phillips, 1997; Rankin & Rae, 1984; Spaniol et al., 1994; Storm et al., 2011; Tiainen et al., 2009; Vassallo et al., 1999). The case studies included between 1–6 cases (Barto, 2010; Khan et al., 2010; Mattu et al., 2002; Nolan & Soar, 2005; Trevino et al., 1971).

3.3. Research designs

Of the 55 studies extracted, four used experimental designs specifically randomized controlled trials (RCT) (Cheng et al., 1996; Frank et al., 1997; Janke et al., 1996; Nathan & Polis, 1995). Of the remaining 51 studies, 13 were prospective cohort studies (Durakovic et al., 1999; Emslie-Smith et al., 1959; Fleming & Muir, 1956; Graham et al., 2001; Hicks et al., 1956; Okada, 1984; Ovrum et al., 2000; Pezawas et al., 2004; Pezawas et al., 2007; Storm et al., 2011; Tiainen et al., 2009; Vassallo et al., 1999; Wong et al., 1999) and eight were retrospective cohort studies (de Souza et al., 2007; Hannan et al., 2010; Insler et al., 2000; Karalapillai et al., 2011; Mowery et al., 2011; Rankin & Rae, 1984; Ranucci et al., 2007; Waibel et al., 2009). Two descriptive studies were identified (Phillips, 1997; Spaniol et al., 1994) and five reports were case studies (Barto, 2010; Khan et al., 2010; Mattu et al., 2002; Nolan & Soar, 2005; Trevino et al., 1971). The remaining, and vast majority of the studies retrieved were review articles (Aslam et al., 2006; Campos & Paniagua, 2008; Creswell et al., 2005; Danzl & Pozos, 1994; Davis, 2012; De Witte & Sessler, 2002; Esnaola & Cole, 2011; Gardner & Glauser, 2009; Gussak et al., 1995; Hermann et al., 2003; Insler & Sessler, 2006; Kelly & Nolan, 2010; Kupchik, 2009; Lee-Chiong & Stitt, 1996; Leslie & Sessler, 1998; Osguthorpe, 1993; Pande et al., 2003; Polderman, 2009; Polderman & Herold, 2009; Slovis & Jenkins, 2002; Weinberg, 1993; Wittmers, 2001; Wong, 1983).