What is the value of topical cooling as an adjunct to myocardial protection?

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Abstract

A best evidence topic in cardiac surgery was written according to a structured protocol. The question addressed was ‘What is the value of topical cooling as an adjunct to myocardial protection?’ Using the reported search, 9 papers represented the best evidence to answer the clinical question. The authors, journal, date and country of publication, patient group studied, study type, relevant outcomes and results of these papers are tabulated. The studies included four randomized controlled trials (RCTs). Two RCTs demonstrated no cardioprotective effects of topical hypothermia as they found no statistically significant differences in myocardial markers between patients with or without topical cooling. In a randomized study of 249 patients undergoing elective cardiac surgery, phrenic nerve injury and failure of extubation occurred more frequently with the use of topical hypothermia with iced slush (P = 0.009 and P = 0.034, respectively). One retrospective analysis found that patients who received iced topical hypothermia had longer postoperative hospitalization, higher incidence of atelectasis and higher left diaphragms on chest X-ray. Another study showed increased morbidity and mortality associated with postoperative diaphragmatic dysfunction resulting from the use of iced slush topical cooling of the heart. We conclude that topical cooling is an unnecessary adjunct to myocardial protection in patients undergoing cardiac surgery. There is no evidence of any additional cardioprotective benefit. Several studies showed that the use of topical hypothermia is associated with phrenic nerve injury, leading to diaphragmatic paralysis and increased pulmonary complications. Moreover, long-term follow-up data showed often incomplete regression of the phrenic nerve paralysis. However, few randomized studies exist on the value of topical cooling as an adjunct to myocardial protection.

Keywords: Review • Topical cooling • Myocardial protection • Coronary artery bypass surgery

INTRODUCTION

A best evidence topic was constructed according to a structured protocol. This is fully described in the ICVTS [1].

THREE-PART QUESTION

In [patients undergoing cardiac surgery] is [topical cooling] a valuable adjunct to [myocardial protection]?

CLINICAL SCENARIO

You are assisting your consultant in an aortic valve replacement operation for a 63-year old male patient with severe aortic valve stenosis. You noted that the consultant used topical cooling in addition to antegrade cardioplegia for myocardial protection. You are confused as other consultants in the department do not use the technique of topical hypothermia. You decided to do a search on the subject to address whether topical cooling is a necessary adjunct to myocardial protection in patients undergoing cardiac surgery.

SEARCH STRATEGY

A search was done in Medline from 1950 to January 2014 using the PubMed interface (topical hypothermia) OR ice-slush) OR topical cooling) OR topical cardiac hypothermia) AND thoracic surgery [MeSH Terms].

SEARCH OUTCOME

A total of 117 papers were found using the reported search. From these, nine papers provided the best evidence to answer the question. These are presented in Table 1.

RESULTS

Braathen et al. [2] performed a randomized controlled trial of 60 patients undergoing aortic valve replacement (AVR). The primary aim of the study was to evaluate the effect of ice slush on acknowledged markers (CK-MB, troponin-T) of myocardial damage during AVR. Thirty patients were randomized to achieve additional topical cooling with ice slush in addition to cold crystalloid
### Table 1: Best evidence papers

<table>
<thead>
<tr>
<th>Author, date, journal and country</th>
<th>Study type (level of evidence)</th>
<th>Patient group</th>
<th>Outcomes</th>
<th>Key results</th>
<th>Comments</th>
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<tr>
<td>Braathen et al. (2006), Scand Cardiovasc J, Norway [2]</td>
<td>Randomized controlled trial (level 1b)</td>
<td>60 patients undergoing AVR received cold crystalloid antegrade cardioplegia every 20 min. 30 patients were randomized to achieve additional topical cooling with ice slush</td>
<td>CK-MB and troponin-T</td>
<td>No significant differences in myocardial markers between patients with or without ice slush</td>
<td>This study showed that topical cooling with ice slush does not provide additional cardioprotective effects</td>
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<tr>
<td>Baur et al. (1986), Ann Thorac Surg, USA [3]</td>
<td>Randomized controlled trial (level 1b)</td>
<td>100 patients undergoing CABG were randomized to 2 different myocardial preservation techniques</td>
<td>Perioperative myocardial necrosis during coronary artery bypass surgery</td>
<td>Myocardial creatine kinase release was 193 ± 33 IU/l × h in Group 1 patients operated on with cardioplegia and 210 ± 31 IU/l × h in Group 2 patients operated on with topical hypothermia (P &lt; 0.5)</td>
<td>This randomized trial showed that addition of cardioplegia to topical hypothermia does not improve myocardial protection over topical hypothermia with local interruption of the coronary circulation during coronary artery bypass surgery</td>
</tr>
<tr>
<td>Efthimiou et al. (1992), QJM, UK [4]</td>
<td>Randomized controlled trial (level 1b)</td>
<td>In a prospective study, 100 patients undergoing open heart surgery were randomly allocated to receive ice-slush topical hypothermia for myocardial protection (Group I, n = 56) or not (Group II, n = 44). Chest radiographs, diaphragm screening, lung function and phrenic nerve conduction time were assessed preoperatively and at 1 week and 1 month postoperatively in all patients and subsequently at 3 months, 6 months, 1 year and 2 years in all patients with radiological evidence of diaphragm paralysis</td>
<td>Chest radiographs, diaphragm screening, lung function and phrenic nerve conduction time</td>
<td>Myocardial creatine kinase peaks were 9.2 ± 1.9 IU/l and 10.0 ± 1.6 IU/l, respectively (P &gt; 0.5)</td>
<td>This study showed that use of ice-slush topical hypothermia during open heart surgery is associated with a high incidence of diaphragm paralysis due to phrenic nerve injury</td>
</tr>
<tr>
<td>Cassese et al. (2006), J Card Surg, Italy [5]</td>
<td>Randomised controlled trial (level 1b)</td>
<td>249 patients undergoing elective cardiac surgery were randomized to receive either ‘shallow technique’ (ST) (dripping and prompt removal of cold saline solution from the epicardial surface) plus normothermic cardiopulmonary bypass (Group A), or mild hypothermic cardiopulmonary bypass plus iced slush (Group B)</td>
<td>Postoperative phrenic nerve injury</td>
<td>Phrenic nerve injury and failure of extubation occurred more frequently in Group B (P = 0.009 and P = 0.034, respectively)</td>
<td>This study showed that the shallow technique of myocardial protection likely reduces the incidence of postoperative phrenic nerve injury</td>
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<tr>
<td>Maccherini et al. (2005), J Card Surg, Italy [6]</td>
<td>Case study (level 3)</td>
<td>Postoperative chest X-rays of 50 patients undergoing elective coronary artery bypass with normothermic CPB were compared with postoperative chest X-rays of 50 patients operated upon with hypothermia</td>
<td>X-ray changes post-CABG</td>
<td>In the cold group, transitory diaphragmatic paralysis, as well as pleural effusions and thoracentesis related to the hypothermia, and topical cooling were statistically increased compared with the warm group</td>
<td>This study demonstrated that topical cooling with ice slush is responsible for phrenic nerve injury and that warm heart surgery has no associated incidence of diaphragmatic injury</td>
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<td>Diehl et al. (1994), J Thorac Cardiovasc Surg, France [7]</td>
<td>Case study (level 3)</td>
<td>13 consecutive patients over a 2-year period with unexplained and prolonged difficulties in weaning from mechanical ventilation following cardiac surgery were evaluated</td>
<td>Diaphragmatic function was evaluated at the bedside from oesophageal and gastric pressure measurements</td>
<td>Diaphragm dysfunction was found in all 13 patients (mean $-0.39 \pm 0.64$). The difference between the 13 patients and all control groups was found to be highly significant. In 1 of 2 patients evaluated a second time, about 5 weeks later, a marked improvement was observed</td>
<td>Prolonged postoperative diaphragmatic dysfunction may cause severe life-threatening complications after cardiac operation and can be limited to some extent by avoiding the use of iced slush topical cooling of the heart</td>
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<td>Brodaty et al. (1981), Nouv Presse Med, France [8]</td>
<td>Case series (level 3)</td>
<td>750 patients undergoing open heart surgery with topical cooling</td>
<td>Long-term follow-up of cold-induced paralysis of the phrenic nerve</td>
<td>50 cases (6.6%) of phrenic nerve paralysis were observed</td>
<td>Infectious and respiratory complications (including atelectasis, bronchial obstruction, pleural effusion, pneumonia and bacteremia) were significantly more frequent ($P &lt; 0.05$) in these patients</td>
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<tr>
<td>Nikas et al. (1998), Ann Thorac Surg, USA [9]</td>
<td>Case study (level 3)</td>
<td>505 consecutive patients undergoing coronary artery bypass grafting</td>
<td>Postoperative morbidity and mortality</td>
<td>Postoperative cardiac morbidity, manifested as intra-aortic balloon use, low cardiac output, inotrope use and perioperative myocardial infarction, was decreased in Group B (Group A, 3.14%; Group B, 3.82%)</td>
<td>Topical hypothermia did not offer any additional cardioprotective benefit over systemic hypothermia and cold blood cardioplegia alone in coronary bypass patients, but significantly increased the incidence of diaphragmatic paralysis and</td>
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Antegrade cardioplegia. Authors concluded that topical cooling with ice slush does not provide additional cardioprotective effects as they found no statistically significant differences in myocardial markers between patients with or without ice slush.

Baur et al. [3] studied the effect of two different myocardial preservation techniques on perioperative myocardial necrosis in a randomized study of 100 patients undergoing CABG. Topical hypothermia with cold potassium cardioplegia was used in 50 patients (Group 1), and topical hypothermia with local interruption of the coronary circulation was used in the other 50 patients (Group 2). Myocardial creatine kinase was measured every 6 h for 36 h after surgery. Myocardial creatine kinase release was 193 ± 33 IU/l × h in Group 1 patients operated on with cardioplegia and 210 ± 31 IU/l × h in Group 2 patients operated on with topical hypothermia (P > 0.5). In addition, they demonstrated that myocardial creatine kinase peaks did not differ significantly between the two groups.

Efthimiou et al. [4] randomized 100 patients undergoing open heart surgery to receive ice slush topical hypothermia for myocardial protection (Group I, n = 56) or not (Group II, n = 44). Radiological evidence of partial left lower lobe collapse was more frequent in Group I (79 vs 36%, P < 0.01). Twenty (36%) Group I patients developed unilateral diaphragm paralysis compared with none in Group II. Diaphragm paralysis was still present in 19 patients (34%) at 1 month and in 5 patients (9%) at 1 year postoperatively.

Phrenic nerve conduction time was recorded in 98% of patients preoperatively, but was unrecordable on the appropriate side in all 20 patients with diaphragm paralysis 1 week postoperatively. Prolonged phrenic nerve conduction time on the left side was found in a further 7 Group I patients 1 week postoperatively.

In a randomized study of 249 patients undergoing elective cardiac surgery, Cassese et al. [5] compared two different strategies for myocardial protection: the ‘shallow technique’ (ST) (dripping and prompt removal of cold saline solution from the epicardial surface) plus normothermic cardiopulmonary bypass (Group A), versus mild hypothermic cardiopulmonary bypass plus iced slush (Group B). They found that phrenic nerve injury and failure of extubation occurred more frequently with the use of iced slush (P = 0.009 and P = 0.034, respectively). Abnormal diaphragmatic movement was persistent at 6 months only in 30% of Group B patients who suffered from this complication in the early postoperative period.

Similar findings were observed by Maccherini et al. [6] who compared postoperative chest X-rays of 50 patients who underwent elective coronary artery bypass with normothermic CPB with postoperative chest X-rays of 50 patients operated upon with hypothermia. In the cold group, transitory diaphragmatic paralysis, as well as pleural effusions and thoracentesis related to the hypothermia, and topical cooling were statistically increased compared with the warm group.
Diehl et al. [7] evaluated 13 consecutive patients over a 2-year period with unexplained and prolonged difficulties in weaning from mechanical ventilation and studied the correlation between respiratory complications and use of topical hypothermia. Authors reported a clinically relevant diaphragmatic dysfunction in 0.5% of patients when no topical cooling was used and 2.1% when iced saline with no insulation pad was added for myocardial protection (P <0.005). The clinical course of the 13 patients was marked by severe intercurrent events, including cardiorespiratory arrest after early tracheal extubation in 5 patients, nosocomial pneumonia in 11, prolonged mechanical ventilation in all (58 ± 41 days) and a fatal outcome in 3. Authors showed that prolonged postoperative diaphragmatic dysfunction may cause severe life-threatening complications after cardiac operation and can be limited to some extent by avoiding the use of iced slush topical cooling of the heart.

Brodaty et al. [8] studied the long-term course of cold-induced phrenic nerve injury in a series of 750 patients undergoing open heart surgery with topical cooling. Fifty cases (6.6%) of phrenic nerve paralysis were observed. These patients had significantly increased incidence of infectious and respiratory complications including atelectasis, bronchial obstruction, pleural effusion, pneumonia and prolonged assisted ventilation and intensive care stay. Moreover, long-term follow-up of 42 patients (mean: 14 months; range: 3–42 months) showed often incomplete regression of the phrenic nerve paralysis.

The lack of additional myocardial protection and increased risk of respiratory complications were also observed by Nikas et al. [9] who divided a group of 505 consecutive CABG patients into two separate groups. Group A included 191 patients who received topical and systemic hypothermia with iced flush in addition to cold blood cardioplegia. Group B included 314 patients who received systemic hypothermia and intermittent cold blood cardioplegia but no topical hypothermia. No significant differences were noticed regarding cardiac morbidity or mortality but greater incidence of diaphragmatic paralysis was noted in group A, which in turn increased pulmonary complications.

Allen et al. [10] performed a retrospective analysis involving 150 patients undergoing CABG and divided them into three groups each of 50 patients, where all patients received multidose cold blood cardioplegia followed by warm blood cardioplegic reperfusion through the grafts. The first group received iced flush. The second group received topical 4 degrees saline, while the last group received no topical cooling. It was found that patients who received iced topical hypothermia had longer postoperative hospitalization, higher incidence of atelectasis and higher left diaphragmatic paralysis. However, patients who received cold saline had more incidence of atelectasis. Supplemental topical cooling does not improve postoperative haemodynamics neither does it reduce inotropic requirements, enzyme release or risk of myocardial infarction.

**CLINICAL BOTTOM LINE**

Topical cooling is an unnecessary adjunct to myocardial protection in patients undergoing cardiac surgery. No additional cardioprotective benefit has so far been shown. Several studies demonstrated that the use of topical hypothermia is associated with increased diaphragmatic paralysis and pulmonary complications. Ice slush topical hypothermia during open heart surgery is associated with a high incidence of phrenic nerve cold injury. Moreover, long-term follow-up data showed often incomplete regression of the phrenic nerve paralysis. However, few randomized studies exist on the value of topical cooling as an adjunct to myocardial protection.

**Conflict of interest:** none declared.

**REFERENCES**