Does moderate hypothermia really carry less bleeding risk than deep hypothermia for circulatory arrest? A propensity-matched comparison in hemiarch replacement

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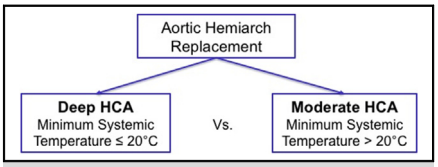
ABSTRACT

Background: Moderate (MHCA) versus deep (DHCA) hypothermia for circulatory arrest in aortic arch surgery has been purported to reduce coagulopathy and bleeding complications, although there are limited data supporting this claim. This study aimed to compare bleeding-related events after aortic hemiarch replacement with MHCA versus DHCA.

Methods: Patients who underwent hemiarch replacement at a single institution from July 2005 to August 2014 were stratified into DHCA and MHCA groups (minimum systemic temperature $\leq 20°C$ and $>20°C$, respectively) and compared. Then, 1:1 propensity matching was performed to adjust for baseline differences.

Results: During the study period, 571 patients underwent hemiarch replacement: 401 (70.2%) with DHCA and 170 (29.8%) with MHCA. After propensity matching, 155 patients remained in each group. There were no significant differences between matched groups with regard to the proportion transfused with red blood cells, plasma, platelet concentrates, or cryoprecipitate on the operative day, the rate of reoperation for bleeding, or postoperative hematologic laboratory values. Among patients who received plasma, the median transfusion volume was statistically greater in the DHCA group (6 vs 5 units, $P = .01$). MHCA also resulted in a slight reduction in median volume of blood returned via cell saver (500 vs 472 mL, $P < .01$) and 12-hour postoperative chest tube output (440 vs 350, $P < .01$). Thirty-day mortality and morbidity did not differ significantly between groups.

Conclusions: MHCA compared with DHCA during hermiarch replacement may slightly reduce perioperative blood-loss and plasma transfusion requirement, although these differences do not translate into reduced reoperation for bleeding or postoperative mortality and morbidity. (J Thorac Cardiovasc Surg 2016;■:1-11)



Comparing the effect of deep versus moderate hypothermic circulatory arrest on bleeding.

Central Message

Moderate hypothermic circulatory arrest compared with deep hypothermic circulatory arrest may slightly reduce perioperative blood-loss and plasma transfusion requirement, although transfusion of other products was similar.

Perspective

In this single-institution propensity matched analysis, moderate compared with deep hypothermia for circulatory arrest in hemiarch replacement led to slightly reduced perioperative blood-loss and plasma transfusion requirement. These differences did not translate into reduced transfusion of other blood products or differences in 30-day postoperative morbidity and mortality.

ACQ

The induction of hypothermia before circulatory arrest during aortic arch reconstruction has been used effectively as an organ-protection strategy for more than 4 decades[1]; however, the optimal degree of hypothermia at which adequate organ protection is achieved and hypothermia-associated complications are minimized remains uncertain and a topic of intense debate.[2] Because the nervous system is highly susceptible to injury with only brief periods of hypoxia, achieving adequate cerebral protection traditionally has been the driving concern during these procedures. Proponents of relatively deeper degrees of hypothermia have advocated that optimal cerebral

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Abbreviations and Acronyms

ASA = American Society of Anesthesiologists
CPB = cardiopulmonary bypass
DHCA = deep hypothermic circulatory arrest
DUMC = Duke University Medical Center
HCA = hypothermic circulatory arrest
IQR = interquartile range
MHCA = moderate hypothermic circulatory arrest
PRBC = packed red blood cells
rFVIIa = recombinant activated factor VII

protection occurs with maximal suppression of cerebral metabolic activity or temperatures sufficient to produce electrocerebral inactivity on electroencephalography,[3-9] usually 16°C or less.[10,11] With the introduction of adjunctive regional cerebral perfusion strategies that provide continued perfusion and cooling of the brain after the initiation of systemic circulatory arrest,[12,13] however, it is unclear whether cooling to the deep degrees of hypothermia required to reach electrocerebral inactivity is necessary. Indeed, advocates of more moderate degrees of hypothermic circulatory arrest (HCA) coupled with adjunctive cerebral perfusion have asserted that this approach provides comparable cerebral and visceral protection while potentially mitigating complications associated with deeper degrees of hypothermia.[14-21]

Coagulopathic bleeding is a common problem in surgery of the aortic arch with HCA and arises from a number of factors, including coagulation factor consumption caused by prolonged periods of cardiopulmonary bypass (CPB) support and hypothermia-related platelet dysfunction.[22] Theoretically, deeper degrees of hypothermia may increase the severity of hypothermia-related coagulopathy and place the patient at risk for increased bleeding and blood product transfusion, which are known to lead to worse outcomes after cardiothoracic surgery.[23-26] Currently, there is limited empirical evidence to support this claim. In this study, we sought to determine whether moderate hypothermic circulatory arrest (MHCA) compared with deep hypothermic circulatory arrest (DHCA) reduced the risk of bleeding and blood product transfusion in patients undergoing hemiarch replacement with circulatory arrest.

METHODS

Patient Selection

This retrospective cohort study was approved by the Duke University Medical Center (DUMC) institutional review board, which waived the need for individual patient consent. The study included all patients who underwent replacement of the aortic root or supracoronary ascending aorta (with or without aortic valve replacement) with concomitant hemiarch replacement using HCA at DUMC from July 2005 to August 2014. Patient and procedural characteristics as well as clinical outcomes data were obtained from the prospectively maintained Duke Thoracic Aortic Surgery institutional database. The Society of Thoracic Surgeons definitions were used to define patient comorbidities and postoperative outcomes.[27] Transfusion data were obtained from a prospectively maintained registry of the DUMC Blood Bank and Transfusion Service. Laboratory values, chest tube output, and intraoperative autologous blood transfusion volumes were determined through additional review of the medical record.

Conduct of Procedures

Anesthetic and surgical techniques for aortic hemiarch replacement at our institution have been described previously.[5,9,10,28,29] Before July 2013, our institution predominately employed a practice of DHCA as described previously[5]; however, beginning in July 2013, our institution transitioned to a practice of MHCA with selective antegrade cerebral perfusion in these procedures, in which circulatory arrest was initiated after cooling to a temperature of no greater than 28°C.[29] The rationale behind this change in practice was based on the good outcomes reported by a number of centers that used an MCHA approach[14-18] and the perceived potential to limit complications putatively associated with deeper degrees of hypothermia.

Transfusion Practices

Aspects of our institutional transfusion practices during aortic surgery have been published previously.[22,30] Driven by societal perioperative transfusion guidelines,[24,31] our approach to transfusion during aortic reconstruction with HCA has evolved into an algorithm, formally implemented in 2010, to allow for rapid and balanced blood product resuscitation during coagulopathic bleeding frequently encountered in these cases (Figure E1). Antifibrinolytic therapy with epsilon-aminocaproic acid is administered as a 5-g loading dose followed by a 1-g/h infusion and a cell saver (BRAT II blood cell salvage machine; Cobe Cardiovascular Inc, Arvada, Colo) is used for every case. Before separation from CPB, upon rewarming and reperfusion, the bypass reservoir is primed with 4 units of plasma with concomitant hemofiltration to ameliorate coagulation factor dilution, and a set of laboratory tests is obtained to help guide management. Protamine sulfate is then administered at a dose of 1 mg/100 units of initial heparin dosing, followed by additional 25- to 50-mg doses until activated clotting time is normalized or plateaus.

At the time of separation from CPB, a 0.3 μg/kg dose of desmopressin acetate is administered for platelet dysfunction and antifibrinolytic therapy with epsilon-aminocaproic acid is redosed as a 5-g bolus with continuation of the 1-g/h infusion until bleeding is minimal. If hemostasis is not immediately achieved, 1 unit of allogeneic, single-donor apheresis platelets is transfused followed by a second unit if bleeding persists. At this point, laboratory values are rechecked and if bleeding persists, an additional unit of platelets and 2 units of plasma are administered. In accordance with returning laboratory results, a unit of pooled (10 donor) cryoprecipitate (if fibrinogen level <200 mg/dL), platelets, and/or 2 plasma units are then transfused. If bleeding continues, recombinant activated factor VII (rFVIIa; 1-2 mg) is administered.[30] If hemostasis is still not obtained, packed red blood cells (PRBCs) and plasma are administered at a 1:1 ratio with additional cryoprecipate, platelets, and hemostatic adjuncts administered at the clinical discretion of the attending physicians. With regard to red blood cell transfusion, serial hematocrits are drawn before and after separation from CPB. The return of washed, shed red blood cells (BRAT II blood cell salvage machine; Cobe Cardiovascular Inc) to the patient is used in all cases and additional red blood cell transfusion is avoided if the hematocrit is greater than 0.20.

Analysis

To assess the impact of the degree of hypothermia on bleeding and transfusion requirement, the cohort was stratified into DHCA and MHCA groups based on whether the minimum systemic temperature (measured in the urinary bladder) was ≤20°C or >20°C, respectively. Although a