Hypothermic Circulatory Arrest and Retrograde Cerebral Perfusion for Aortic Surgery at Siriraj Hospital : A Preliminary Review of Anesthetic Management

VORAPA SUWANCHINDA, M.D.*,
SIRILAK SUKSOMPONG, M.D.*,
UNGKAB PRAKANRATTANA, M.D.*,
SUNEERAT KONGSAYREEPONG, M.D.*

Abstract

Objective : To evaluate the anesthetic management in patients undergoing aortic surgery under hypothemic circulatory arrest and retrograde cerebral perfusion; with particular emphasis on intraoperative brain protection, blood salvage and postoperative outcomes.

Material and method : Retrospective case series. Data on medical conditions, anesthesia, surgery and postoperative care from patients who underwent operation between June 1993 and December 1999 were analyzed.

Results : There were 53 patients involved in this study. They all received general balanced anesthesia; 70.6 per cent had single-lumen endotracheal intubation, while the remaining required double-lumen endotracheal intubation. The duration of the anesthetic procedure, aortic cross-clamping and circulatory arrest, were 365.58 ± 89.21, 126.35 ± 34.64 and 48.35 ± 19.47 min respectively. The lowest nasopharyngeal and rectal temperature were 17.42 ± 1.40°C and 21.26 ± 2.80°C respectively. Thiopental 804.68 ± 353.93 mg and dexamethasone 14.41 ± 7.88 mg were administered for brain protection, in addition to retrograde cerebral perfusion; 82.35 per cent received 785.71 ± 273.86 mg of tranexamic acid and only 23.52 per cent received aprotinin in order to reduce blood loss. However, massive blood replacement therapy was always necessary. In the postoperative period, the patients were ventilated for 39.18 ± 59.53 h, the length of hospital stay was 14.58 ± 5.83 d, and the mortality was 13.2 per cent.

Conclusion : This preliminary data indicate that hypothermic circulatory arrest in aortic surgery is associated with a high mortality rate, despite attempts to provide adequate cerebral protection as well as intraoperative blood salvage.

Key word : Anesthetic Management, Aortic Surgery, Hypothermia Circulatory Arrest, Retrograde Cerebral Perfusion

SUWANCHINDA V, PRAKANRATTANA U, SUKSOMPONG S, KONGSAYREEPONG S
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* Department of Anesthesiology, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok 10700, Thailand.

Thoracic aortic surgery involving the aortic arch remains a high risk procedure, requiring careful consideration with regard to anesthetic management as well as surgical planning. A major problem of this surgery is neurological damage, resulting from interruption of blood flow to the brain. Several techniques have been used to prevent ischemic injury to the brain. These include hypothermic circulatory arrest[1], selective cannulation and perfusion of cerebral vessels[2], retrograde cerebral perfusion[3] and pharmacological brain protection[4,5]. A combination of these techniques has been utilized at Siriraj Hospital since 1993 in an effort to diminish the adverse effects of ischemic brain injury in these patients. Despite improvements in technology and materials, the frequency of neurological and respiratory complications and postoperative bleeding is still significant and may lead to increased mortality.

The aim of this study was to evaluate the anesthetic management in patients who underwent aortic surgery at Siriraj Hospital, using the technique of hypothermic circulatory arrest and retrograde cerebral perfusion with regard to cerebral protection, blood salvage and postoperative outcomes.

MATERIAL AND METHOD

The records of all patients, undergoing aortic surgery with hypothermic circulatory arrest and retrograde cerebral perfusion at Siriraj Hospital from June 1993 to December 1999 were reviewed. There were fifty-three patients who had a dissection or aneurysm involving the ascending or descending aorta with extension to the aortic arch, or a combination of all types. The general demographic data together with perioperative and postoperative data of these patients were collected. All data were analyzed and presented as mean ± standard deviation (SD).

RESULTS

Demographic and preoperative data are shown in Table 1. The majority of patients was male (32/53) with the average age of 63.47 ± 11.59 years (range 31-78 years). Sixty-five per cent of patients were in Class III according to the American Society of Anesthesiologists (ASA) classification. General balanced anesthesia was provided in all patients with simultaneously controlled ventilation. A single-lumen endotracheal tube was inserted in 70.6 per cent of the cases; the remaining required double-lumen endotracheal intubation, because the distal arch or descending thoracic aorta was approached in the lateral decubitus position. Hemodynamic parameters, and temperature changes were recorded continuously; while the arterial blood gas, activated clotting time, blood sugar and electrolytes were measured intermittently.

Table 1. Demographic and preoperative data.

No patients	53
Age (y)	63.47 ± 11.59
Weight (kg)	56.82 ± 7.78
Gender, male/female	32/21
ASA classification (%)	
ASA II	6
ASA III	65
ASA IV	17
ASA V	12
Endotracheal tube (%)	
Single-lumen	70.6
Double-lumen	29.4

Data are presented as mean ± SD unless otherwise indicated.
ASA = American Society of Anesthesiologists.

Table 2. Intraoperative data.

Time (min)	
Anesthesia	365.58 ± 89.21
CPB	172.82 ± 46.48
Circulatory arrest	48.35 ± 19.47
Lowest temperature (°C)	
Nasopharynx	17.42 ± 1.40
Rectum	21.26 ± 2.86
Brain protection	
Retrograde cerebral perfusion (ml/min)	300-500
Dexamethasone (mg)	4.41 ± 7.88
Thiopental (mg)	804.68 ± 353.93
Antifibrinolytic agent	
Tranexamic acid (mg)	785.71 ± 273.86
Aprotinin (ml)	100-200

Data are expressed as mean ± SD or range.
CPB = cardiopulmonary bypass.

Table 2 shows the intraoperative data. The duration of anesthetic time was 365.58 ± 89.21 min, which included 172.82 ± 46.48 min of cardiopulmonary bypass (CPB), requiring large temperature changes to achieve profound hypothermia, and also rewarming after the vascular repair was accomplished. Circulatory arrest was provided for 48.35 ± 19.47 min (range 20-95 min) at the lowest nasopharyngeal and rectal temperature of 17.42 ± 1.40 and 21.26 ± 2.80°C respectively; while cerebral blood flow was maintained with retrograde intra-

venous perfusion after the aortic arch was opened. Dexamethasone 14.41 ± 7.88 mg and thiopental 804.68 ± 353.93 mg were administered intravenously at the start of the operation for the purpose of brain protection. Intraoperative blood salvage was performed by giving tranexamic acid 785.71 ± 273.86 mg in 82.35 per cent of patients, whereas the other 23.52 per cent received 100-200 ml of aprotinin. However, the transfusion of several units of blood and blood products was also necessary.

During the postoperative period, the patients required ventilatory support for an average of 39.18 ± 59.53 h (range 11 h – 9 d), and the average length of hospital stay was 14.58 ± 5.83 d (Table 3). The mortality in this study was 13.2 per cent. The most common complication was postoperative bleeding, which occurred in 18.9 per cent and eventually needed re-exploration, 1.9 per cent of patients suffered paraplegia and a similar percentage suffered hemiplegia.

Table 3. Postoperative data.

Ventilatory support (h)	39.18 ± 59.53
Hospital stay (d)	14.58 ± 5.83
Complication	%
Bleeding	18.9
Hemiplegia	1.9
Paraplegia	1.9
Mortality	13.2

Data are mean ± SD or n (%).

DISCUSSION

Since Ueda, et al.[3] described the surgical treatment of aneurysm or dissection involving the ascending aorta and aortic arch, the method of retrograde cerebral perfusion under profound hypothermic circulatory arrest has been successfully performed in many centers. Despite an improvement in surgical technique, this procedure appears to be relatively rare. Therefore, only 53 patients were involved in this study over a period of more than 6 years. Not only does the increasing life expectancy of Thai population contribute to an increase in the number of patients with more advanced aortic pathology, but also advances in preoperative assessment and optimizing hemodynamic status substantially increase the number of patients undergoing aortic surgery.

The results of this study indicate that the surgery consumed a considerable length of anesthetic time. The majority of the anesthetic time was spent preparing for CPB to induce deep hypothermia until a temperature below 20°C was achieved and to establish rewarming to 37°C after cessation of circulatory arrest. Sodium nitroprusside and/or nitroglycerin were commonly administered to produce vasodilatation during cooling and rewarming. Several studies have shown that the use of sodium nitroprusside leads to an increased incidence of neurological injury in patients undergoing thoracic aortic surgery[6-8]. Vasodilatation of the cerebral vasculature from sodium nitroprusside increases cerebrospinal fluid pressure, decreases spinal cord perfusion pressure, and increases the incidence of ischemia. Although neurological damage may result from inadequate perfusion during cooling and rewarming, the most important factor in avoiding neurological complications is the length of circulatory arrest. The occurrence of neurological deficit in this study are comparable with others[9-13], although the circulatory arrest time was quite prolonged with a maximum of 95 min. Continuous retrograde cerebral perfusion used in the study, when combined with deep hypothermia, and steroids and barbiturates, may provide brain protection that reduces the risk of neurological dysfunction. The possible mechanisms by which retrograde cerebral perfusion may enhance cerebral protection during circulatory arrest include the maintenance of low cerebral temperature; the continuous delivery of oxygen and substrate to the brain; and a decreased risk of embolization[14].

Excessive bleeding and coagulopathy are the other common causes of death during aortic arch surgery[15]. These results agree with our findings that postoperative bleeding requiring re-exploration was as high as 18.9 per cent. Deep hypothermia and extracorporeal circulation produce a coagulation defect of multifactorial origin; which includes platelet dysfunction, thrombocytopenia, a reduction of coagulation factors; fibrinogen and plasminogen. Both hypothermia and CPB increase fibrinolytic and antithrombin activity. Antifibrinolytic agents such as aprotinin and tranexamic acid were administered before CPB, are significantly associated with a reduction in blood loss[16-18]. The hemostatic effects of aprotinin are more complex than tranexamic acid. When aprotinin is administered during CPB, it inhibits the contact activation of the intrinsic coagulation pathway that results from exposure of blood

to the CPB circuit. Aprotinin blunts the inflammatory response and reperfusion injury related to CPB and deep hypothermia circulatory arrest[19]. Platelet function is preserved through the prevention of plasmin-mediated platelet inhibition and the protection of platelet surface glycoprotein receptors. However, aprotinin may also predispose to thrombosis and paradoxically increase bleeding[20]. Not only being aware of these serious complications, but also because of the limitation of cost, aprotinin was not commonly used in our patients. Therefore, tranexamic acid was usually given whenever the massive bleeding was expected.

In conclusion, this study showed that hypothermic circulatory arrest in aortic surgery is associated with a high mortality rate. Improvement in cerebral protection and blood salvage techniques, together with increased experience of the medical teams should minimize the incidence of postoperative complications.

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การผ่าตัด aorta ด้วยเทคนิค hypothermic circulatory arrest และ retrograde cerebral perfusion ที่โรงพยาบาลศิริราช : ศึกษาการให้ยาระงับความรู้สึกในระยะเริ่มแรก

วรภา สุวรรณจินดา, พ.บ., อังกาบ ปราการรัตน์, พ.บ.*, ศิริลักษณ์ สุขสมปอง, พ.บ.*, สุณีรัตน์ คงเสรีพงศ์, พ.บ.**

วัตถุประสงค์ : เพื่อศึกษาการให้ยาระงับความรู้สึกสำหรับการผ่าตัด aorta ด้วยเทคนิค hypothermic circulatory arrest และ retrograde cerebral perfusion โดยศึกษาการปกป้องสมองจากภาวะขาดเลือด ข้อปฏิบัติที่นิยมใช้เพื่อลดการสูญเสียเลือด และการประเมินผลในระยะหลังผ่าตัด

วิธีการศึกษา : ได้ศึกษาข้อมูลย้อนหลังตั้งแต่มิถุนายน พ.ศ. 2536 ถึงธันวาคม พ.ศ. 2542 โดยรวบรวมข้อมูลจากรายงานของผู้ป่วย บันทึกการให้ยาระงับความรู้สึก รายงานการผ่าตัดและการดูแลรักษาในหอผู้ป่วยหนักเมื่อเสร็จสิ้นการผ่าตัด

ผลการศึกษา : มีผู้ป่วยเข้ารับการผ่าตัดชนิดนี้จำนวน 53 ราย ได้รับการบริหารยาสลบแบบ balanced โดยร้อยละ 70.6 ได้รับการช่วยหายใจผ่านท่อหลอดคอชนิด single-lumen ส่วนที่เหลือนั้นใช้ท่อ double-lumen ระยะเวลาที่ใช้สำหรับการระงับความรู้สึก การ cross-clamping aorta และหยุดการไหลเวียนเลือดคือ 365.58 ± 89.21, 126.35 ± 34.64 และ 48.35 ± 19.47 นาทีตามลำดับ อุณหภูมิต่ำสุดขณะหยุดการไหลเวียนเลือดนั้นวัดที่ nasopharynx ได้ 17.42 ± 1.40°ซ และที่ทวารหนัก 21.26 ± 2.80°ซ นอกจากนี้ยังปกป้องสมองขาดเลือดด้วยวิธี retrograde cerebral perfusion ร่วมกับผู้ป่วยได้รับยา thiopental 804.68 ± 353.93 มก. และ dexamethasone 14 41 ± 7.88 มก. สำหรับวิธีที่นิยมใช้เพื่อบรรเทาการเสียเลือดนั้นผู้ป่วยร้อยละ 82.35 ได้รับ tranexamic acid 785.71 ± 273.86 มก. อีกร้อยละ 23.52 ได้รับ aprotinin ภายหลังการผ่าตัดต้องช่วยหายใจผู้ป่วยเป็นเวลานาน 39.18 ± 59.53 ชั่วโมง ระยะเวลาที่ต้องอยู่ในโรงพยาบาลอีก 14.58 ± 5.83 วัน และมีอัตราตายร้อยละ 13.2

สรุป : การบริหารยาระงับความรู้สึกสำหรับผ่าตัด aorta ด้วยเทคนิค hypothermic circulatory arrest และ retrograde cerebral perfusion นั้น ถึงแม้จะใช้มาตรการเพื่อปกป้องสมองจากการขาดเลือด และมีวิธีลดการสูญเสียเลือด ยังต้องระวังภาวะแทรกซ้อนรุนแรงที่ทำให้ผู้ป่วยเสียชีวิตซึ่งพบได้บ่อยมาก

คำสำคัญ : การบริหารยาระงับความรู้สึก, การผ่าตัด aorta, hypothermia circulatory arrest, retrograde cerebral perfusion

วรภา สุวรรณจินดา, อังกาบ ปราการรัตน์, ศิริลักษณ์ สุขสมปอง, สุณีรัตน์ คงเสรีพงศ์
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* ภาควิชาวิสัญญีวิทยา, คณะแพทยศาสตร์ศิริราชพยาบาล, มหาวิทยาลัยมหิดล, กรุงเทพ ฯ 10700