Original Research Article

Cardio-pulmonary bypass for non-cardiac surgeries

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Abstract

Introduction: Cardio pulmonary by pass is an adjunct that is routinely used for cardiac procedures to facilitate an immobile and blood less field and be able to alter the temperature and basal metabolic rate. It was observation study in cases where CPB was offered as an adjunct to surgery. As the procedures for each case varied, so did our approach need modifications for cannulation and conduct of bypass.

Materials and methods: It was observational and retrospective study done from 2015 to 2020 in Department of Cardiothoracic Surgery with records in the hospital data base for the last 5 year.

Results: We found that a total of 20 non cardiac procedures were performed CPB. These included 8 isolated limb perfusions for malignant melanoma, 4 tracheal surgery cases, 3 renal surgeries, 4 mediastinal masses and 1 neurosurgical case. 4 cases of mediastinal masses required CPB because of the proximity of the mass to a major vessel and/heart. To decompress the heart and hence the tumor to provide for a hassle free dissection.

Conclusion: Patient outcomes have been favorable and encouraging with few complications. The different aspects of bypass being an effective cardio pulmonary substitute, the ability to generate varying flow rates, to warn or cool the patient to drain the vascular volume externally to be transfused back later make it as versatile tool that can be used in different fields of surgery.

Key words

Cardiopulmonary bypass, Onco Surgery, Non cardiac uses, Renal Surgery, Soft Tissue Sarcoma, Malignant Melanoma, Brain Aneurysm, Vascular Tumor.

Introduction

It was John Gibbon in the year 1953 who first used the Cardio Pulmonary bypass that revolutionized cardiac surgery in the 20th century. The CPB performs the function of the heart and lungs as well as altering the temperature of the patient. Besides cardiac surgery, CPB finds extensive use in facilitating technically challenging procedures that otherwise may not be feasible to perform. Non cardiac applications of CPB have been extended and modified over time to include a wide variety of procedures. Using the same principle, we offered CPB for non-cardiac surgeries where the approach and treatment modality were limited. We have excluded cases of pulmonary thrombo-emboloectomy and thoraco-abdominal aortic diseases. CPB can be used in a wide range of oncological, thoracic, neurosurgical, renal and other fields of surgery. The various aspects of cannulation and conducting CPB, to generate varying flow rates and change temperature, drain the intravascular volume and transfuse it later makes the usage of CPB a versatile tool that can be applied for different procedures which may not be possible otherwise.

In the last few years, the usage of CPB for non-cardiac procedures has evolved. It has a significant role to play to facilitate surgeries that are otherwise not feasible. We review our experience with cases where CPB was offered as an adjunct to surgery. As the procedures for each case varied, so did our approach need modifications for cannulation and conduct of bypass.

Materials and methods

It was observational and retrospective study done from 2015 to 2020 in department of cardiothoracic surgery with records in the hospital data base for the last 5 year. As the indications were varied, a lot of modifications had been required for each case. We reviewed the indications and protocols in each and the lessons learnt from it. The study protocol was approved by the Hospital ethics committee. Data had been presented as continuous and categorical variables. The results were compared with other studies and presented.

Results

On reviewing the records in the hospital data base for the last 5 years, we found that a total of 20 non cardiac procedures were performed CPB. These included 8 isolated limb perfusions for malignant melanoma, 4 tracheal surgery cases, 3 renal surgeries, 4 mediastinal masses and 1 neurosurgical case.

All the 8 onco-surgical cases required CPB support for isolated limb perfusion. They were diagnosed cases of malignant melanoma of the lower limb-in 2 recurrent malignant melanoma. They underwent primary excision of the tumor with lymph node dissection. At the same sitting, Isolated limb perfusion was advised to reduce tumor burden. Once the inguinal lymph node dissection was performed, the common femoral artery and vein were isolated and looped. Tight tourniquet was applied at the level of groin using steel fixatures and elastic esmarch bands. Since it was an isolated limb perfusion, a pediatric reservoir disposable pack will suffice. Priming/ preparing of the pump was done with 1000 ml of balanced electrolyte solution, 1 unit of packed red blood cells- to avoid hemodilution and 1500 units of heparin. After adequate heparinization, a smaller cannula than that required was introduced distally into the artery after clamping the proximal aspect. Flow was checked and connected to the arterial line. Similarly the vein was also cannulated distally and connected to the by-pass circuit. Hyperthermia plays an important role in the management of melanoma. So the temperature of the limb was gradually increased to 40degrees by keeping the perfusate temperature at 42 degrees centigrade. Temperature probes helped monitor. The initial part of the protocol was to steadily raise the temperature of the limb to the needed at the rate of 1 degree per 4 min and to assess leaks. Increased flow rates of 700-1300 ml/min resulted in loss of perfusate to the systemic circulation

that was noted by a fall in the venous reservoir volume. This results in systemic spread of the drug which may cause toxicity/dilution and inadequate dosage. Changes in the reservoir volume may be because of missed collateral vessel/ when the cannula or its side holes were placed above the level of the tourniquet. Any changes in the reservoir volume were effectively and immediate managed by readjusting the tourniquet or the cannula position before addition of the chemotherapy drug. Once the desired temperature was reached, melphalan and/or tumor necrosis factor were added to the perfusate and circulated for 30-90 min. After completion of the procedure, the limb was cooled at the rate of 1 degree for 2-3 min and the limb and circuit were washed with 2 ltrs of saline and 1 ltrs of polymer dextran blood. The tourniquet was realized and the patient is weaned off the bypass and serially decannulated. The artery and vein were repaired and flow was re-established to the limb. Heparin was reversed 50% by protamine to avoid deep vein thrombosis and after proper hemostatic the skin was closed in layers.

Regional complications of the procedure were graded using the Wieberdink grading system [1]

Grade	Result
I	No reaction
II	Slight erythema/edema
III	Considerable erythema/ edema with some blistering
IV	Extensive epidermolysis and/or obvious damage to the deep tissues, causing functional disturbances, threatening or established compartmental syndrome
V	Reaction which may necessitate amputation

All our patients developed grade II regional toxicity which resolved spontaneously in 2-3 weeks. Nerve paraesthesia and pain was reported in 2 patients which took up to 8 weeks to resolve. No long term neurological or vascular complications were noted.

4 tracheal surgery cases were operated using CPB as support for providing adequate ventilation. These were cases of tracheal stenosis at the level of the carina or just above which made intubation and ventilation challenging. 3 cases were a result of tracheostomy and prolonged ventilation. And 1 was a case of malignancy at the level of the carina. To keep the operative field accessible for an extensive surgery, all these patients were electively put on femoro-femoral bypass under local anesthesia. The surgery for the tracheal stenosis/ obstruction can be accomplished without the aid of CPB. However, in cases where there in an anticipated difficulty in intubation or ventilation or in cases where resection is needed distally, CPB can be offered as a support to not only provide adequate oxygenation, but also a clear field. The surgery went as planned once the patient was on bypass. The air way was established for ventilation after repair of the stenosed segment. In addition, CPB provides good clearance, avoid tension at anastomotic site. There were no complications that were noted in these cases.

4 cases of mediastinal masses required CPB because of the proximity of the mass to a major vessel and/heart. To decompress the heart and hence the tumor to provide for a hassle free dissection.

In urology surgery, 3 cases of primary renal cell carcinoma with the tumor extending beyond the supradiaphramatic IVC in to the RA were operated up on using CPB. Surgical intervention is the standard treatment for such cases. To minimize complications and ensure adequate exposure and blood less field to extract the tumor. In such cases the right atrium/IVC may be opened. In such cases adequate discussion and planning may help teams prepared for CPB and use of deep hypothermic circulatory arrest. A combined abdominal and thoracic approach is needed in these patients. Once the abdominal part of the procedure was completed the kidney left attached only to the renal vein, a sternotomy was performed and the patient is put on bypass with ascending aortic and right atrial cannulation.

The left heart was vented the patients was cooled to the desired temperature. Surface cooling of the myocardium and cardioplegia helps preventing fibrillation of the heart once the desired temperature was reached to a core on 18-20 deg. The CPB was terminated and blood drained. This provided a virtually blood less field. Then it was opened and the ivc was mobilized. The tumor then was easily extracted and renal vein ligated and tumor delivered. Once clearance was achieved, the pump was restarted and the RA> IVC closed and patient rewarmed and weaned. In all the cases operated we were able to achieve complete clearance of the tumor load.

The one case of neurosurgery, we operated was a giant aneurysm of the brain in which clipping was required. But due to the friability and size of the tumor, it was difficult to clip it without the support of IABP. Partial bypass was instituted using fem bypass and cooling was done at the rate of 0.2 degree/min. Once the brain temperature reached 16 degree, the pump was stopped. Complete mobilization and ligation of the aneurysm was done then. There was a reduction of cerebral oxygen consumption at lower temp to almost 10% of normal at 15 degree. This permits for adequate protection and bloodless field.

Discussion

Creech and Krementz first introduced a novel drug delivery method for advanced cancer patients and named it ISOLATED limb perfusion [2]. They used the newly invented technique of CPB to deliver high doses of chemotherapeutic agents. After observing that hyperthermia also has a role in tumor regression, Stehlin, et al. modified and added this to the treatment modality [3]. The response rates and improved disease free interval in almost 25% of patients for 10 years promoted the use of CPB for ILP [4]. Neuro and vascular toxicity is a reported complication. Thrombosis 2.5% and DVT 10% are reported despite heparinization [5]. Gibbon developed the pump oxygenator to operate on pulmonary embolism [6]. CPB is not needed for lung surgery, however, in case of inadequate maintenance of ventilation and in cases where extended resection the trachea bronchial tree is needed, and other special situations. CPB makes it feasible. Depending on the approach, a peripheral cannulation can be performed which will give a blood less surgical field, removes the presence of different cannula and instruments to protect the airway [7, 8, 9]. Grillo in Massachusetts General Hospital in the year 1969 reported successful outcomes in 31 patients over a 7 years period for tracheal resection [10]. Tumor thrombus in the IVC of the primary renal cell carcinoma occurs in 4-10% of patients [11]. There is no systemic therapy available. Hence surgery is the only standard treatment available to reduce the tumor burden. The use of cardio pulmonary bypass with deep hypothermic circulatory arrest is recommended and an established technique for surgical management of patients with renal tumors and large IVC tumor thrombi [11].

Conclusion

CPB can be used for a wide range if isolated limb perfusion for soft tissue sarcoma, thoracic and renal or tracheal surgeries. CPB also can induce profound hypothermia so that circulation can be arrested to provide a bloodless field for repair or resection of vascular anomalies. Patient outcomes have been favorable and encouraging with few complications. The different aspects of bypass being an effective cardio pulmonary substitute, the ability to generate varying flow rates, to warn or cool the patient to drain the vascular volume externally to be transfused back later make it as versatile tool that can be used in different fields of surgery.

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