Selective aortic arch perfusion enables to avoid deep hypothermic circulatory arrest for extirpation of renal cell carcinoma with tumour thrombus extension into the right atrium

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INTRODUCTION

Radical surgery remains a mainstay of curative treatment in renal cell carcinoma (RCC) even in the presence of advanced intravascular progression of a tumour thrombus. Most difficult surgical situation is in RCC patients with a true intracardiac tumour thrombus (Level IV) where collaboration of urologist and cardiac surgeon at the operating theatre is required. With maximum stress on safety, precision and radicality, extirpation of the caval and intracardiac thrombus is achieved under deep hypothermic circulatory arrest, at a price of its non-physiological burden and time constraints. We propose a simple surgical manoeuvre enabling selective arch perfusion allowing for a milder hypothermia and liberal interval of circulatory arrest.

RESULTS: Using selective aortic arch perfusion, successful and uncomplicated extirpation of voluminous caval and intracardiac tumour thrombi was accomplished in 3 presented patients. Unexpectedly difficult thrombus adhering to hepatic veins in 1 patient required 42 min of circulatory arrest. Postoperative courses were uneventful in all 3 patients.

CONCLUSIONS: Second aortic cross-clamp to start selective closed aortic arch perfusion provides excellent surgical control of the operative field over a liberal time interval during circulatory arrest under milder hypothermia.

Keywords: Renal cell carcinoma • Intracardiac tumour thrombus • Deep hypothermia • Circulatory arrest • Cerebral perfusion
At the desired temperature, the aorta is cross-clamped in a standard manner and cardioplegia is administered in the aortic root. Then, in a very short circulatory arrest, a second aortic clamp is securely placed on the aortic arch beyond the left carotid artery (Fig. 2). Cardiopulmonary bypass is again restarted with the arterial line perfusing the aortic arch between the two clamps, i.e. the innominate artery and left common carotid artery. The flow is established to be $800 - 1000 \text{ ml min}^{-1}$ at a temperature of $25^\circ\text{C}$. The snare around the venous cannula in the superior vena cava is tightened while the venous cannula introduced in the cranial free wall of the right atrium is blocked. A right atriotomy close to the inferior vena cava is performed to expose the intracardiac portion of the tumour thrombus (Fig. 3). Simultaneously via laparotomy, the stump of the renal vein is circumcised in the inferior vena cava and the caval incision is extended cephalad. A meticulous digital blunt dissection of the tumour mass from the caval wall is undertaken with the counter-help of the finger introduced into the cava from the right atrium. Great care is paid to enucleating the thrombus unfragmented (Fig. 4) which is feasible in most cases; however, unpredictable difficult areas of firm adherence may be present at the ostia of the hepatic veins in large obturating thrombi. A bloodless field and a comfortable safe duration of the circulatory arrest enabled by the selective arch perfusion (SAP) are
of utmost importance in case of a difficult piece-meal extirpation of adherent tumour thrombus.

The procedure is completed by a direct suture of the subhepatic inferior vena cava and the right atriotomy. Both aortic clamps are released and full cardiopulmonary bypass is reintroduced. Should a concomitant cardiac procedure be required (valve or coronary artery surgery), the proximal clamp stays in place and the procedure is performed in the period of systemic rewarming.

PATIENTS

The technique of CA with SAP for nephrectomy and removal of a large intracardiac tumour thrombus was successfully used in 3 patients. Patient 1, a 46-year old obese lady had a voluminous tumour thrombus (Fig. 5), the removal of which turned out to be unexpectedly difficult in its intrahepatic course and required 45 min of CA. In Patient 2, a 79-year old male, the tumour extirpation was accomplished easily within 10 min of CA/SAP and additional aortic valve replacement was performed during the systemic rewarming period. In Patient 3, a 64-year old male, extirpation of the tumour thrombus reaching into the right ventricle required 28 min of CA/SAP. During CA/SAP, the cerebral perfusion was monitored by a near infrared spectroscopy (NIRS) cerebral oxymetry (FORE-SIGHT; CAS Medical Systems, Inc.; Brandford, CT, USA), with values of cerebral oxygen saturation never falling below 60%. All postoperative courses were uneventful, with no signs of neurological deficit or visceral organ dysfunction. All patients are alive at a follow-up of 24, 19 and 1 months, respectively. Patient 2 had a liver metastasis documented 8 months after surgery, which is well controlled by a biological therapy.

DISCUSSION

Radical and extensive operation—nephrectomy with extraction of the tumour thrombus—remains the only chance for survival for patients with RCC and intracardiac extension of the tumour thrombus (Level IV) [1]. Reflecting the topographical complexity of the situation, various strategies for this demanding procedure have been elaborated.

We have published our single-institution series of 21 patients who were operated on with use of cardiopulmonary bypass and DHCA [2]. The advantage of this technique is safe and exact complete extraction of the tumour thrombus in a bloodless operative field. The same opinion is supported by published case reports [3–6] and series of 4–21 patients operated with use of cardiopulmonary bypass and DHCA [7–16]. Other authors seek to avoid DHCA and use normothermic cardiopulmonary bypass and the Pringle manoeuvre for control of bleeding and visualization of the field [17–21]. Alternatively, cardiopulmonary bypass with mild hypothermia and intermittent supraceliac abdominal aortic occlusion may also be employed [22]. On the other hand, the technique of blind displacement of the tumour into the inferior vena cava and its removal without cardiopulmonary bypass may be associated with a risk of embolic complications [23].

The broad variety of surgical strategies reflects the dilemma between securing the optimal surgical conditions at a price of DHCA or trying to decrease the procedural burden by avoiding DHCA, usually at a cost of extensive sub- and suprahepatic dissection to improve the vascular control of the operative field [24, 25]. In our opinion, the safety and exactness of the tumour removal is the cornerstone of this radical surgery; however, there is no doubt that DHCA prolongs the duration of the procedure and negatively affects bleeding and inflammatory response. Therefore, we tried to translate the experience from aortic arch surgery into a dissection for the second aortic clamp. This single manoeuvre allows easy transformation of routine cardiopulmonary bypass into a selective aortic arch perfusion. This results in a milder hypothermia required and much wider time constraints while maintaining the unparalleled benefits of a bloodless operative field. Should the extirpation turn out to be exceedingly time consuming, the second clamp should be released due to concerns of spinal and visceral organs ischaemia after 40–45 min (with respect to the actual temperature). A relief of the second clamp at this phase does not hamper the procedure which is almost at its end.

Analogously, the principle of mid-to-mildly hypothermic closed perfusion of the first two arch branches during CA may be potentially considered, e.g. for pulmonary thrombendarterectomy.

CONCLUSION

A second aortic cross-clamp to start selective closed aortic arch perfusion during CA is a useful manoeuvre for extirpation of tumour emboli extending from the inferior vena cava into the right atrium. It provides excellent surgical control of the field over a liberal time interval and in a milder hypothermia.

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REFERENCES


