Thoracoabdominal aneurysm surgery. Update on "open" versus "hybrid" treatment and personal experience

Pier P. Zanetti

Department of Cardiovascular and Thoracic Surgery, "Centre for thoracic aortic surgery and Marfan disease", Policlinico of Monza, Monza (Milan), Italy

Despite different surgical adjuncts, advanced anaesthesia, and improved critical care, mortality and morbidity rates following "open" repair of thoracoabdominal aneurysms (TAA) remain high, sometimes prohibitively. The mortality rate ranges from 4% to 30%, paraplegia/paraparesis (P/P) from 4% to 15%, acute renal failure (ARF) from 5% to 15%.

With the promising results of endovascular repair of abdominal and thoracic aneurysm, several centres have developed a new option for treatment of thoracoabdominal aneurysm. The "hybrid" technique involves a primary phase with open revascularization of visceral and renal arteries, and subsequent endovascular grafting for the exclusion of the TAA.

At the moment the indications for use of one or the other procedure represent a debatable question, particularly with regard to a population of patients more and more elderly, with co-morbidity present in a large number, and consequently unfit for "open" procedure, and, on the other hand, the need for continued development of endovascular technologies and increasing experience in the "hybrid" procedure, in order to obtain an alternative treatment option in patients with challenging TAA.

The experience with pure endoluminal stent graft "fenestrated" or "branched" for treatment of TAA remains limited and purely experimental.

In the light of our experience, based on 476 TAA treated from 1995 to 2007, we propose our surgical options, with reference to "open" versus "hybrid" surgery.

"Open" surgical repair continues to be for us the standard therapy for thoracoabdominal aneurysms, evaluating the features of patients (age, smoker, ex-IMA) and of TAA (type I or II dissecting aneurysm).

In fact for a patient less than 70 years old, ASA class type I or II, respiratory functionality not compromised, renal chronic failure with serum creatinine level less than 2 mg/dl, and absence of serious diabetes – all these factors favour "open" surgical treatment.

In the same way, the "open" procedure is chosen for urgent presentations such as symptomatic or covered rupture of TAA, and much more in emergency, as in free rupture, and finally in all patients, in urgency or emergency, but haemodynamically unstable.

Regarding TAA, all types, according Crawford's classification, are treated with "open" procedure especially if it is the first operation, or in Marfan syndrome evaluating the aortic wall disorder evolution.

Our current approach to TAA repair has evolved substantially during a 15-year period, but several aspects have remained consistent. Patients were anaesthetized and intubated using a double-lumen endotracheal tube. An arterial line and a pulmonary artery catheter monitored patient haemodynamics through central venous access. A catheter, placed in the third or fourth lumbar space, provided cerebrospinal fluid (CSF) drainage and monitoring of CSF pressure. The CSF pressure was maintained at less than 10 mm Hg., and the drainage was kept in place postoperatively for 3 days.

Contraindication for CSF drainage use includes cases of free rupture, hypotension, sepsis or active bacteraemia, recent history of intracerebral haemorrhage or previous surgery.

The surgical access is through a left thoraco-abdominal incision, and the thorax is entered between the V° and IX° intercostal space, according to TAA type. Routinely circumferential division of the diaphragm was utilized, but in a patient with poor respiratory function (FV_1 <60%) only the muscle segment of the diaphragm was cut in order to obtain a quicker functional recovery.

In our experience it is possible, in TAA type IV°, to have the aortic cross clamping without diaphragmatic section, only through the abdomen via cutting the left diaphragmatic pillar. The advantages to respiratory function, in post-operative time, are clear.

Systemic heparin administration (1 mg/kg) was utilized in our experience, not mild, permissive hypothermia.

Address for correspondence: Prof. Pier P. Zanetti, Department of Cardiovascular and Thoracic Surgery, "Centre for thoracic aortic surgery and Marfan disease", Policlinico of Monza, Monza (Milan), Italy, Email: pp.zanetti@policlinicodimonza.it

Left heart bypass (LHB) was routinely used in surgical repair of TAA type I°, II°, III°, during proximal anastomosis and intercostal artery reimplantation. For visceral and renal vessels our behaviour changed according to the particular situation; in presence of CT and superior mesenteric artery (SMA) with good "back flow" we did not use perfusion or normothermic blood or 4°C Ringer's lactate solution, but only Fogarty occlusion in order to avoid the "steal" syndrome. The artery reimplantation was performed as quickly as possible according to the "clamp and go" technique.

In contrast, in presence of an occluded CT, no rare situation in our experience, we perfused with Ringer's lactate solution the superior mesenteric artery, during the reimplantation time.

In presence of serum creatinine level >2 mg/dl, two separate balloon catheters were inserted into the renal arteries. The perfusate was Ringer's lactate solution cooled to 4°, with bolus infusion (400 to 600 ml), followed by additional intermittent infusion (200 ml). A total of approximately 1.0 to 1.5 L of crystalloid solution was infused in an attempt to achieve a renal temperature of 15°.

Large volumes were avoided to limit the potential hazards of fluid overload, and severe systemic hypothermia.

Technically the visceral and renal arteries were reimplanted using a single "patch" as small as possible, and only in the presence of very large TAA, the left renal artery was reimplanted alone.

Regarding the intercostal and lumbar arteries we proposed an aggressive and extensive reattachment of critical segmental arteries (T8-L1), without endoluminal perfusion, but only obtaining the "back flow" reduction with use of Fogarty's catheter.

Localized aortic endarterectomy was used in the presence of mural calcification, obtaining a haemostatic anastomosis, and in order to achieve reattachment of important intercostal arteries located in a severely diseased portion of the aortic wall.

Type IV° TAA were treated with the "clamp and go" technique. In the presence of serum creatinine level >2 mg/dl the use of Ringer's lactate solution was expected.

The TAA mortality rate with "open" surgery ranges in the literature from 4% to 30%, with 4% to 8% in elective surgery, and from 10% to 30% in emergency. Our experience shows 7% in election, and 28% in emergency. Powerful risk factors were age, urgency or emergency treatments, preoperative renal insufficiency, intraoperative hypotension, postoperative P/P, and postoperative acute renal failure.

Paresis and paraplegia (P/P), following repair of a thoracoabdominal aneurysm, remain a devastating complication. The incidence of postoperative neurological deficit currently ranges between 4% and 15%, in our experience 8% in elective surgery, 18% in urgency or emergency.

The multifactorial aetiology of neurological injury includes aortic ischaemic period, extent of the aneurysm, acute or chronic dissection of aortic lesion, intra- and post-operative hypotension, and preoperative renal failure. In our experience, in order to reduce the P/P rate, numerous adjuncts were utilized such as distal perfusion and CSF drainage; in contrast to Coselli's experience, we did not use moderate hypothermia. Neither somatosensory-evoked potential (SSEP) nor motor-evoked potential (MEP) monitoring was used. The SSEP reflect the integrity of the somatosensory system that lies in the dorsal spinal cord, whereas the neurons critical for motor function are located in a more ventral area of the cord. MEP allows for the early detection of spinal cord ischaemia, but is not suitable for postoperative monitoring. In both procedures the false positive and false negative rates are unacceptably high, frequently time-consuming for intercostal artery mapping out and cumbersome in the operative field.

We are advocates, in the age-old problem about the intercostal and lumbar artery reimplantation, of aggressive and liberal reimplantation, with particular care for the segment between T8 and L1.

Our policy completely contrasts with R. Gripp's experience, who suggests the complete ligature of intercostal arteries, before the aortic aneurysm opening, having confidence in a rich collateral pathway, avoiding the "steal" phenomenon of intercostal arteries ostia "back flow", and finally using CSF drainage and a high blood pressure.

Acute renal failure (ARF) remains a significant and potential lethal complication after TAA repair, and reveals an incidence ranging from 5% to 30%, in our experience 13%.

As risk factors, the time of renal ischaemia during aortic cross-clamping, type of lesion (type I or II), acute or chronic dissection, intraoperative hypotension and finally reperfusion injury.

According to J. Coselli we have used renal perfusion with cold Ringer's lactate instead of normothermic blood perfusion. In fact normothermic blood does not alleviate postoperative renal dysfunction. Several explanations are possible: non-pulsatile flow has been demonstrated to activate the renin-angiotensin system and increase renal vasoconstriction, which may have a deleterious effect. The perfusion pressure in the renal arteries may not be enough to compensate the metabolic requirements of the stressed kidney. Finally, in the setting of an ischaemic insult the benefits of blood flow may be outweighed by the detrimental effect of maintaining renal normothermia.

Pulmonary complications, after TAA repair, are present in most series with an incidence of 30%-36%. Powerful risk factors are age (>70 years old), protracted smoking history, extent of aneurysm (type I-II), poor preoperative pulmonary function, due to chronic obstructive pulmonary disease (COPD), and preoperative renal failure (creatinine greater than 2-2.5 mg/dl).

The large thoracoabdominal incision and the division of the diaphragm may have a negative impact on postoperative pulmonary function. Prolonged intubation, reintubation due to pneumonia, and finally the tracheostomy, also early, produced hospital mortality in 50% of patients.

A clear correlation exists between patients with impaired renal function and respiratory insufficiency. In fact the prevention of renal failure often involves administration of

a large volume to achieve sufficient renal preload, raising the risk of respiratory insufficiency due to volume overload.

Consequently it seems to be very important to have carefully balanced postoperative fluid management.

Postoperative bleeding, stroke and IMA are present in TAA repair, with rates not different compared to normal cardiac surgery.

The "hybrid" treatment of TAA has shown early encouraging results, with a reduction in mortality and morbidity rates, compared to "open" surgery. We present our indications and contraindications for use of this procedure.

The key of this strategy is the retrograde revascularisation of the visceral and renal arteries via an abdominal approach, followed by endovascular stent graft to exclude a TAA.

In our experience (10 cases) the "hybrid" treatment was reserved for patients who were known to be high risk, and no candidate for "open" surgery. It concerns patients more than 70 years old, ASA III-IV, COPD with FEV1 less than 60%, renal chronic insufficiency with creatinine level more than 2-2.5 mg/dl, distal limbs arteriopathy.

Ideal candidates for the "hybrid" procedure were also patients already operated on in the thoracoabdominal aortic segment, with "frozen" thorax or "ostilis" abdomen, redo operation and complex cases with pseudo-aneurysm in visceral, renal and intercostal patches, and finally in complex intercostal artery reimplantation owing to calcified aortic wall. "Open" surgery, in our hands, has had, in these cases, a mortality rate of 40%.

The advantages of the "hybrid" proposal are clear, allowing the avoidance of thoracotomy and thoracic aortic cross-clamping. In this way we are able to obtain minimal visceral, renal and spinal ischaemia, greater haemodynamic stability, and blood loss reduction. Moreover, paraplegia/paraparesis, acute renal failure and postoperative respiratory insufficiency were substantially reduced, ranging between 0% and 4%.

Disadvantages of the "hybrid" procedure regarded the retrograde vessels' revascularisation and the stage of endoluminal stent graft inclusion in the thoracoabdominal aorta.

In the first phase surgical access was transperitoneal, using as a donor vessel the abdominal aorta near carrefour, or iliac arteries. The safety and durability of retrograde bypass grafting has remained controversial but the literature suggests 98% bypass patency rate at medium follow-up of 8 months.

In our experience the thrombosis of bypass regarded in two cases renal arteries, in one case the superior mesenteric artery, never CT.

The length of the grafts is crucial for successful graft placement, particularly the limb of the SMA which is routed in a "C" fashion to avoid kinking once the bowel is repositioned. The graft to the CT needed the retroperitoneal route behind the pancreas. The renal grafts must be short and direct.

It must be emphasized that there must be ligation of native inflow from the aorta in order to prevent subsequent retrograde flow and development of a type II endoleak after endograft placement.

Our behaviour, regarding CT treatment, proposes always a surgical revascularisation, in presence of occluded or patent vessel. In fact several surgeons have proposed only superior mesenteric artery grafting, in presence of occluded CT, having confidence in the good quality of the collateral pathway, but postoperative pancreatitis and cardial ulcer have been observed.

The second stage of the "hybrid" procedure, regarding stent graft introduction, presents some drawbacks such as the small calibre or arteriosclerotic obstruction of the donor vessel, and unfit area for landing zone. The high incidence of type I endoleaks reflects the difficulty in creating an adequate landing zone for the graft and probably the inappropriate design of current stent grafts for extensive TAA. Consequently endoleaks were present in 20% of cases, and in the first 5 years the need for additional stents concerned 50% of cases.

Moreover, type III endoleaks may be the cause of late aneurysm rupture.

The use of "hybrid" technique obtains a drastic redaction of P/P rate, bringing down the neurological damage to around 0% to 4%. In fact with this procedure the ischaemic time, intraoperative hypotension, and revascularisation damage were substantially reduced.

As a drawback, it is possible to mention the impossibility of intercostal artery reimplantation, microembolic event in intercostal arteries after atheromatic debris dislodgment, and total trust in the collateral pathway.

CSF drainage and substantial increase of arterial pressure were the only disposable instruments for spinal cord protection.

The temporary stent graft device proposed by Watanabe did not enjoy surgeons' favour.

In conclusion, "open" surgical repair continues to be, in our experience, the standard therapy for TAA, but in the presence of patients who have prohibitive risks and very heavy co-morbidity, a combined technique with visceral and renal artery translocation followed by endoluminal repair of the aneurysm seems to be a viable option.

Nevertheless, the encouraging results attest to the potential of the "hybrid" procedure and demonstrate the requirement for further investigations.