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Review Article

Anaesthesia for living-related liver transplantation

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Liver transplant is now recognised as a well-established treatment for end-stage liver disease. Cadaveric liver transplantation is done all over the world and the number of living-related liver transplantation is also increasing. Over the decade, improvement in surgical technique, better understanding of physiological changes taking place at various stages of the procedure by the anaesthetic team has resulted in improved survival. We at Apollo Hospital, New Delhi have a dedicated team of anaesthetists to provide anaesthetic service in the perioperative period. Here, we discuss the anaesthetic management being followed in our centre.

PREOPERATIVE ASSESSMENT

A multidisciplinary preoperative assessment should be performed by a hepatologist, a surgeon and an anaesthetist before listing for transplantation. Assessment involves evaluation of hepatic dysfunction, associated path physiological complications and existing concomitant diseases. Assessment of the functional status of these patients is a significant challenge, in order to predict the haemodynamic, respiratory and hepatic reserve in this population.

Immediately before transplant, laboratory determination of complete blood count, coagulation parameters, blood urea, creatinine, bilirubin and albumin should be obtained. Blood products according to the hospital protocol is typed, cross matched and made readily available.

CARDIAC EVALUATION

Cardiac evaluation for diagnosis of silent ischaemic heart disease and cardiomyopathy is done by a combination of the following investigations:

- ECG
- Echocardiogram
- Dobutamine stress test
- Coronary angiography (in selected patients)

Atherosclerotic coronary disease has been found to have higher incidence in liver transplant patients especially in the Indian subcontinent (associated with higher incidence of diabetes mellitus) as compared to the normal population. The presence of coronary artery disease is associated with high mortality and morbidity (50% and 81% respectively).[1] Dobutamine stress echocardiogram (DSE) test is preferred in our institution for preoperative screening, which has a 92–97% negative predictive value. Moreover, DSE mimics the ability of heart to tolerate IVC clamping.

In DSE positive patients, we do coronary angiography through trans-radial route which causes less morbidity. CAG is done in patients on beta-blocker where target heart rate cannot be achieved during DSE.

PULMONARY EVALUATION

Up to 10% of cirrhotic patients suffer from some form of pulmonary involvement. Lung diseases like pleural effusion, restrictive lung diseases, hepatopulmonary syndrome can be diagnosed using:

- chest x-ray
- lung function tests
- pulse oximetry
- arterial blood gas analysis
- contrast echocardiography
- CT chest (selected cases).

Room air-oxygen saturation measured using pulse oximetry may give an early indication of impaired pulmonary gas exchange or inadequate ventilatory reserve.[2] Using cut-off values of 97% and 94% identifies patients with an arterial PO_2 below 70 mmHg and 60 mmHg respectively. On finding an abnormal value, arterial blood gas analysis and pulmonary function tests are done.

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Pulmonary function tests are of limited value because cirrhotic patients often have pleural effusion and ascites which abnormally affect the pulmonary function tests.

A contrast (bubble) echocardiogram has high sensitivity for intracardiac and intrapulmonary shunt. In cardiac shunts, the bubble appears immediately in left atrium after venous injection of bubbles, and in intrapulmonary shunts they appear 3 or more beats after injection whereas in V/Q mismatch, the bubbles are absorbed in the lungs.[3] Quantification of intrapulmonary shunts using macroaggregated albumin (MAA) scan is done in patients with $PO_2 < 60$ mmHg. MAA shunt fraction of 20% or more is the strong predictor of post-operative mortality and is also one of the MELD exception criteria.

Approximately 4–40% of the patients with chronic liver disease have port pulmonary hypertension (PPH). Port pulmonary hypertension is defined as mean pulmonary artery pressure >25 mmHg or pulmonary vascular resistance of 120 dynes.s.cm^{-5} in the presence of normal pulmonary capillary wedge pressure. Mild PAP (25–35 mmHg) or moderate PAP (35–45 mmHg) does not contraindicate liver transplantation. When PAP >35 mmHg and PVR is >250 dynes.s.cm^{-5}, increased peri-operative mortality is associated with liver transplantation.[4]

Our approach to severe PPH: Assuming no other contraindications to orthotropic liver transplant is present (left ventricular function is preserved on DSE) patients undergo right heart catheterization. If mean PA pressure is >40 mmHg, we prefer to give oral sildenafil citrate. When the patient goes to the cath lab for coronary evaluation, we also like to do left heart catheterization to get a complete picture.

Hepatic dysfunction is roughly evaluated by prothrombin time and albumin levels. Urinary sodium levels and fractional excretion of Na^+ is done to rule out hepato-renal syndrome. Risk stratification is done using Child-Turcotte-Pugh scoring system and MELD scores.

INTRA-OPERATIVE MANAGEMENT

Dedicated anaesthesia teams are involved in the liver transplant programme comprising two anaesthesiologists (one at a senior level and the other at a junior level to assist), anaesthesia technicians specially trained in assisting in transplant anaesthesia and nursing personnel. Laboratory services kept ready before the start of the surgery include systems for obtaining complete blood counts, PT, PTT, INR, arterial blood gas analysis machine and thromboelastograph.

Monitoring: Routine monitoring of ECG, oxygen saturation (SPO_2) and non-invasive blood pressure (NIBP) are established before induction. Further, invasive cardiovascular monitoring is established either pre or post-induction depending on the cardiovascular safety of patients. We place pulmonary artery (PA) catheters in most of adult liver transplant recipients, though placement of PA catheters is controversial. Transesophageal echocardiogram is placed in selected group of patients. Bispectral (BIS) index are also used in our centre.

A nasogastric tube, urinary catheter and oesophageal temperature probe are inserted.

Positioning: The patient is positioned supine with both arms adducted. A warming hot air blanket is used.

Induction of anaesthesia: An IV crystalloid infusion is commenced before induction. The main requirement of induction is the cardiovascular stability. Short acting drug combinations, including midazolam, fentanyl and propofol are used in our centre.

Maintenance of anaesthesia: After intubation, IPPV is established with a suitable volatile agent, for example, isoflurane (0.5–1.0 minimum alveolar concentration [MAC]) to ensure unconsciousness. Nitrous oxide is avoided to reduce cardiovascular depression, gut distension and expansion of air bubbles formed in the vascular system. A fentanyl infusion provides intra-operative analgesia and Atracurium is the preferred neuromuscular blocking (NMB) agent in our centre, though all NMB agents have been used in the literature.

IV fluids and blood products: Large bore cannulae are required for rapid transfusion of blood products and fluids. A 3–5 mm lumen central line is inserted under ultrasonic guidance. A rapid infusion system (e.g. Level 1) allows rapid transfusion of warmed fluids (37–38°C at the rates up to 1500 mL/min). Fresh frozen plasma, cryoprecipitate and platelet infusions are administered according to the measures of coagulopathy and clinical bleeding. Monitoring of full blood counts, clotting, electrolytes and blood gas analysis is carried out hourly or as clinically indicated. This guides the management of ventilation, calcium supplementation, glycaemia and acid–base balance as well as blood replacement therapy.

Surgery falls into three phases. Each phase of liver transplantation presents particular problems for the anaesthetist.

Phase I (pre-an hepatic phase): The surgical approach normally utilizes an inverse T or 'Mercedes' incision. This phase involves dissection, mobilization of liver and identification of porta hepatitis. With abdominal incision and drainage of ascites, hypovolemia occurs. Hypovolemia is treated in an anticipatory fashion with colloid-containing fluids. In presence of pre-existing coagulopathy, fresh frozen plasma is indicated soon after incision. Fibrinolysis is unusual during pre-hepatic stage, so cryoprecipitate administration is typically unnecessary. Citrate intoxication in the