Perioperative Monitoring in Liver Transplant Patients

Shweta Singh, Vaibhav Nasa, Manish Tandon

Dept. of Anesthesiology and Critical Care, Institute of Liver and Biliary Sciences, D1 Vasant Kunj, New Delhi 110070, India

Liver transplant (LT) is a major surgical undertaking involving major fluid shifts, hemodynamic instability and metabolic derangements in a patient with preexisting liver failure and multisystemic derangements. Monitoring and organ support initiated in the preoperative phase is continued intraoperatively and into the postoperative phase to ensure an optimal outcome. As cardiovascular events are the leading cause of non-graft related death among LT recipients, major emphasis is placed on cardiovascular monitoring. The other essential monitoring are the continuous assessment of coagulapathy, extent of metabolic derangements, dyselectrolytemis and intracranial pressure monitoring in patients with fulminant hepatic failure. The type and extent of monitoring differs with need according to preexisting child status of the patient and the extent of systemic derangements. It also varies among transplant centers and is mainly determined by individual or institutional practices. (J Clin Exp Hepatol 2012;2:271–278)

Liver transplant (LT) has become a feasible treatment option for acute as well as chronic end stage liver disease (ESLD), irresectable liver malignancies and also for several metabolic abnormalities. Liver diseases, necessitating LT can either be acute or chronic. Each disease entity presents unique features as well as important differences.

While cirrhosis is a slow and insidious liver dysfunction, acute liver failure (ALF) presents with liver dysfunction, coagulopathy and hepatic encephalopathy occurring within days or weeks, often leading to a life-threatening multisystem illness and a rise in intracranial pressure (ICP). Severe hemodynamic, hematological and metabolic abnormalities are common.

Keywords: liver transplant, ALF, cirrhosis, coagulopathy, intracranial pressure monitoring

Received: 13.3.2012; *Accepted:* 26.6.2012; *Available online:* 25.8.2012

Address for correspondence: Shweta Singh, Associate Professor, Dept. of Anesthesiology and Critical Care, Institute of Liver and Biliary Sciences, D1 Vasant Kunj, New Delhi 110070, India. Tel.: +91 9810625177

E-mail: drshwetasingh29@gmail.com

Abbreviations: LT: liver transplant; ESLD: end stage liver disease; ALF: acute liver failure; ICP: intracranial pressure; CO: cardiac output; SVR: systemic vascular resistance; PAC: pulmonary artery catheter; CVP: central venous pressure; PAOP: pulmonary arterial occlusion pressure; TDCO: thermodilution principle; CCO: continuous CO; mPAP: mean pulmonary artery pressure; RVEDV: right ventricular end-diastolic volume; SV: stroke volume; EVLWI: extra vascular lung water index; CI: cardiac index; TEE: transesophageal echocardiography; CCTs: conventional coagulation tests; PT: prothrombin time; APTT: activated partial thromboplastin time; TEG: thrombelastography; ROTEM: rotation thrombelastometry; TEG: thrombelastography; MA: maximum amplitude; CL: clot lysis; ACT: activated clotting time; CR: clot rate; PF: platelet function; ICP: intracranial pressure; ICH: intracranial hypertension; TCD: transcranial Doppler; ONSD: optic nerve sheath diameter; PI: pulsatility index; ICG: indocyanine green; ARDS: acute respiratory distress syndrome

http://dx.doi.org/10.1016/j.jceh.2012.06.003

LT is a major surgical undertaking involving major hemodynamic shifts and metabolic derangements necessitating extensive monitoring and support of all organ systems. It is now becoming increasingly possible to offer transplant to sicker patients with multiple co-morbidities and organ dysfunction, as monitoring and organ support initiated in the preoperative phase is continued intraoperatively and into the postoperative phase to ensure an optimal outcome.

HEMODYNAMIC MONITORING

Cardiorespiratory failure has been identified as the commonest cause for ICU readmission after LT and cardiovascular events are the leading cause of non-graft related death among LT recipients.[1] Major emphasis is therefore placed on cardiovascular monitoring during perioperative care of these patients.

Patients with cirrhosis and portal hypertension have a hyperdynamic circulatory state, with high cardiac output (CO) and a low systemic vascular resistance (SVR).[2] There is systemic vasodilatation and marked increase in splanchnic capacitance. As a result, the central blood volume is significantly reduced. Due to this relative hypovolemia and major fluid shifts which occur during surgery, there is a need for a reliable hemodynamic monitoring tool for fluid management, so as to maintain the delicate balance between optimizing preload and avoiding pulmonary edema.[3]

Standard hemodynamic monitoring used routinely during adult LT includes continuous 5 lead ECG, invasive arterial pressure and cardiac output (CO) monitoring. Often both the radial arteries or a radial and a femoral artery are cannulated due to the need for frequent blood sampling and to enable continuous invasive blood pressure monitoring during the long surgery. Femoral arterial catheter is preferred over radial artery catheter by many, since central aortic pressure monitoring is considered more accurate especially at times of hemodynamic instability. Besides blood pressure monitoring using the radial artery is known to get affected by rib cage retraction causing subclavian artery compression.[4]

Changes in arterial and venous tone, intravascular volume, ventricular performance, peripheral vascular reactivity, core body temperature and changes in blood rheology make moment-to-moment assessment of cardiovascular status difficult. Clinical parameters like heart rate, blood pressure, blood loss and urine output are insufficient to direct fluid therapy for a recipient of LT. More detailed and accurate measurements are therefore needed for assessing cardiac preload, directing volume replacement and optimizing CO.[5]

Traditionally, pulmonary artery catheter (PAC) has been used for invasive hemodynamic monitoring during LT. Cardiac filling pressures, namely central venous pressure (CVP) and pulmonary arterial occlusion pressure (PAOP) measured using the PAC serve as a guide to right and left heart preload respectively. Till recently these cardiac filling pressures were widely used to guide fluid therapy, but recent studies have shown that these pressure-derived parameters, which are indirect indicators of ventricular filling volumes,[6,7] have little positive predictive value in improving hemodynamics or tissue perfusion.[8]

The PAC was initially used only to measure intracardiac pressures, but CO measurement using the thermodilution principle (TDCO) has now become an integral function of the PAC. Advances in technology have allowed for the development of continuous CO (CCO) monitoring by incorporating a heating coil within the PAC (CCOmbo/Vigilance, Edwards Lifesciences LLC, Irvine, CA; Opti Q CCO/Q-vue, Abbott Critical Care Systems, Mountain View, CA). This obviates the need for bolus injections and provides average CO over time compared with intermittent bolus techniques[9] and still allows for monitoring of CVP, mean pulmonary artery pressure (mPAP) and PAOP. Advances in computation techniques have resulted in development of algorithms to calculate the global end-diastolic volume and the right ventricular end-diastolic (RVEDV) and end-systolic volumes, thereby facilitating better estimation of intravascular blood volume.[10] RVEDV is a valuable index of cardiac preload and is a more sensitive indicator of intravascular volume when compared with CVP and PAOP.[11,12] The PAC however, might be inaccurate if it is not positioned correctly and may not reflect changes in intravascular volume rapidly enough. With reported hazards of PAC insertion like ventricular arrhythmias,[13] and due to availability of less invasive monitoring tools, the use of PAC is declining. It is now increasingly reserved, for those cases where there is a suspicion of porto pulmonary hypertension,[14] as severe pulmonary hypertension (mPAP > 45) is associated with high perioperative mortality and, if not successfully treated, is a contraindication to LT.[15]

Standard hemodynamic monitoring, such as arterial pressure monitoring, can also be extended for the assessment of CO, preload and afterload. A number of such devices are commercially available which provide a continuous estimate of CO through analysis of the shape of the arterial pulse wave from a peripherally placed arterial catheter. This technique helps measure stroke volume (SV) and CO on a beat-to-beat basis and helps assess requirement of therapies such as fluid challenge and/or inotropes.[16]

The PiCCO system (Pulsion Medical System; Munich, Germany) is a commercially available, continuous CO monitor in which a femoral arterial catheter with a thermistor in its wall analyses the pulse contour. The working principle is based on an algorithm which analyzes the shape of the arterial pressure waveform and computes the pulsatile systolic area. Beat-to-beat calculations are averaged over 30-s cycles and are displayed as a numerical value providing information regarding the patient's preload (intrathoracic blood volume, ITBVI), afterload, myocardial contractility, CO and extra vascular lung water index (EVLWI).[17] ITBVI has shown a strong correlation with cardiac index (CI) as opposed to filling pressures in cirrhotics. It is regarded as a more reliable preload index during different phases of LT like during IVC clamping, graft reperfusion, bleeding and surgical manipulations.[18] The device is initially calibrated by TDCO, using cold saline injection via central venous catheter and subsequent detection by the thermistor in the femoral arterial catheter. Beat-to-beat calculations are averaged over 30-s cycles and displayed as a numerical value. CCO assessed by PICCO and by TDCO have been found to be comparable. The monitor however, needs to be recalibrated if the SVR changes markedly.[19,20]

Other popular commercial equipment that make use of pulse power analysis include the LiDCO plus (LiDCO Ltd; Cambridge, UK) and the FloTrac/Vigileo (Edwards Lifesciences LLC; Irvine, CA). Both devices use proprietary algorithms to derive CO and like PiCCO, both display pulse pressure variation and stroke volume variation, which are indicative of intravascular volume status.[21] Flo-Trac/Vigileo derives CO from the arterial waveform in conjunction with patient demographic data, without the need for an independent method of calibration. CO can be measured directly from a conventional arterial line attached to the sensor.[22] The LiDCO system needs to be calibrated using lithium dye. However, its advantage over other pulse contour derived methods is that it provides beat to beat changes in CO, while the Vigileo computes and displays SV values every 20 s. The values obtained from LiDCO and the FloTrac have been compared with PAC and found to be comparable.[23]

More recently transesophageal echocardiography (TEE) has become an essential perioperative diagnostic and monitoring tool.[24] It provides direct visualization of the function and volume status of the heart. It allows quick

