The main factors influencing the complex hemodynamics of our case report in the setting of liver transplantation and heart diseases are:

1) End-stage liver disease patient (ESLD): liver failure is the cause of several underlying and overlapping pathophysiological conditions that contribute to intraoperative hemodynamic instability, such as vasodilation, hyperdynamic circulatory profile, cirrhotic cardiomyopathy, ESLD-associated porto-pulmonary hypertension (PoPH). The patient in the case report had a terminal liver failure (MELD 35) with a combined pre- and post-capillary PH due to the valvulopathy and the likely probable initial PoPH (Transpulmonary Pressure Gradient, TPG 15 mmHg). It also had reduced systemic resistance (SVRI 1132 dyn/sec/m2/cm-5) with no increase in cardiac index ([CI] 3.8 L/min/m2); indeed, ESLD often has much increased CI to ensure adequate peripheral perfusion due to cirrhotic cardiomyopathy in addition to valvular heart disease.

2) Heart disease secondary to valvulopathy: the patient suffered from rheumatic mitral stenosis associated with severe mitral insufficiency, biatrial dilatation, pulmonary hypertension and severe tricuspid insufficiency. Preoperative echocardiographic assessment of the mitral valve stenosis showed the following parameters: maximal pressure gradient (PGmax) 27 mmHg, mean PG 15 mmHg, mitral valve area calculated using pressure half-time 4 cm2, PAPs 65 mmHg, left atrial anteroposterior diameter 61 mm. Mitral stenosis was symptomatic and indicated for surgical correction (performed ten months after LT). Additionally, the patient had atrial fibrillation with a rapid ventricular response. The PAC hemodynamic data before and after the fluids challenge, poorly tolerated by the patient, are available in supplementary table 1.

3) Surgical phase: severe hemodynamic changes related to the transplantation often cause patient instability, poor perfusion, arrhythmias and sometimes death. The main expected hemodynamic pathophysiological changes are:

- Acute reduction in preload (instant decrease of more than 80% of venous return) due to total caval clamping, massive bleeding, and acute drainage of ascites. These occur during the anahepatic phase and are treated with a rapid fluidic filling. The fluid challenge in this step will further increase the venous return of the next phase.

- Acute increase in preload (instantaneous) after graft reperfusion; in addition to inferior vena cava reperfusion (usually providing 80% of venous return), there is also portal vein reperfusion after prolonged vein clamping in a patient with portal hypertension. It determines an overflow of the portal vein with a reduction of the splanchnic venous tension. Portal overflow alone can cause pulmonary edema and acute pulmonary hypertension, such as after placement of a transjugular intrahepatic portosystemic shunt, even in the absence of evident heart disease.
Reperfusion syndrome (PRS), defined as severe hypotension requiring vasopressor infusion associated with hemodynamically significant arrhythmias (incidence 4 and 81%, respectively) S1. Hypotension secondary to PRS is related to an acute decrease in systemic vascular resistance or new onset ventricular dysfunction due to ischemic-reperfusion injury. After graft reperfusion, the acute collapse of systemic resistance, the rapid alterations in electrolyte and acid/base balance, the rapid hypothermia and the use of catecholamines predispose to malignant arrhythmias (both tachycardia and bradycardia).

Regarding the ECMO indications, the preoperative multidisciplinary evaluation (surgeons, anaesthetists, cardiologists and hepatologists team) considered the patient unsuitable for transplantation due to the high risk of intraoperative death. Furthermore, the patient's conditions (liver disease and heart disease), combined with the transplant surgery's characteristics, were considered at risk of haemodynamic instability with a high probability of intraoperative cardio-circulatory arrest, with an incidence of about 3.7% during LT. S3 In additions, physicians estimated that the patient would not tolerate rapid fluctuations in preload, afterload, heart rate and reperfusion syndrome expected in the course of LT. However, if the patient had survived, he would have been at high risk of graft dysfunction.

For all these reasons, using VA-ECMO should be considered the only transplant solution. The purpose of VA-ECMO was to provide temporary cardiopulmonary support in anticipation of a refractory shock state during the various surgical phases, to provide for possible extracorporeal life support during cardiac arrest and to preserve the graft function.

Supplementary references

