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REVIEW ARTICLE

Preoperative Cardiological Assessment in Liver Transplant Candidates

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ABSTRACT

Objectives: This study aims to collect information from the literature on cardiologic assessment in patients who are candidates for liver transplantation (LT) and to present the main findings and evidence related to this topic. **Methods:** This review article collects the evidence available in the literature regarding the importance of cardiological evaluation in patients who are candidates for LT to improve patient selection and care. To prepare this review article, articles published in scientific databases on the PubMed/MEDLINE, LILACS, and SciELO platforms were consulted and selected. **Results:** The coronary artery disease in LT (CAD-LT) score has a high sensitivity for predicting the risk of CAD in patients who are candidates for LT and should be used whenever possible. Currently, coronary angiography remains the gold standard for assessing CAD in these patients. If this test is not indicated, multidetector computed tomography (CT) angiography can be used as a substitute, as it can classify the degree of atherosclerotic lesion, although it is less sensitive. Echocardiography under pharmacological stress with dobutamine can help detect myocardial ischemia and, in particular, investigate heart failure (HF) and other cardiomyopathies, as its sensitivity for CAD is low compared with other tests. **Conclusion:** LT is the second most performed massive viscus transplantation procedure in the world, second only to kidney transplantation. As it is a complex procedure, some complications are possible, with cardiovascular complications being the leading cause of death not related to the graft and the third overall cause of death among patients undergoing LT. Considering the high prevalence of cardiovascular diseases and their presentation as one of the main causes of death worldwide, it is essential that candidates for LT undergo rigorous screening prior to undergoing LT.

Descriptors: Liver Transplantation; Heart Disease; Preoperative.

Avaliação Cardiológica Pré-Operatória em Candidatos ao Transplante de Fígado

RESUMO

Objetivos: O objetivo deste estudo é reunir informações da literatura sobre a avaliação cardiológica em pacientes candidatos ao transplante de fígado (TF) e apresentar os principais achados e evidências relacionadas a esse tema. **Métodos:** Este artigo reúne as evidências disponíveis na literatura acerca da importância da avaliação cardiológica em pacientes candidatos ao TF para aprimorar a seleção e o cuidado desses pacientes. Para a elaboração deste artigo de revisão, foram consultados e selecionados artigos publicados em bases científicas nas plataformas PubMed/MEDLINE, LILACS e SciELO. **Resultados:** O escore de doença arterial coronariana (DAC) em TF apresenta alta sensibilidade para predizer o risco de DAC em pacientes candidatos ao TF e deve ser utilizado sempre que possível. Atualmente, a angiografia coronária permanece como padrão-ouro para a avaliação da DAC nesses pacientes. Caso este exame não seja indicado, a angiotomografia computadorizada multidetectores pode ser utilizada como alternativa, pois permite classificar o grau da lesão aterosclerótica, embora seja menos sensível. A ecocardiografia sob estresse farmacológico com dobutamina pode auxiliar na detecção de isquemia miocárdica e, em especial, na investigação de insuficiência cardíaca e outras cardiomiopatias, já que sua sensibilidade para DAC é inferior à de outros exames. **Conclusão:** O TF é o segundo procedimento de transplante de vísceras maciças mais realizado no mundo, ficando atrás apenas do transplante renal. Por se tratar de um procedimento complexo, algumas complicações são possíveis, sendo as cardiovasculares a principal causa de óbito não relacionado ao enxerto e a terceira causa geral de morte entre os pacientes submetidos ao TF. Considerando a alta prevalência das doenças cardiovasculares e sua

apresentação como uma das principais causas de morte no mundo, é fundamental que os candidatos ao TF sejam submetidos a uma triagem rigorosa antes da realização do transplante.

Descritores: Transplante de Fígado; Doenças Cardíacas; Período Pré-Operatório.

INTRODUCTION

Liver transplantation (LT) is a therapeutic option for selected patients with end-stage liver disease, with precise clinical indications and in combination with therapy to prevent immune rejection. The main indications for LT are related to causes such as hepatocellular carcinoma, hepatitis C, and alcoholic cirrhosis. In addition, current guidelines expand these to fulminant hepatic failure, life-threatening systemic complications of liver disease (e.g., severe coagulopathy and refractory sepsis), liver-based metabolic defects (e.g., familial amyloid polyneuropathy and Wilson's disease), decompensated cirrhosis with complications such as hepatic encephalopathy, ascites, portal-hypertension-related bleeding, or hepatorenal syndrome.[1-3] It should be noted that many patients with liver disease already have significant systemic complications, such as altered renal function, cardiovascular disease (CVD), and coagulopathies.

In this scenario, the selection of patients who are candidates for LT is based on a careful preoperative clinical assessment, evaluating the risks, benefits, and safety of the operation in the intraoperative and postoperative periods, given the adverse scenario of increasing demand for transplant candidates and the limited number of donors.[4]

The etiology of cardiovascular complications in LT candidates goes beyond the hemodynamic effects and blood-volume changes associated with end-stage liver disease and preexisting coronary artery disease (CAD). Immediately after graft implantation, abrupt shifts in cardiac preload and afterload substantially increase myocardial workload.[5] Over the longer term, reduced physical activity, increased appetite, weight gain, and chronic immunosuppressive therapy (notably corticosteroids and calcineurin inhibitors) foster metabolic syndrome and further elevate cardiovascular risk.[5,6] Consequently, cardiac events are now recognized as the third-leading cause of death among LT recipients.[6]

The hemodynamic effects and blood-volume changes associated with LT are the main factors responsible for adverse cardiovascular outcomes in patients with end-stage liver disease and preexisting CAD. It is therefore essential to assess the cardiovascular risk of these patients undergoing the procedure.

RESULTS

The CAD in LT (CAD-LT) score has a high sensitivity for predicting the risk of CAD in patients who are candidates for LT and should be used whenever possible. Currently, coronary angiography remains the gold standard for diagnosing CAD in these patients. If this test is not indicated, multidetector CT angiography can be used as a substitute, as it can classify the degree of atherosclerotic lesion, although it is less sensitive. Similarly, the coronary artery calcium score (CACS) shows lower sensitivity than angiography, but its use can be considered. On the other hand, the use of echocardiography under pharmacological stress with dobutamine can help detect myocardial ischemia and, in particular, investigate heart failure (HF) and other cardiomyopathies, as its sensitivity for CAD is low compared with other tests. Cardiac magnetic resonance imaging (MRI) can be reserved if echocardiographic images are suboptimal. Therefore, given the individuality of each LT candidate, it is suggested that some diagnostic tools, such as electrocardiogram (EKG), echocardiography, treadmill test, angiography, and nuclear tests, may be used separately in the evaluation of these patients. Nonetheless, the presence of limitations of these exams must be considered, and a combination of methods may be used for better evaluation.

DISCUSSION

LT represents a life-saving procedure indicated for patients with end-stage liver disease, fulminant hepatitis, or liver cancer.[7] It offers an alternative to medical therapy for patients with a variety of liver diseases. The main goal of the procedure is to prolong the life of the recipient and thus improve his or her quality of life. Three principles dictate which patients should be referred for and potentially undergo transplant: first, the recipient should have irreversible liver disease that is expected to be fatal without transplantation; second, the patient should have sufficient reserve to survive the operative and perioperative period; third, the candidate should be expected to have significant survival and quality-of-life benefit from LT. The main indications include: acute liver failure; hepatic artery thrombosis within 14 days of LT; cirrhosis with decompensation; Model for End-Stage Liver Disease (MELD) score ≥ 15; hepatopulmonary syndrome or portopulmonary hypertension (PoPH) in selected patients; and primary hepatic neoplasms, hilar cholangiocarcinoma (highly selected, after neoadjuvant therapy protocol), hepatocellular carcinoma

within the Milan criteria; and inborn metabolic conditions, cystic fibrosis with concomitant lung and liver disease, primary hyperoxaluria type I with significant renal insufficiency and familial amyloid polyneuropathy.[8]

Although medical advances have made LT successful and the number of patients on the list is increasing, the availability of organ donors remains extremely limited.[4]

Another factor that makes the procedure difficult is the rigorous evaluation process, which is not only costly and time-consuming but also potentially dangerous if it involves invasive tests. As donated organs remain a scarce resource and the evaluation process for transplantation is complex, it is essential to select the patients who will benefit most from such a procedure.[9] Moreover, it is crucial to identify the specific risk factors and predictors for LT to achieve the best possible graft and patient survival after the procedure.[10]

For more than 30 years, the main predictor of operative risk in patients with cirrhosis has been the Child-Turcotte-Pugh score or Child-Pugh class (CP). Retrospective studies have shown that perioperative mortality and morbidity in patients with cirrhosis correlate well with the Child-Turcotte cirrhosis classifications.[11] Perioperative mortality rates of 10%, 31%, and 76% were observed in 100 patients with predominantly alcohol-associated cirrhosis undergoing abdominal surgery who were CP classes A, B, and C, respectively.[12]

Among the criteria used to determine the need for evaluation for LT, the MELD score has proven effective in assessing short-term mortality in patients with liver disease. The classification evaluates serum bilirubin, serum creatinine, and international normalized ratio (INR).[13] Patients with a MELD score ≥15 are usually candidates for LT. As such, it has become an effective tool for prioritizing patients on LT waiting lists. In 2016, it was updated to include a sodium score (MELD-Na), given the need to assess the risk of hyponatremia and its association with increased mortality.[14]

LT is the second most common major visceral transplantation in the world, after kidney transplantation.[15] Being a complex procedure, some complications are possible, with cardiovascular complications being the leading cause of non-transplant death and the third overall cause of death in patients undergoing LT.[16] The spectrum of cardiovascular events ranges from coronary artery syndromes, cardiomyopathy, or even right HF as a result of PoPH, to arrhythmias, stroke, and pulmonary embolism, as the risk is higher in patients with previous CAD.[17] Consequently, a history of CAD or the presence of traditional risk factors is associated with increased cardiovascular mortality in the perioperative period and within 5 years of transplantation.[18]

Hemodynamic stress and significant volume changes during and after LT are the main factors for adverse cardiovascular outcomes in patients with end-stage liver disease and preexisting CAD.[19] The risk of acute ventricular failure, reduced myocardial contractility, reactive cytokine release, and the hypertensive response to immunosuppressive drugs worsens the hemodynamic condition of the patient.[20] The prevalence of CAD in patients with end-stage liver disease is thought to vary from 2.5% to 27%, which is questionable due to the variation in data and the definition of CAD used in the studies.[21] This highlights the importance of cardiovascular risk stratification in patients with end-stage liver disease, although there is no consensus in the literature regarding the ideal non-invasive cardiac imaging test.[22] An EKG and chest X-ray are recommended to screen for common heart and lung diseases. Cardiac assessment before LT usually includes an assessment of CAD and an assessment of cardiac function by echocardiography.[23,24]

In accordance with the American Heart Association (AHA) guidelines, it is advisable to develop a risk factor-based strategy to exclude patients with CAD when assessing candidates for LT.[25] In this context, Rachwan et al.[26] introduced the CAD-LT score, which, by assessing age, sex, diabetes mellitus, hypertension, smoking, and family and personal history of CAD, allows patients to be stratified into low, intermediate, and high-risk groups, thus aiding in the selection of pretransplant cardiac evaluation methods. In its cohort study of 1,771 patients, the tool showed good accuracy in predicting the risk of significant CAD, with a sensitivity of 97%.[26]

As stated by Rodrigues et al.,[25] CAD-LT was highly sensitive in predicting significant CAD in the patients studied, demonstrating the usefulness and accuracy of the tool in identifying high-risk populations and better guiding preoperative assessment, helping in the choice of tests, and reducing the need for invasive procedures. In addition, the study concludes that coronary angiography integrated with CAD-LT can guide better use of coronary angiography and better selection of patients who really need the procedure, given that it is an invasive method.[25]

The European Association for the Study of the Liver (EASL) guideline suggests initial coronary imaging, invasive or non-invasive, for LT candidates at high risk of significant CAD. LT candidates with non-revascularizable significant CAD (defined by significant CAD, characterized by ≥ 50% stenosis in at least one major coronary artery or ≥ 70% stenosis in a moderate-sized branch vessel) should be considered ineligible for LT. Additionally, all LT candidates must undergo a minimal cardiological evaluation, including EKG and transthoracic echocardiogram (TTE). Coronary computed tomography (CT) angiography is recommended for patients with risk factors for CAD or diabetes mellitus.[27]

The American Association for the Study of Liver Diseases (AASLD) guidelines recommend an initial non-invasive evaluation with echocardiography. For LT candidates with cardiac risk factors (hyperlipidemia, hypertension, diabetes, cigarette consumption,

age > 60 years), non-invasive stress testing and cardiology evaluation are indicated. Cardiac evaluation should assess cardiac risk factors, with stress echocardiography as an initial screening test. Cardiac catheterization, as clinically indicated, and cardiac revascularization should be considered for LT candidates with significant coronary artery stenosis before transplant.[23]

Cardiovascular assessment with pharmacological dobutamine stress echocardiography, although widely used and even recommended by guidelines, has low sensitivity and positive predictive value for detecting CAD in patients with end-stage liver disease.[28] It also has low sensitivity compared with coronary angiography for detecting CAD in LT candidates.[29] Buggs et al.[30] showed that stress echocardiography has a low correlation with coronary angiography and low accuracy in predicting coronary calcification in LT candidates, and may classify patients as low risk who may benefit from cardiac revascularization. Although non-obstructive coronary lesions (coronary stenosis < 50%) are unlikely to be detected by stress echocardiography, it may be useful in the assessment of acute coronary syndromes, such as unstable angina, acute myocardial infarction (AMI), and sudden death.[31] The disadvantages of pharmacological stress echocardiography in patients with end-stage liver disease are the presence of circulatory disturbances, left ventricular (LV) hypercontractility, and the prophylactic use of beta-blockers. It should be noted that pharmacological stress echocardiography has diagnostic limitations in detecting CAD compared with coronary angiography and may indicate inadequate preoperative risk stratification in patients who are candidates for LT.[32] One of the factors limiting pharmacological stress echocardiography is the inability of patients to achieve more than 82% of the maximum predicted heart rate. However, this inability may be a variable that correlates with an increase in cardiovascular events.[33]

Due to the low sensitivity of other imaging modalities for detecting CAD, coronary angiography is still considered the gold standard for assessing CAD in pre-LT patients.[34] Raval et al.[35] showed that in 161 LT candidates who underwent coronary angiography, more than 25% had at least one coronary artery with moderate or severe obstruction. Regardless of the degree of obstruction, Yong et al.[36] reported that the presence of multivessel CAD is one of the most important markers of outcome after LT. In addition, Lee et al.[37] found that 50% of patients with two or more cardiovascular risk factors had CAD on coronary angiography, making it a test to consider in these cases. Furthermore, a single-center retrospective study evaluating three different periods from 2000 to 2010 was able to associate an increase in the rates of coronary angiography and percutaneous coronary intervention with a reduction in the rates of AMI and all-cause death in the 1st year after transplantation, suggesting that a more invasive cardiovascular assessment strategy could be used.[38]

Although individuals with end-stage liver disease often have coagulopathies and altered renal function, the indication for cineangiography may be maintained.[39] It should be noted, however, that patients with concomitant renal disease are at risk of acute renal failure after contrast administration. The most common complications in this population are bleeding, thrombocytopenia, coagulopathy, anemia, renal disease, and the need for hemotransfusion.[40] The preferred access for transplant candidates is the radial artery, as it is associated with lower complication rates and better hemostasis.[41]

In cases where cardiac catheterization is contraindicated, multidetector CT angiography with coronary assessment is a viable option. A prospective study of 65 patients who were candidates for LT without diagnosed CAD showed the presence of atherosclerotic lesions in 91% of patients and was able to classify the lesions as mild, moderate, or severe.[42] Some of the predictors of advanced atherosclerosis, defined as stenosis greater than or equal to 50% in the coronary artery in coronary CT studies, are male gender and the presence of comorbidities such as diabetes mellitus and dyslipidemia.[43] In addition, coronary CT angiography can rule out AMI after LT in patients who are candidates for transplantation and suspected of having CAD, with a negative predictive value of 97.5%. Also, the test can identify those patients who need follow-up coronary angiography to better define coronary anatomy.[44] Nevertheless, limitations of CT angiography with coronary assessment in patients with high calcium scores include the fact that massive plaques in the coronary arteries make it difficult to visualize the lumen, which may lead to errors in interpretation.[45] On the other hand, single-photon emission CT (SPECT) was not effective in detecting CAD in patients with end-stage liver disease, with a sensitivity and specificity of 37% and 63%, respectively, compared with coronary cineangiography.[46]

The coronary artery calcium score (CACS), obtained by CT, is another tool that can help detect CAD in patients who are candidates for LT. Using the Agatston score, it assesses the area and density of calcium deposits in the coronary artery walls, detects and quantifies the presence of calcified plaques, and indicates the risk of CAD and cardiovascular events.[47] Regarding the sensitivity and specificity of the method, a study by Choi et al.[48] analyzing the CACS and its role in the detection of obstructive CAD in transplant candidates showed values of 80% and 62.8%, respectively. Furthermore, according to Pagano et al.,[49] a CACS score ≥ 400 correlates with the occurrence of cardiovascular events after LT surgery. In line with this, Zorzi et al.[50] showed, after analyzing 301 patients, that the incidence of cardiovascular events after surgery was significantly increased in individuals with a high CACS score. In addition, CACS can also be very useful as an exclusion function, as observed in the study by Bhatti et al.,[51] who obtained results showing that a score of less than 346 excluded significant CAD in the population studied. However, this is still a method that has limitations. Kleb et al.[47] point out an important limitation of the CACS when it comes to quantifying the degree of coronary artery stenosis, which may require additional tests such as coronary angiography. As discussed in the study by

Tiwari et al.,[52] the presence of other factors that also have a high CACS score, such as advanced age, may confound the assessment. Therefore, further studies are needed to assess the predictive ability of CACS when it comes to cardiovascular outcomes after LT.[52]

In patients with confirmed CAD, intravascular imaging is beneficial for a better assessment of lesion severity and extension. Although invasive coronary angiography has been regarded as the gold standard, the visual assessment of stenosis severity is imprecise, with angiographic evaluations showing errors in up to 30% of cases due to its limitations, as it offers only a two-dimensional view of a complex three-dimensional structure. Additionally, some lesion-specific characteristics may also complicate physiological evaluation, such as aorto-ostial, left main, and tandem lesions, as well as areas affected by diffuse disease. These particular lesion subsets are examples that can benefit from assessment with the use of intravascular imaging, primarily intravascular ultrasound or optical coherence tomography.[53] By providing detailed insights into the extent and morphology of coronary calcification, these intracoronary imaging techniques are highly valuable, helping in the choice of the most appropriate calcium modification strategy.[54]

Apart from CAD, patients with chronic liver disease who present with pulmonary arterial hypertension (PAH) can also have associated portal hypertension (PoH) with a dysfunction in hepatic hemodynamics. In this scenario, to confirm PoH in combination with PAH, right heart catheterization (RHC) can be performed, especially in candidates for LT. This condition is known as PoPH, and its cause is still unclear.[55] PoPH is defined as the presence of otherwise unexplained precapillary PH in patients with PoH, with or without cirrhotic etiology, which has poor survival rates due to the progression of liver disease and increased pulmonary arterial pressure (PAP), leading to right ventricular failure.[56-58] Considering the prognostic significance of this condition, preoperative cardiopulmonary assessment is crucial for detecting PoPH.[24,57] RHC is the gold standard for the diagnosis of PoPH, and it can evaluate if PoH is complicated by PAH.

RHC is an invasive diagnostic method that measures pressures both in the right heart chambers and in the pulmonary circulation to confirm or rule out the presence of PH. Precapillary PH is defined as a mean PAP (mPAP) ≥ 20 mmHg, a pulmonary artery wedge pressure (PAWP) of < 15 mmHg, and a pulmonary vascular resistance (PVR) > 3 Wood units (WU).[55] In patients undergoing LT, PoPH is estimated to occur in at least 5-8.5% of them. This condition is associated with higher perioperative morbidity and mortality when uncontrolled, and it is considered a contraindication to LT in severe cases.[59]

A recent meta-analysis found that patients undergoing LT with PoPH had higher 1-year post-LT mortality and graft failure rates when compared to candidates without PoPH.[60] As patients with PoPH are often asymptomatic or have non-specific symptoms, international guidelines recommend that all candidates for LT should be screened. Transthoracic echocardiography (TTE) is widely recommended as the initial screening tool, but due to multiple limitations and the inability to distinguish different causes of PAH, RHC remains the gold standard for diagnosing and classifying PoPH.[61] Once a confirmed diagnosis is established, the severity of PoPH should be classified based on the degree of mPAP: mild (20 ≤ mPAP < 35 mmHg), moderate (35 ≤ mPAP < 45 mmHg), and severe (mPAP ≥ 45 mmHg).[58] Current international guidelines recommend different approaches in LT candidates based on the risk stratification.[23] Therefore, when available, RHC plays a key role in the preoperative evaluation of LT.

Furthermore, there is an association between liver disease and alcohol-induced myopathy in many cirrhotic patients who are candidates for transplantation. The prevalence of cardiomyopathy in cirrhotic patients and alcoholics may be as high as 50%, according to some studies. Acute alcohol intoxication has a transient toxic effect on cardiac performance. However, chronic alcohol consumption can cause permanent damage to the heart's ability to contract due to the effects of ethanol and its metabolites. Alcoholic cardiomyopathy is related to the average daily intake and the duration of consumption. When planning surgery for LT, alcohol-induced cardiomyopathy should be suspected in individuals with a history of alcoholism and signs of LV dilatation and HF. Assessment of alcoholic cardiomyopathy in cirrhotic patients is mandatory in candidates with a high index of suspicion and should include echocardiography and assessment of CAD. Tests such as cardiac magnetic resonance and tomography can be used if echocardiographic images are suboptimal.[62]

After these assessments, patients diagnosed with HF with reduced ejection fraction are universally excluded due to high intraoperative mortality.[63] Although practice varies in the assessment of CAD, patients with an abnormal CAD assessment undergo coronary cineangiography, which is the gold standard test for the assessment of CAD and, if necessary, for revascularization.[24] Those who cannot be revascularized are also removed from the LT queue.[63] However, it is still unclear whether CVD and mortality after the procedure represent an exacerbation of the non-obstructive CAD present at the time of transplantation or whether they result from recipients at increased risk of accelerated atherosclerosis, as not all patients who receive a transplant undergo coronary cineangiography.[16,24]

It is known that the risk of CVD increases after LT because patients have a higher risk of developing dyslipidemia, which is an independent predictor of mortality.[16] There are several mechanisms that increase the incidence of dyslipidemia after LT, including corticosteroids, chronic exposure to immunosuppression, weight gain, genetic predisposition, and the development of non-alcoholic fatty liver disease.[4] Additionally, in the follow-up of patients after LT, it is noteworthy that the prevalence rates of

CVD increase with the year of follow-up, with 10.6% in the 1st year, 20.7% in the 5th year, and 30.3% in the 8th year.[64] Also, death due to CVD is the main cause of postoperative mortality in the first 30 days, accounting for 42.1% of the causes.[65]

When it comes to CAD and cardiovascular events after LT, the relationship between the two needs to be better understood. According to Patel et al.,[66] after analyzing 283 patients, 25.4% of whom had cardiovascular events after transplantation, no direct relationship was found between the presence of CAD and cardiovascular outcomes. According to the study, only diabetes was associated with the likelihood of a cardiovascular event occurring within 4 weeks of surgery.[66] However, in a study by Rodrigues et al,[43] the presence of advanced atherosclerosis on coronary angiography by CT is highly significant in predicting the occurrence of cardiovascular events after transplantation.

CONCLUSION

Cardiovascular assessment is an important step in the evaluation of patients undergoing LT. A history of CAD and the presence of multiple risk factors are predictors of cardiovascular mortality in patients undergoing LT. Coronary cineangiography is still considered the gold standard for assessing CAD in pre-LT patients, and this preoperative screening technique is preferable to pharmacological stress echocardiography for cardiac assessment. As a result, the use of CAD screening in transplant candidates is expected to improve surgical success rates and postoperative morbidity and reduce the rate of all-cause cardiovascular events in the 1st year after transplantation. However, accurate prediction of transplant outcomes cannot be achieved without considering donor and graft characteristics alongside recipient evaluation. Factors such as donor age, graft quality (e.g., degree of steatosis), cold ischemia time, and other graft-related variables play a critical role in post-transplant survival and complication rates, and their integration into preoperative risk stratification models may further enhance both patient selection and perioperative management.[67,68]

Finally, we suggest this evaluation flow to guide the appropriate selection of complementary tests to be performed on LT candidates.

In the initial clinical evaluation, a detailed medical history is taken with a focus on identifying cardiovascular risk factors such as advanced age, diabetes mellitus, systemic arterial hypertension, smoking, and dyslipidemia. Additionally, the degree of liver failure is classified using the Child-Pugh score to help estimate surgical risk. The basic cardiovascular investigation includes an EKG, a chest X-ray, and a TTE. The CAD-LT score is applied to the obtained data. This score incorporates variables such as age, sex, diabetes, hypertension, smoking, and family or personal history of CAD. The aim is to stratify patients into low, intermediate, or high cardiovascular risk groups. Patients classified as low risk should undergo clinical follow-up and be referred to the transplant list according to hepatic indication. For intermediate- to high-risk patients, additional noninvasive tests are recommended, such as pharmacological stress echocardiography with dobutamine or coronary CT angiography. If findings suggest significant CAD or if the tests are inconclusive, coronary cineangiography is indicated. It is considered the diagnostic method of choice for evaluating the coronary arteries. Identification of severe coronary lesions not amenable to revascularization is a contraindication to LT and renders the patient ineligible for the procedure.

In addition to a cardiological evaluation, the protocol should include additional investigations. Patients with suspected PoPH should undergo echocardiography screening, with RHC for diagnostic confirmation if necessary. Similarly, alcoholic cardiomyopathy should be considered in patients with a history of chronic alcoholism and investigated with appropriate cardiac imaging tests. In the post-transplant period, it is essential to continuously monitor for cardiovascular complications and dyslipidemia, which are often aggravated by the use of immunosuppressive agents. Controlling cardiovascular risk factors, including diabetes, hypertension, dyslipidemia, and obesity, is critical to achieving better clinical outcomes, optimizing survival, and improving recipients' quality of life.

CONFLICT OF INTEREST

Nothing to declare.

AUTHOR'S CONTRIBUTION

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All dataset were generated or analyzed in the current study.

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