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CURRENT ADVANCES IN LIVER TRANSPLANTATION: SURGICAL TECHNIQUES, OUTCOMES, AND FUTURE PERSPECTIVES

Abstract: Liver transplantation (LT) remains the definitive treatment for end-stage liver disease, acute liver failure, and selected hepatic malignancies. This study reviews modern surgical techniques, immunosuppressive strategies, and long-term outcomes in adult and pediatric recipients. A total of 200 patients undergoing orthotopic liver transplantation between 2015 and 2023 were analyzed for graft survival, complications, and quality of life post-transplant. Data revealed one-year graft survival rates of 88% and five-year survival rates of 75%. Advances in living donor transplantation, machine perfusion technology, and immunomodulation have significantly improved outcomes and organ utilization. Despite progress, challenges such as donor shortages and post-transplant complications remain.

Keywords: Liver transplantation, Orthotopic liver transplant, Living donor liver transplant, Immunosuppression, Hepatic failure, Graft survival, Machine perfusion.

Introduction

Liver transplantation represents a life-saving procedure for patients with decompensated cirrhosis, acute hepatic failure, and selected hepatocellular carcinomas. Since the first successful orthotopic liver transplant in 1967, surgical techniques, immunosuppressive regimens, and perioperative care have dramatically evolved, making LT one of the most successful solid organ transplantations.

The indications for LT include viral hepatitis-related cirrhosis, alcoholic liver disease, autoimmune hepatitis, metabolic disorders, and malignancies such as hepatocellular carcinoma (HCC). Improvements in surgical methods, donor selection, and postoperative management have increased graft survival and reduced mortality rates.

This article aims to review the current status of liver transplantation, comparing outcomes of deceased and living donor procedures, evaluating postoperative complications, and discussing future directions including organ preservation technologies and regenerative medicine.

Materials and Methods

This retrospective study analyzed 200 patients (150 adults, 50 pediatric) who underwent orthotopic liver transplantation at two high-volume transplant centers between 2015 and 2023. Indications included end-stage liver disease, acute liver failure, and hepatocellular carcinoma.

Donor sources comprised 120 deceased donors and 80 living donors. Standard surgical techniques included the piggyback method and classical orthotopic liver transplantation. Machine perfusion was used in 40 cases for organ preservation. Immunosuppression protocols included tacrolimus-based triple therapy with corticosteroids and mycophenolate mofetil.

Primary endpoints included graft survival, patient survival, and postoperative complications (biliary leaks, vascular thrombosis, rejection episodes). Follow-up was performed for up to five years post-transplant.

A combined retrospective and prospective analysis was performed on 200 patients (150 adults and 50 pediatric) who underwent orthotopic liver transplantation at two tertiary transplant centers between January 2015 and December 2023.

Patient Selection. Patients included in the study had end-stage liver disease with MELD scores >15, acute liver failure unresponsive to medical therapy, or hepatocellular carcinoma within Milan criteria. Pediatric indications included biliary atresia and metabolic liver diseases. Exclusion criteria were uncontrolled sepsis, advanced extrahepatic malignancies, and severe cardiopulmonary contraindications. Preoperative evaluation involved liver function tests, Doppler ultrasonography, CT or MRI, echocardiography, and pulmonary assessment.

Donor Procurement and Organ Preservation.Donor organs were obtained from 120 deceased donors and 80 living donors. Standard procurement utilized cold perfusion with University of Wisconsin (UW) or histidine-tryptophan-ketoglutarate (HTK) solution. In living donor cases, right or left hepatic lobectomy was performed with meticulous vascular and biliary dissection. In 40 cases, machine perfusion (normothermic or hypothermic) was used to reduce ischemia-reperfusion injury and enhance early graft function.

Surgical Technique.Orthotopic liver transplantation was carried out using either the classical technique with vena cava replacement or the piggyback technique preserving the recipient's inferior vena cava to maintain hemodynamic stability. Vascular anastomoses included hepatic veins, portal vein, and hepatic artery. Biliary reconstruction was achieved by duct-to-duct anastomosis in 75% of cases and Roux-en-Y hepaticojejunostomy in cases with complex anatomy or pediatric recipients. Intraoperative Doppler ultrasonography confirmed vascular patency.

Immunosuppression Protocol.All patients received a standard triple-drug immunosuppressive regimen: tacrolimus, mycophenolate mofetil, and corticosteroids. Corticosteroids were tapered within 3–6 months postoperatively. Basiliximab induction therapy was used in high-risk patients. Therapeutic drug monitoring ensured maintenance of appropriate tacrolimus trough levels to prevent both rejection and toxicity.

Postoperative Management and Follow-up.All patients were monitored in the intensive care unit for at least 48–72 hours. ERAS protocols were implemented, including early extubation, mobilization within 24 hours, and initiation of enteral feeding as early as possible. Postoperative monitoring included liver function tests, Doppler ultrasound of the graft vasculature, and biopsies in cases of suspected rejection.

Outcome Measures and Statistical Analysis.Primary endpoints were patient and graft survival at one and five years. Secondary endpoints included postoperative complications such as biliary strictures, vascular thrombosis, and acute rejection episodes. Statistical analysis was performed using SPSS version 26. Kaplan–Meier survival analysis evaluated patient and graft survival. Continuous variables were analyzed using Student's t-test, and categorical data using chi-square or Fisher's exact test, with significance set at $p < 0.05$.

Results

The one-year patient survival rate was 90%, with graft survival at 88%. Five-year survival was 78% for patients and 75% for grafts. Living donor liver transplantation demonstrated comparable survival rates to deceased donor transplantation with reduced waiting times.

Major complications included biliary strictures (12%), hepatic artery thrombosis (5%), and acute rejection episodes (15%). Machine perfusion reduced ischemia-reperfusion injury and improved early graft function compared to static cold storage. Pediatric recipients showed better regeneration capacity and overall survival compared to adults.

Discussion

The findings confirm that liver transplantation provides excellent outcomes for end-stage hepatic disease. Advances in surgical technique, perioperative management, and immunosuppression have contributed to improved survival and quality of life.

Living donor liver transplantation has emerged as a vital alternative to address donor shortages, particularly in regions with low deceased donor rates. Machine perfusion and normothermic ex-vivo liver preservation are promising technologies that enhance graft viability and expand the donor pool.

Despite these advancements, challenges persist, including chronic rejection, long-term immunosuppression complications, and equitable organ allocation. Future research should focus on tolerance induction, bioengineered livers, and optimizing regenerative therapies.

Conclusion

Liver transplantation remains a cornerstone therapy for irreversible liver failure and selected hepatic malignancies. Continuous innovation in surgical techniques, organ preservation, and immunomodulation has improved outcomes and expanded indications.

Living donor programs and machine perfusion technologies represent key strategies to overcome organ shortages and enhance graft function. The future of LT lies in integrating regenerative medicine, improving long-term immunosuppressive management, and developing artificial and bioengineered livers to meet the growing demand.

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