J Contemp Healthc Analytics: 2023

The isolated intestinal transplantation (IITx), liver-intestinal transplantation (L-ITx), multivisceral transplantation (MVTx), and modified MVTx

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Abstract

Organ transplantation, an ever-evolving medical field, has introduced various visceral transplantation procedures based on the unique needs of patients with end-stage organ diseases. The choice between four primary procedures — isolated intestinal transplantation (IITx), liver-intestinal transplantation (L-ITx), multivisceral transplantation (MVTx), and modified MVTx — is contingent on specific medical indications, the organs involved, and the nature of the underlying disease. IITx is typically recommended for cases like short bowel syndrome without liver complications or certain vascular thromboses isolated to the intestines. This procedure mainly involves transplanting the donor's small intestine. L-ITx, on the other hand, addresses conditions like short bowel syndrome with liver complications and necessitates the transplantation of both the liver and intestine, demanding extensive vascular modifications. MVTx is a more comprehensive procedure targeting diffuse portomesenteric thrombosis, multi-organ failures, or abdominal tumors affecting multiple organs. This method requires transplantation of multiple

organs like the stomach, liver, pancreas, and small bowel, depending on the specific case. The modified MVTx mirrors the MVTx but is opted for when the liver functions sufficiently and thus, excludes liver transplantation. Deciding among these transplantation options requires a holistic, multidisciplinary approach that takes into account the patient's unique health condition and disease progression. Advancements in surgical techniques, coupled with enhanced post-operative care and modern immunosuppressive regimens, have notably elevated the success rates of these transplantations over the past years.

Keywords: Organ transplantation, Isolated intestinal transplantation (IITx), Liver-intestinal transplantation (L-ITx), Multivisceral transplantation (MVTx), Modified MVTx

Introduction

Organ transplantation is a rapidly advancing medical field that has seen significant innovations over the years, particularly in the realm of visceral transplantation. Visceral transplantation refers to the transplantation of abdominal organs such as the liver, pancreas, and intestines. The development of this specialized area has been driven by the increasing prevalence of end-stage organ diseases, which render the affected organs non-functional and necessitate their replacement for patient survival. Advances in immunosuppressive therapies, surgical techniques, and post-operative care have made it possible to successfully transplant these complex organs with increasing rates of success. The selection criteria for visceral transplantation have also evolved, incorporating a range of factors such as the patient's overall health, the severity of the disease, and the availability of suitable donors, thereby allowing for more personalized treatment plans [1], [2].

The complexity of visceral organs, particularly their intricate vascular and neural connections, poses unique challenges that require specialized surgical expertise. For instance, liver transplantation involves not only the replacement of the liver but also the reconnection of multiple blood vessels and bile ducts. Similarly, intestinal transplantation is complicated by the need to restore both vascular supply and neural connections to ensure proper digestive function. The development of microsurgical techniques and imaging modalities has been instrumental in addressing these challenges. Real-time imaging, such as intraoperative ultrasound, aids in the precise placement and connection of the transplanted organ, thereby reducing the risk of complications such as ischemia or graft failure .

Immunosuppressive therapies have also undergone significant advancements, contributing to the success of visceral transplantation. The introduction of newer

immunosuppressive drugs with fewer side effects and better efficacy has improved the long-term outcomes for transplant recipients. Calcineurin inhibitors, mycophenolate mofetil, and corticosteroids are commonly used in various combinations to prevent graft-versus-host disease and to minimize the risk of organ rejection. Personalized immunosuppressive regimens, guided by pharmacogenomic data, are increasingly being employed to optimize drug dosages and minimize adverse effects, thereby improving the quality of life for the recipients [3], [4].

Post-operative care is another critical component that has seen substantial improvements. The immediate post-transplant period is crucial for monitoring signs of organ rejection, infection, or other complications. Advanced monitoring techniques, such as graft-specific biomarkers and imaging studies, are used to assess the function of the transplanted organ continually. Nutritional support, physical rehabilitation, and psychological counseling are also integral parts of the comprehensive post-operative care that contribute to the overall well-being and recovery of the patient [5].

The field of organ transplantation is also grappling with ethical and logistical challenges, such as organ trafficking and equitable distribution of available organs. Public health initiatives aimed at increasing organ donation rates and the development of artificial or lab-grown organs are some of the strategies being explored to address the shortage of donor organs. Additionally, telemedicine and cross-border collaborations are being utilized to broaden the reach of expertise and resources, thereby making visceral transplantation procedures more accessible to patients worldwide. These multifaceted efforts underscore the dynamic and evolving nature of the field, aimed at improving the outcomes and quality of life for patients with end-stage organ diseases [6].

Different types of visceral transplantations have evolved to cater to the diverse needs of patients suffering from end-stage organ diseases. The choice between various transplantation types—Isolated Intestinal Transplantation (IITx), Liver-Intestinal Transplantation (L-ITx), Multivisceral Transplantation (MVTx), and Modified Multivisceral Transplantation (Modified MVTx)—is contingent upon several factors, including the specific clinical indications, the organs involved, and the underlying pathophysiology of the disease. For instance, IITx is primarily indicated for patients with intestinal failure who do not have liver disease. This procedure involves the transplantation of the small intestine alone and is often considered for patients who have lost intestinal function due to conditions like short bowel syndrome but have a functioning liver.

Table 1. Transplantation, Indications, Surgical Aspects, and Components

Type of Transplantation	Indications	Surgical Aspects	Components	Immunosuppressive Therapy	Post-Operative Care
Isolated Intestinal Transplantation (IITx)	Short Bowel Syndrome (SBS) not complicated by liver disease. Intestinal motility disorders. Vascular thrombosis affecting only the intestines.	Transplantation of the small bowel only. Removal of recipient's remaining intestine unless a functional segment can be anastomosed.	Donor small intestine.	Calcineurin inhibitors, corticosteroids, mycophenolate mofetil.	Monitoring for signs of organ rejection and infection. Nutritional support via parenteral and then enteral nutrition.
Liver-Intestinal Transplantation (L-ITx)	SBS complicated by liver disease due to TPN. Combined end-stage liver and intestinal diseases.	Transplantation of both liver and intestine. Extensive vascular reconstruction.	Donor liver. Donor small intestine.	Combination of calcineurin inhibitors, corticosteroids, and mycophenolate mofetil. Tailored based on specific organs involved.	Intensive monitoring for graft rejection, infection, and other complications. Nutritional support initially via parenteral nutrition, transitioning to enteral.
Multivisceral Transplantation (MVTx)	Diffuse portomesenteric thrombosis. Combined multi-organ failure including liver, intestine, stomach, and sometimes pancreas. Abdominal tumors involving multiple organs.	Transplantation of stomach, liver, pancreas, small bowel, and sometimes other organs. Sophisticated surgical techniques for complex vascular and biliary reconstructions.	Donor stomach. Donor liver. Donor pancreas. Donor small intestine. Other organs as required.	Complex regimen often involving a combination of multiple drugs to prevent rejection across multiple types of tissue.	Highly specialized post-operative care including intensive monitoring and nutritional support.
Modified Multivisceral	Conditions similar to	Similar to MVTx but	Donor stomach.	Tailored to the specific organs	Intensive monitoring for

Transplantation (Modified MVTx)	MVTx but where the liver is functioning adequately and is not included.	excludes liver transplantation. Vascular anastomoses for the transplanted organs.	Donor pancreas. Donor small intestine. Other organs as required but not the liver.	transplanted, typically involving a combination of calcineurin inhibitors, corticosteroids, and mycophenolate mofetil.	signs of graft rejection, infection, and other potential complications. Nutritional support via parenteral and then enteral nutrition.

Liver-Intestinal Transplantation (L-ITx) is another specialized procedure that involves the simultaneous transplantation of the liver and intestine. This is particularly useful for patients who have both liver and intestinal failure, often resulting from conditions like advanced liver cirrhosis complicated by intestinal issues [7]. The complexity of L-ITx is significantly higher than IITx due to the need for dual organ transplantation and the associated vascular and ductal anastomoses. The surgical team must possess expertise in both liver and intestinal transplantation techniques, and the post-operative care involves a more complex immunosuppressive regimen to prevent rejection of both transplanted organs [8], [9].

Multivisceral Transplantation (MVTx) is an even more complex procedure that involves the transplantation of multiple abdominal organs, such as the liver, pancreas, stomach, and intestines [10]. This is typically indicated for patients with multiple organ failure or complex anatomical abnormalities that cannot be addressed by transplanting a single organ. The surgical procedure for MVTx is highly intricate, requiring the coordinated efforts of a multidisciplinary team of surgeons, anesthesiologists, and other medical specialists. Post-operative care is also more complicated, involving the management of multiple organ systems and a highly specialized immunosuppressive regimen.

Modified Multivisceral Transplantation (Modified MVTx) is a variation of MVTx that allows for the transplantation of selected abdominal organs, excluding the liver. This procedure is indicated for patients who have multiple organ failure but possess a functioning liver. The surgical complexity is somewhat reduced compared to MVTx, but the post-operative care still involves intricate management of multiple organ systems. Like MVTx, Modified MVTx requires a multidisciplinary approach for both the surgical procedure and post-operative care. The selection between these different types of visceral transplantations is a complex decision-making process that involves a thorough evaluation of the patient's medical history, current health

status, and the specific organs involved. Advanced diagnostic tools, such as imaging studies and organ function tests, are employed to assess the extent of organ damage and to guide the choice of transplantation type.

Isolated Intestinal Transplantation (IITx)

Isolated Intestinal Transplantation (IITx) is a specialized form of visceral transplantation that focuses solely on the replacement of the small intestine. The primary indications for IITx are quite specific and include conditions such as Short Bowel Syndrome (SBS), which is often the result of extensive bowel resection. In such cases, the remaining intestinal length is insufficient to support adequate nutrient absorption, leading to malnutrition and other complications. Importantly, IITx is considered for these patients only when liver disease is not a complicating factor, as the presence of liver disease would necessitate a more complex, multi-organ transplantation approach [11], [12].

Another key indication for IITx is intestinal motility disorders, such as chronic intestinal pseudo-obstruction. This condition mimics the symptoms of a mechanical obstruction without any physical blockage present in the intestinal lumen. Patients with this disorder experience severe digestive issues, including malabsorption and malnutrition, and often do not respond well to conventional treatments. IITx offers a curative approach by replacing the dysfunctional intestine with a healthy donor organ. The surgical procedure involves the removal of the diseased intestine and the anastomosis of the donor intestine, with careful attention to vascular and neural connections to ensure proper function post-transplantation [13].

Vascular thrombosis affecting the intestines is another condition that may warrant IITx. In these cases, blood clots obstruct the vascular supply to the intestines, leading to ischemia and eventual organ failure. The indication for IITx in the context of vascular thrombosis is highly specific; it is considered only when the thrombosis is localized to the intestines without affecting other abdominal organs. This ensures that the transplantation focuses solely on the affected organ, minimizing surgical complexity and potential complications.

The surgical techniques employed in IITx have evolved over time, incorporating advances in microsurgical methods and imaging technologies. Intraoperative imaging, such as Doppler ultrasound, is often used to confirm adequate blood flow to the transplanted intestine, thereby reducing the risk of post-operative ischemia. Immunosuppressive regimens for IITx are generally less complex than those for multi-organ transplants but still require careful management to prevent graft-versus-

host disease and organ rejection. Commonly used immunosuppressive agents include calcineurin inhibitors, corticosteroids, and mycophenolate mofetil.

Post-operative care following IITx is a critical aspect of the treatment process. Patients are closely monitored for signs of organ rejection, infection, and other complications. Nutritional support is particularly important, as the newly transplanted intestine may take time to fully assume its absorptive functions. A multidisciplinary team, including gastroenterologists, dietitians, and transplant coordinators, is involved in the post-operative care to ensure optimal outcomes and to manage any complications that may arise. This comprehensive approach to patient care underscores the complexity and specialized nature of IITx as a treatment option for specific end-stage intestinal diseases [14].

The surgical aspects of Isolated Intestinal Transplantation (IITx) are highly specialized and focus exclusively on the transplantation of the small bowel. Unlike multi-organ transplant procedures, IITx does not involve the transplantation of other abdominal organs such as the liver or pancreas. The surgical procedure typically necessitates the removal of the recipient's remaining intestine, particularly if it is non-functional due to disease or injury. However, in cases where a functional segment of the recipient's intestine remains, this segment may be preserved and anastomosed, or surgically connected, to the donor intestine. This approach aims to maximize the functional capacity of the digestive system post-transplantation.

The primary component involved in IITx is the donor small intestine. Obtaining a suitable donor organ is a critical step that involves multiple considerations, including blood type compatibility, size match, and the absence of transmissible diseases in the donor. Once a suitable donor intestine is identified, it is harvested with great care to preserve its vascular and neural structures, as these will need to be meticulously reconnected in the recipient to ensure proper function. The harvested donor intestine is then transported under carefully controlled conditions to minimize ischemic time and preserve organ viability.

The surgical procedure for IITx involves several key steps, starting with the removal of the recipient's diseased intestine. This is followed by the preparation of the abdominal cavity to receive the donor intestine. Vascular anastomoses are performed to connect the donor intestine's blood supply to the recipient's vascular system, typically involving the superior mesenteric artery and vein. Ensuring proper blood flow is crucial for the success of the transplant and is often confirmed intraoperatively using imaging techniques like Doppler ultrasound.

Following vascular anastomosis, the next step involves the reconnection of the intestinal lumen, either to a remaining functional segment of the recipient's intestine or to the stomach or colon, depending on the specific clinical scenario. This step is critical for restoring the digestive tract's continuity and is performed using specialized suturing techniques to minimize the risk of post-operative complications such as leaks or strictures [15]. The neural connections are not explicitly reconnected, as they tend to regenerate over time, guided by the inherent properties of the enteric nervous system.

Post-operative care in IITx is focused on monitoring the graft for signs of rejection or ischemia, as well as managing the patient's nutritional needs and immunosuppressive regimen. Immunosuppressive drugs, typically a combination of calcineurin inhibitors, corticosteroids, and mycophenolate mofetil, are administered to prevent graft rejection. Nutritional support is often provided via parenteral nutrition initially, transitioning to enteral nutrition as the transplanted intestine begins to function. The patient's progress is closely monitored through a range of diagnostic tests, including imaging studies and blood tests, to assess graft function and to detect any potential complications at an early stage.

Liver-Intestinal Transplantation (L-ITx)

Liver-Intestinal Transplantation (L-ITx) is a complex surgical procedure that involves the simultaneous transplantation of the liver and the small intestine. This type of transplantation is indicated for a specific subset of patients who have both end-stage liver disease and intestinal failure. One of the primary indications for L-ITx is Short Bowel Syndrome (SBS) complicated by liver disease, often as a result of long-term Total Parenteral Nutrition (TPN). TPN, while life-saving, can lead to liver complications such as steatosis, cholestasis, and eventually cirrhosis, thereby necessitating a dual organ transplant. Another indication for L-ITx is the presence of combined end-stage liver and intestinal diseases, where both organs have failed and single-organ transplantation would not suffice to restore health [16].

The surgical aspects of L-ITx are highly intricate due to the need for dual organ transplantation. Both the liver and the small intestine are harvested from the donor, requiring meticulous surgical technique to preserve the vascular structures of each organ. Once harvested, the organs are transported under strictly controlled conditions to minimize ischemic time. In the recipient, the diseased liver and intestine are removed, and the abdominal cavity is prepared for the transplantation of the donor organs. Vascular anastomoses are performed for both the liver and the intestine, often involving the hepatic artery, portal vein, and superior mesenteric

artery and vein. The complexity of these vascular connections requires a high level of surgical expertise and is often guided by intraoperative imaging techniques [17], [18].

Following the vascular anastomoses, the next steps involve the reconnection of the biliary and intestinal lumens. For the liver, the bile duct is connected to the recipient's bile duct or to a segment of the small intestine, a procedure known as a Roux-en-Y hepaticojejunostomy. For the small intestine, the lumen is either anastomosed to a remaining functional segment of the recipient's intestine or to the stomach or colon, depending on the clinical scenario. These anastomoses are critical for restoring the functional continuity of the digestive and hepatic systems.

Immunosuppressive therapy in the context of L-ITx is particularly complex due to the need to prevent rejection of two different organs. A combination of immunosuppressive agents, including calcineurin inhibitors, corticosteroids, and mycophenolate mofetil, is commonly used. The regimen may be further tailored based on pharmacogenomic data and monitored through regular blood tests to assess drug levels and efficacy. Given the complexity of managing dual organ transplants, a multidisciplinary team involving hepatologists, gastroenterologists, transplant surgeons, and other specialists is essential for optimal patient care.

Post-operative management in L-ITx is a critical phase that requires intensive monitoring and specialized care. Patients are closely observed for signs of graft rejection, infection, and other complications such as bleeding or thrombosis. Advanced diagnostic tools, including liver function tests, imaging studies, and graft-specific biomarkers, are employed to continually assess the function of the transplanted organs. Nutritional support is also a key component of post-operative care, often starting with parenteral nutrition and transitioning to enteral nutrition as the patient's condition stabilizes. This comprehensive approach to post-operative care is vital for the successful outcome of L-ITx procedures.

Liver-Intestinal Transplantation (L-ITx) is a highly specialized surgical procedure that involves the simultaneous transplantation of both the liver and the small intestine. The complexity of this dual organ transplantation necessitates a multidisciplinary approach, involving hepatologists, gastroenterologists, and highly skilled transplant surgeons. One of the most challenging aspects of L-ITx is the requirement for extensive vascular reconstruction. Both the liver and the small intestine have intricate vascular networks that must be carefully anastomosed to the

recipient's vascular system. This involves connections to major vessels such as the hepatic artery, portal vein, superior mesenteric artery, and superior mesenteric vein. The precision required for these vascular anastomoses is considerable and often employs advanced imaging techniques like intraoperative Doppler ultrasound to ensure successful blood flow to the transplanted organs.

The primary components in L-ITx are the donor liver and the donor small intestine. These organs are harvested from the donor simultaneously, and great care is taken to preserve the vascular and biliary structures for both. The harvested organs are then transported under controlled conditions to minimize ischemic time, which is the period during which the organs are without a blood supply. Once in the operating room, the recipient's diseased liver and intestine are removed to make way for the donor organs. The abdominal cavity is prepared with meticulous attention to the vascular and biliary structures that will need to be reconnected.

The surgical procedure for L-ITx is sequenced in a manner that first focuses on the vascular anastomoses. The donor liver is usually placed first, with connections made to the hepatic artery and portal vein. Following this, the donor small intestine is positioned, and its vascular supply is connected to the recipient's superior mesenteric artery and vein. Given the complexity of these vascular connections, a team of surgeons often works in a coordinated manner to ensure that each anastomosis is performed with the highest level of precision [19], [20].

After the vascular connections are secured, the next step involves the reconnection of the luminal structures. For the liver, this involves anastomosing the donor and recipient bile ducts, which is critical for the drainage of bile and the overall function of the liver. For the small intestine, the luminal anastomosis involves connecting the donor intestine to either a remaining segment of the recipient's intestine or to another part of the digestive tract, such as the stomach or colon. These luminal connections are vital for restoring the functional continuity of the digestive system.

Post-operative care in L-ITx is particularly intensive due to the transplantation of two major organs. Immunosuppressive therapy is complex and often involves a combination of multiple drugs to prevent rejection of both the liver and the intestine. Monitoring for complications such as graft rejection, infection, or vascular thrombosis is continuous and employs a range of diagnostic tools, including liver function tests, imaging studies, and endoscopic evaluations. Nutritional support, initially through parenteral routes and gradually transitioning to enteral nutrition, is

another critical aspect of post-operative care. The management of patients undergoing L-ITx thus requires a comprehensive, multidisciplinary approach to ensure successful outcomes.

Multivisceral Transplantation (MVTx)

Multivisceral Transplantation (MVTx) is an advanced surgical procedure that involves the transplantation of multiple abdominal organs, often including the liver, intestine, stomach, and sometimes the pancreas. This procedure is indicated for a range of complex medical conditions that affect multiple organs simultaneously. One such indication is diffuse portomesenteric thrombosis, a condition characterized by extensive clotting in the portal and mesenteric veins, leading to compromised blood flow to multiple abdominal organs. Another key indication for MVTx is combined multi-organ failure, where diseases or conditions have led to the simultaneous failure of the liver, intestine, stomach, and occasionally the pancreas. Additionally, MVTx is considered for patients with abdominal tumors that involve multiple organs and cannot be effectively treated through resection or other localized therapies.

The surgical aspects of MVTx are highly complex due to the involvement of multiple organs, each with its own set of vascular and luminal connections. The procedure begins with the harvesting of the required organs from the donor, which is a meticulous process that aims to preserve the vascular integrity of each organ for successful transplantation. Once harvested, the organs are transported under controlled conditions to minimize ischemic time. In the recipient, the diseased or non-functional organs are removed, and the abdominal cavity is prepared for the transplantation of the donor organs. Given the multiple organs involved, extensive vascular reconstruction is often required. This includes anastomoses involving major vessels such as the hepatic artery, portal vein, superior mesenteric artery, and superior mesenteric vein, among others [21].

After the vascular anastomoses are completed, the next step involves the luminal anastomoses for each organ. For the liver, this typically involves connecting the bile ducts; for the intestine, the luminal continuity is restored either by connecting it to a remaining functional segment or to another part of the digestive tract. If the stomach is involved, it may be connected to the esophagus and the small intestine, and if the pancreas is included, its duct may be connected to the small intestine as well. The complexity of these connections requires a high level of surgical expertise and often involves a team of surgeons specializing in different aspects of abdominal organ transplantation [22], [23].

Immunosuppressive therapy in the context of MVTx is particularly challenging due to the need to prevent rejection across multiple types of tissue. A combination of immunosuppressive agents is typically used, including calcineurin inhibitors, corticosteroids, and mycophenolate mofetil. The regimen is often tailored based on the specific organs involved and may be adjusted over time based on the patient's response and any signs of graft rejection or other complications. Given the complexity of managing multiple transplanted organs, a multidisciplinary team involving hepatologists, gastroenterologists, endocrinologists, and other specialists is often required for comprehensive post-operative care [24].

Post-operative management in MVTx is intensive and involves close monitoring for a range of potential complications, including graft rejection, infection, and vascular or luminal complications. Advanced diagnostic tools, such as imaging studies, endoscopic evaluations, and organ-specific function tests, are employed to continually assess the status of the transplanted organs. Nutritional support is also a critical component of post-operative care, often starting with parenteral nutrition and transitioning to enteral nutrition as the patient's condition stabilizes. Given the complexity and high stakes involved in MVTx, the approach to patient care is highly coordinated and involves specialists from multiple disciplines to optimize outcomes.

Multivisceral Transplantation (MVTx) involves the simultaneous transplantation of multiple abdominal organs such as the stomach, liver, pancreas, and small intestine. In certain cases, additional organs may also be included based on the specific medical indications. The surgical aspects of MVTx are highly intricate, demanding sophisticated surgical techniques and expertise in multiple areas of abdominal organ transplantation. One of the most challenging elements of the procedure is the complex vascular and biliary reconstructions required to ensure the viability and functionality of the transplanted organs. Vascular anastomoses may involve major vessels like the hepatic artery, portal vein, superior mesenteric artery, and superior mesenteric vein, among others. Biliary reconstructions are also often necessary, particularly when the liver is one of the transplanted organs.

The components involved in MVTx are multiple and vary depending on the specific needs of the patient. These typically include a donor stomach, liver, pancreas, and small intestine. Additional organs may also be harvested and transplanted as required by the patient's medical condition. Each of these organs is harvested from the donor with meticulous care to preserve their vascular and luminal structures, which are critical for successful transplantation. Once harvested, the organs are transported

under strictly controlled conditions to minimize the time they spend without a blood supply, known as ischemic time.

In the operating room, the recipient's diseased or non-functional organs are removed to prepare the abdominal cavity for the incoming donor organs. Given the multiple organs involved, the surgical procedure is often lengthy and requires a coordinated effort from a multidisciplinary surgical team. The vascular anastomoses are usually performed first, connecting the blood supply of each donor organ to the corresponding vessels in the recipient. The complexity of these vascular connections requires advanced surgical techniques and is often guided by intraoperative imaging to ensure accurate placement and adequate blood flow [25], [26].

Following the vascular anastomoses, the next step involves the luminal and biliary reconstructions. For the liver, this involves connecting the bile ducts to restore biliary drainage. The stomach, if transplanted, is connected to the esophagus and the small intestine to restore gastrointestinal continuity. The pancreas, if included, may have its duct connected to the small intestine to facilitate digestive enzyme secretion. Each of these steps is performed with great precision to minimize the risk of post-operative complications such as leaks, strictures, or thrombosis.

Post-operative care in MVTx is highly specialized due to the complexity of managing multiple transplanted organs. A tailored immunosuppressive regimen is administered, often involving a combination of calcineurin inhibitors, corticosteroids, and mycophenolate mofetil, to prevent graft rejection. Patients are closely monitored for signs of organ rejection, infection, and other potential complications using a range of diagnostic tools, including imaging studies, blood tests, and endoscopic evaluations. Nutritional support is also a critical component, usually beginning with parenteral nutrition and transitioning to enteral feeding as the patient stabilizes. Given the high complexity and potential risks involved in MVTx, a multidisciplinary approach involving specialists from various medical fields is essential for successful outcomes [27].

Modified Multivisceral Transplantation (Modified MVTx)

Modified Multivisceral Transplantation (Modified MVTx) is a specialized form of organ transplantation that involves the replacement of multiple abdominal organs, excluding the liver. This procedure is indicated for patients with conditions similar to those warranting Multivisceral Transplantation (MVTx), such as diffuse portomesenteric thrombosis, multi-organ failure, or abdominal tumors involving multiple organs. However, Modified MVTx is specifically chosen when the liver is still functioning adequately and does not require transplantation. This distinction is

crucial, as it reduces the complexity of the surgical procedure and the post-operative management to some extent, given that the liver is a critical organ with complex vascular and biliary connections.

The surgical aspects of Modified MVTx are similar to those of MVTx but are somewhat simplified due to the exclusion of the liver. The procedure involves the transplantation of organs such as the stomach, pancreas, and small intestine, among others, depending on the specific medical indications. Each of these organs is harvested from the donor with great care to preserve their vascular and luminal structures. Once harvested, the organs are transported under controlled conditions to minimize ischemic time. In the recipient, the diseased or non-functional organs are removed, and the abdominal cavity is prepared for the transplantation of the donor organs. Vascular anastomoses are performed to connect the blood supply of each donor organ to the corresponding vessels in the recipient, often involving major vessels like the superior mesenteric artery and vein.

Following the vascular anastomoses, the luminal anastomoses are performed. For the stomach, this involves connecting it to the esophagus and the small intestine to restore gastrointestinal continuity. If the pancreas is included in the transplant, its duct may be connected to the small intestine to facilitate the secretion of digestive enzymes. These luminal connections are critical for restoring the functional continuity of the digestive system and require specialized surgical techniques to minimize the risk of post-operative complications such as leaks or strictures [28], [29].

Immunosuppressive therapy in the context of Modified MVTx is tailored to the specific organs transplanted. A combination of immunosuppressive agents is typically used, including calcineurin inhibitors, corticosteroids, and mycophenolate mofetil. The regimen is designed to prevent graft rejection while minimizing the risk of complications such as infections or malignancies. Given that the liver is not involved in Modified MVTx, the immunosuppressive regimen may be less complex than that for MVTx, but it still requires careful management and monitoring to ensure successful outcomes [30]–[32].

Post-operative care in Modified MVTx involves intensive monitoring for signs of graft rejection, infection, and other potential complications [33], [34]. Diagnostic tools such as imaging studies, blood tests, and endoscopic evaluations are employed to assess the function and integrity of the transplanted organs continually. Nutritional

support is also a key component of post-operative care, often starting with parenteral nutrition and transitioning to enteral nutrition as the patient's condition stabilizes [34], [35]. Given the complexity of managing multiple transplanted organs, a multidisciplinary team involving gastroenterologists, endocrinologists, and other specialists is often required for comprehensive post-operative care.

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