UPDATED PROTOCOLS FOR ANESTHESIA IN TRANSPLANTATION SURGERY: A LITERATURE REVIEW

ABSTRACT

The human body is a complex working machinery. There is a lot that goes on within the body of a human being. However, the secret to its success lies in the fact that despite dealing with several stressful events, noxious stimuli, and infectious micro-organisms that are otherwise waiting to take over the body, its defense system and immune functioning do not let anything harmful slide by. It is always due to the diligent working of these complex fighting mechanisms that take care of all the noxious stimuli and ensure that the body keeps working smoothly and as effectively as ever. However, in extreme cases, things turn so negatively that the body's organs and entire organ systems might be compromised. There are several underlying causes that lead up to this sequelae, however, the most common causes are the failure of these organs due to impending conditions that have been building up and causing other complications in the affected patient's body for so long. Although replacing body organs is not as easy as surgically removing them, there are transplantation options available for several body organs. Bone marrow, liver, kidney, and heart are among the most commonly transplanted organs. However, there is an extensive criteria that needs to be fulfilled when opting for transplantation in an affected patient. Only if a patient fulfills all the carefully selected criteria is when they are given a clearance to proceed with the procedure. Just like this criteria, various other steps need to be assured as well in context of the operating teams, surgeons, and the anesthetic procedures. This review aims to deal with the perspective of anesthesia in patients undergoing transplantation surgeries. This review will

go into the details of how an anesthesia is chosen for a particular patient, depending upon the complexity of their procedure. This, in turn, would help in educating the new physicians and anesthetists to become aware of how things proceed after a patient is kept on-list for a transplantation procedure.

Keywords: transplantation, anesthesia, choice of anesthesia, heart transplantation, kidney transplantation, liver transplantation.

INTRODUCTION

While organ transplantation might be a life-saving modality for people with life-threatening illnesses, it is not always possible to eliminate the risks that arise with the possibility of undergoing this surgery. As time is progressing and newer changes are being made in the field of science and technology, the world of transplantation is seeing and achieving new heights with every passing day. Now, there are more chances of success and lesser chances of failure and complications due to the extensive screeningprotocols. However, all these factors are still subjected to an individual's condition and vary from person to person. (1)

However, from a general perspective, the field of organ transplantation holds an important position within the global medical landscape. It serves as a crucial therapeutic modality for the preservation and extension of lives across a diverse spectrum of clinical disorders. (2)

While kidney, heart, liver, lung, and pancreas transplantations are well-recognized, there exist lesser-discussed yet equally significant transplantations involving small bowel, skin, ligaments, bones, and cornea, all of which contribute to the amelioration of temporary or permanent clinical conditions. (3)

In a broader context, organ transplantation stands as a broad term encompassing all features of medical advancement, offering a myriad of benefits: life-saving intervention, prolonged survival, and a marked enhancement in the overall quality of life.

Comment [MF1]: reference

Notably, kidney transplantation has emerged as a shining example within this realm, demonstrated by its superior survival rates in comparison to conventional hemodialysis, coupled with a substantial improvement in the patient's quality of life.

Comment [MF2]: reference

However, it is important to note that the orchestration of these intricate procedures predominantly falls under the purview of regional or national allocation programs. These programs are responsible for setting the precedence in organ allocation, while simultaneously furnishing indispensable logistical support and laboratory infrastructure, which are indispensable components in ensuring the success of the transplantation process.(4)

The 'other side' of transplantation surgery is not hidden from the world too. In fact, it is because of the very existence of this side of the story that many people are reluctant to explore this option for saving their life. The shortage of available organs and the uncertainty of finding a suitable organ donor is among the prevalent issues that creates hurdles for the people who are waiting to get a transplant done. (5)

For an example, data from the Scientific Registry of Transplant Recipients reveals a stark contrast over a decade. In 1999, the waiting list for kidney transplantation in the United States encompassed approximately 40,000 individuals. However, by 2009, this figure had surged to nearly 83,000 individuals, yet only 16,500 patients actually received a kidney transplant.(6)

This dilemma is not unique to the United States; it is a global concern. Concurrently, the number of kidney transplants from deceased donors experienced a decrease from 87 to 65 during the

same period. These statistics underscore the widening chasm between the demand for organs and their limited availability.(7)

OPTIMIZING PRE-ANESTHESIA WORKUP IN ORGAN TRANSPLANTATION

For the sake of convenience and relevance, the discussion of this article will remain within the scope of anesthesia choices in organ transplantation surgery. It is not a hidden fact that anesthesia in itself is a very broad spectrum term when it comes to any surgery at the end of the day. It is due to several factors involved in the induction of a safe and effective anesthesia that make the surgery of a patient possible.

However, in the context of organ transplantation and anesthesia, the journey usually starts with a comprehensive preoperative evaluation and optimization. This begins as soon as an individual becomes a potential organ recipient. This initial assessment is highly important in its contribution to the reduction of perioperative complications and the enhancement of both graft and recipient survival.

During this phase, the recipient undergoes meticulous screening to identify potential contraindications. Malignancies, active infections, and various viral pathogens are scrutinized, including HIV, hepatitis, Epstein-Barr virus, and cytomegalovirus. (7)

Tailored testing protocols are designed based on comorbidities such as coronary artery disease, peripheral artery disease, and cerebrovascular accidents. Additionally, the gathering of crucial medical history information, including allergies, prior solid organ transplantations, blood transfusions, and pregnancies, is indispensable. (8)

This evaluation aids in assessing the recipient's antibody load and guides the formulation of an appropriate immunosuppression regimen. One point that is worth mentioning over here is the potential allergy to rabbit serum, as thymoglobulin, a commonly used immunosuppressant, is

derived from rabbit serum. Further tests are performed in accordance with institutional protocols, ensuring a comprehensive evaluation.(9)

This rigorous assessment is not a one-time endeavor; it requires subsequent evaluations at two-year intervals, with more frequent assessments if there are changes in the recipient's clinical status.

In cases where coronary revascularization is necessitated, a multidisciplinary evaluation is paramount.(10) This collaborative team assesses the timing and type of intervention required, taking into account various factors. The duration of a dual antiplatelet regimen post-revascularization is carefully determined, with minimum periods ranging from four weeks for balloon angioplasty, three months for bare-metal stents, and six to twelve months for drug-eluting stents. While no strict guidelines exist for pulmonary function testing, individuals with uncontrolled chronic obstructive pulmonary disease (COPD), asthma, or interstitial lung disease (ILD) are typically deemed unsuitable candidates for organ transplantation.(11)

Pancreatic transplantation candidates, generally younger and with fewer comorbidities, are not without unique considerations. They may face an elevated risk of micro and macrovascular complications owing to underlying diabetes mellitus.(12)

If the recipient remains eligible for transplantation and a suitable organ becomes available, the surgical phase is meticulously planned. A thorough preoperative assessment is conducted, encompassing airway examination, investigation into bleeding or clotting disorders, prior anesthesia exposure, anesthesia-related complications, and a family history of anesthesia complications. Identification and management of drug allergies are critical to avert intraoperative adverse reactions. Consent for blood and blood product transfusions, history of previous blood transfusions, and any adverse reactions must be diligently recorded. (13)

In cases involving permanent pacemakers or defibrillators, the device should be examined before surgery by a company representative. Skilled personnel must be present throughout the surgical procedure to manage the device and restore its settings to baseline upon completion. This meticulous preoperative evaluation ensures the safety and success of the transplantation process. (14)

UPDATED PROTOCOLS FOR ANESTHESIA DURING ORGAN TRANSPLANTATION

It is vital to note that the utilization of various monitoring and diagnostic tools is paramount to ensure the patient's safety and also to optimize the procedure's success.

Liver Transplant:

Since liver transplantation is one of the most commonly performed transplantation surgeries, it is benign used as an example here to illustrate how anesthesia and its related protocols are carried out in the operating room once a patient has been brought in there. (14)

Central line insertion serves as a fundamental practice, facilitating central venous pressure (CVP) monitoring and vasopressor infusion. Additionally, a second central line or large-bore peripheral cannula may be employed to enable rapid blood and fluid infusion when necessary. In cases of patients with pulmonary hypertension (PHT), the introducer sheath can be instrumental for pulmonary artery (PA) catheter placement, providing continuous monitoring for this specialized group. (15)

Furthermore, the insertion of invasive arterial lines is considered a gold standard during liver transplantation (LT). Typically, these arterial lines are placed after induction, and the specific number can vary depending on the protocols followed by different transplantation centers.(16)

Arterial lines may be inserted into the radial artery; however, it is worth noting that such measurements may underestimate aortic pressure in cases of hypotension, high-dose vasopressor use, or after graft reperfusion. For more accurate blood pressure measurements, some centers opt to insert a second line into the femoral or brachial artery.(17)

The assessment of cardiac output (CO) holds substantial importance during LT. Some transplantation centers employ pulse contour analysis to monitor stroke volume variation and guide fluid management. These methods require periodic calibration through thermo-dilution techniques and offer the advantage of calculating essential preload parameters. Notably, the insertion of a Swan-Ganz catheter is deemed mandatory for recipients with pulmonary hypertension.(18)

Transesophageal echocardiography (TEE) is not routinely used during liver transplantation but can serve as an invaluable diagnostic tool when investigating potential causes of cardiovascular collapse, including PHT, hypovolemia, myocardial depression, clot or air embolism. (19)

It can also rapidly assess the performance of veno-venous bypass, contractility, and the presence of pericardial or pleural effusions. However, it is essential to exercise caution, particularly in recipients with recent esophageal banding and grade III/IV esophageal varices, as TEE insertion may carry risks.(20)

In the interest of patient safety, all invasive monitoring procedures should be conducted in adherence to well-established protocols to minimize the risk of complications such as hematomas. Ultrasound monitoring is now the preferred method accompanying catheter insertion, further enhancing safety. While the incidence of complications related to invasive monitoring is generally low, the potential for severe complications, particularly infections at the femoral site, underscores the importance of vigilance.

Comment [MF3]: reference

Neurologic monitoring plays a significant role in guiding anesthesia management and decision-making during liver transplantation. Bispectral index (BIS) is commonly used to gauge anesthetic depth, whether in total intravenous anesthesia (TIVA) or inhalational techniques. Research has demonstrated that BIS monitoring can mitigate intraoperative awareness by facilitating the titration of anesthetic requirements.(21)

This approach is particularly valuable in patients with acute liver failure (ALF), who may present with increased intracranial pressure (ICP). Cerebral oximetry is another tool utilized during liver transplantation, shedding light on impaired cerebral autoregulation, cerebral deoxygenation during the anhepatic phase, and hyperoxygenation after graft reperfusion.

Jugular venous oxygen saturation (SjvO2) monitoring is crucial in ALF patients, offering insights into the balance between oxygen uptake and consumption.

Neuromuscular monitoring is pivotal for fast track anesthesia, facilitating the diagnosis of residual neuromuscular blockade and diminished pharyngeal tonus. Its implementation significantly reduces perioperative complications in LT patients.(22)

Other critical parameters demand continuous monitoring throughout the transplantation procedure. Hourly diuresis assessments ensure renal function remains optimal, especially in scenarios where some centers may choose to clamp the vena cava. Constant evaluations of hemoglobin, hematocrit, electrolytes, base excess, and lactate are essential, aiding anesthetists in making well-informed decisions regarding patient management. Furthermore, viscoelastic testing is increasingly favored for guiding coagulation management, with tests tailored to each patient's specific bleeding status.

Comment [MF4]: reference

Kidney Transplantation:

Moreover, in the case of kidney transplantation, the application of regional anesthesia in patients undergoing surgical procedures for end-stage renal disease requires a meticulous consideration of multiple factors. These include the patient's uremic bleeding tendency, the influence of residual heparin administered during dialysis, platelet function alterations, depletion of coagulation factors, and the expected duration of surgery. (23)

While a combined spinal-epidural technique offers the advantage of swift onset and effective muscle relaxation through spinal anesthesia, coupled with supplementary analgesia via epidural administration during and post-surgery, many medical centers predominantly favor the use of balanced general anesthesia. This preference arises from the capacity of general anesthesia to maintain stable hemodynamics, provide superior muscle relaxation, and ensure a predictable depth of anesthesia.(24)

Monitoring during such procedures should adhere to standard guidelines, although patients with more advanced comorbid conditions may necessitate more extensive surveillance, including continuous arterial pressure or central venous pressure (CVP) monitoring.

For individuals with severe comorbidities, such as symptomatic coronary artery disease or a history of congestive heart failure, additional monitoring techniques like pulmonary artery catheters or transesophageal echocardiography are recommended. Stringent aseptic measures must be upheld throughout the procedure to minimize the risk of infections.(25)

The risk of aspiration during anesthesia induction necessitates a rapid sequence induction protocol with the maintenance of cricoid pressure to safeguard the airway. To minimize drug-induced hypotension, induction drugs should be administered slowly. Patients with end-stage renal disease exhibit an increased vulnerability to hypotension during induction due to the attenuation of the sympathetic nervous system, diabetic autonomic neuropathy, blood-brain

barrier disruption, elevated levels of unbound drugs, and heightened central nervous system sensitivity. In routine circumstances, anesthetists may utilize drugs such as propofol, thiopentone, or etomidate for induction.(26)

CONCLUSION

Although organ transplantation is a complicated procedure in itself, there are several other possibilities that make it an even more complex process.

The most important ones are the choice and induction of anesthesia. It is important to proceed with a safe and effective means of anesthesia, without compromising any aspect of the patient's life.

Thanks to the wonderful advances in medical science, anesthetists are now capable of opting for the right choice of anesthesia for patients who are about to undergo transplantation.

REFERENCES

Comment [MF5]: doi?? Reference 4without year

1. Grinyó JM. Why Is Organ Transplantation Clinically Important? Cold Spring Harb Perspect Med. 2013 Jun;3(6):a014985.
2. INSERM Collective Expertise Centre. Organ Transplantation: Research perspectives [Internet]. Paris (FR): Institut national de la santé et de la recherche médicale; 2008 [cited 2023 Oct 14]. (INSERM Collective Expert Reports). Available from: http://www.ncbi.nlm.nih.gov/books/NBK24616/
3. Bezinover D, Saner F. Organ transplantation in the modern era. BMC Anesthesiol. 2019 Mar 4;19:32.
4. Nordham KD, Ninokawa S. The history of organ transplantation. Proc Bayl Univ Med Cent. 35(1):124–8.
5. Al-Bar MA, Chamsi-Pasha H. Organ Transplantation. In: Contemporary Bioethics: Islamic Perspective [Internet] [Internet]. Springer; 2015 [cited 2023 Oct 14]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK500177/
6. Vanholder R, Domínguez-Gil B, Busic M, Cortez-Pinto H, Craig JC, Jager KJ, et al. Organ donation and transplantation: a multi-stakeholder call to action. Nat Rev Nephrol. 2021;17(8):554–68.

7. Beyar R. Challenges in Organ Transplantation. Rambam Maimonides Med J. 2011 Apr 30;2(2):e0049.

8. O'Donnell FT. Preoperative Evaluation of the Surgical Patient. Mo Med. 2016;113(3):196–201.

9. Admass BA, Ego BY, Tawye HY, Ahmed SA. Preoperative investigations for elective surgical patients in a resource limited setting: Systematic review. Ann Med Surg. 2022 Sep 23;82:104777.

10. Hall A, Pike A, Patey A, Mortazhejri S, Inwood S, Ruzycki S, et al. Barriers to reducing preoperative testing for low-risk surgical procedures: A qualitative assessment guided by the Theoretical Domains Framework. PLOS ONE. 2022 Dec 8;17(12):e0278549.

11. Bock M, Fritsch G, Hepner DL. Preoperative Laboratory Testing. Anesthesiol Clin. 2016 Mar;34(1):43–58.

12. Bahar SG, Devulapally P. Pancreas Transplantation. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2023 [cited 2023 Oct 14]. Available from: http://www.ncbi.nlm.nih.gov/books/NBK562338/

13. Vitin AA. Perioperative Care for Organ Transplant Recipient: Time for Paradigm Shift. J Crit Care Med. 2019 Aug 9;5(3):87–9.

14. Nandhakumar A, McCluskey SA, Srinivas C, Chandy TT. Liver transplantation: Advances and perioperative care. Indian J Anaesth. 2012;56(4):326–35.

15. Singh S, Nasa V, Tandon M. Perioperative Monitoring in Liver Transplant Patients. J Clin Exp Hepatol. 2012 Sep;2(3):271–8.

16. Brezeanu LN, Brezeanu RC, Diculescu M, Droc G. Anaesthesia for Liver Transplantation: An Update. J Crit Care Med. 2020 May 6;6(2):91–100.

17. Rudnick MR, Marchi LD, Plotkin JS. Hemodynamic monitoring during liver transplantation: A state of the art review. World J Hepatol. 2015 Jun 8;7(10):1302–11.

18. Biais M, Nouette-Gaulain K, Cottenceau V, Vallet A, Cochard JF, Revel P, et al. Cardiac output measurement in patients undergoing liver transplantation: pulmonary artery catheter versus uncalibrated arterial pressure waveform analysis. Anesth Analg. 2008 May;106(5):1480–6, table of contents.

19. De Pietri L, Mocchegiani F, Leuzzi C, Montalti R, Vivarelli M, Agnoletti V. Transoesophageal echocardiography during liver transplantation. World J Hepatol. 2015 Oct 18;7(23):2432–48.

20. Feltracco P, Biancofiore G, Ori C, Saner FH, Della Rocca G. Limits and pitfalls of haemodynamic monitoring systems in liver transplantation surgery. Minerva Anestesiol. 2012 Dec;78(12):1372–84.

21. Cao YH, Chi P, Zhao YX, Dong XC. Effect of bispectral index-guided anesthesia on consumption of anesthetics and early postoperative cognitive dysfunction after liver transplantation: An observational study. Medicine (Baltimore). 2017 Sep;96(35):e7966.

22. Trzebicki J, Flakiewicz E, Nowakowski P, Kosieradzki M, Lisik W, Chmura A. Is external jugular venous pressure a good predictor of volume status in kidney graft recipients? Transplant Proc. 2009 Oct;41(8):3033–5.

23. Baxi V, Jain A, Dasgupta D. Anaesthesia for Renal Transplantation: An Update. Indian J Anaesth. 2009 Apr;53(2):139–47.

24. Srivastava D, Tiwari T, Sahu S, Chandra A, Dhiraaj S. Anaesthetic Management of Renal Transplant Surgery in Patients of Dilated Cardiomyopathy with Ejection Fraction Less Than 40%. Anesthesiol Res Pract. 2014;2014:525969.

25. Ricaurte L, Vargas J, Lozano E, Díaz L, Organ Transplant Group. Anesthesia and kidney transplantation. Transplant Proc. 2013 May;45(4):1386–91.

26. Jaszczuk S, Natarajan S, Papalois V. Anaesthetic Approach to Enhanced Recovery after Surgery for Kidney Transplantation: A Narrative Review. J Clin Med. 2022 Jun 15;11(12):3435.