Transplant anesthesia

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Contents

- Anesthetic management of organ donor
- Renal Transplantation
- Liver Transplantation
- Management of Transplant patient for non-transplant surgery
- Immunosuppressive agents

Anesthetic management of organ donor

Anesthetic management of organ donor

- **Deceased donors**

  - Brain-dead Donors
  (Donation after Neurologic death)

  - Donation after cardiac death
  (Donation after circulatory determination of death)

- **Living donors**

  - Living kidney donors

  - Living liver donors

Brain-dead Donors

- Brain death is declared when the clinical picture is consistent with irreversible cessation of all brain functions. (Both cerebral and brainstem functions)

- Potentially reversible causes of coma must be ruled out (hypothermia, hypotension, drugs, toxins) before declaration of brain death.

- Brain-dead patients may have intact spinal reflexes, so they may require neuromuscular blockade during organ procurement.

Barash, P. G. (2017). Clinical Anesthesia (8th edition). Wolters Kluwer.

บันทึกการตรวจวินิจฉัยสมองตาย

ชื่อ .....นามสกุล ..... อายุ ..... ปี .....เดือน

โรงพยาบาล ..... HN .....

แพทย์ผู้ดูแล .....

คณะแพทย์ผู้วินิจฉัยสมองตาย

1. .....
2. .....
3. .....

วัน/เดือน/ปี ที่ประเมิน

ครั้งที่ 1 วันที่ .....เดือน..... พ.ศ.....เวลา .....น.

ครั้งที่ 2 วันที่ .....เดือน..... พ.ศ.....เวลา .....น.

(ระยะเวลาระหว่างการตรวจครั้งที่ 1 และครั้งที่ 2 ต้องไม่น้อยกว่า 6 ชั่วโมง ยกเว้นผู้ป่วยทารกอายุระหว่าง 7 วัน ถึง 2 เดือน ต้องไม่น้อยกว่า 48 ชั่วโมง หากอายุระหว่าง 2 เดือนถึง 1 ปี ต้องไม่น้อยกว่า 24 ชั่วโมง)

โปรดใช้เครื่องหมาย ✓ ในขั้นตอนที่ตรวจ

1. สภาวะก่อนการวินิจฉัยสมองตาย

1.1 โรค หรือภาวะที่ทำให้สมองตาย .....

1.2 ผู้ป่วยไม่รู้สึกตัว ไม่หายใจ และอยู่ในเครื่องช่วยหายใจ
ตั้งแต่ วันที่ .....เดือน..... พ.ศ.....เวลา .....น.

1.3 ภาวะที่ทำให้ผู้ป่วยไม่รู้สึกตัวและไม่หายใจเกิดจากสิ่งต่อไปนี้หรือไม่

	ครั้งที่ 1 ไม่	ครั้งที่ 2 ไม่
1.3.1 พิษยา (intoxication) ยาเสพติด ยานอนหลับ ยาคลายกล้ามเนื้อ หรือ สารพิษที่ทำให้กล้ามเนื้อไม่ทำงาน	[ ]	[ ]
1.3.2 ภาวะอุณหภูมิในร่างกายต่ำรุนแรง (<32°C)	[ ]	[ ]
1.3.3 ภาวะผิดปกติของระบบต่อมไร้ท่อ และเมตาโบลิก (endocrine and metabolic disturbances)	[ ]	[ ]
1.3.4 ภาวะช็อก (shock)	[ ]	[ ]
1.3.5 สาเหตุอื่น ๆ ที่มีหนทางเยียวยาได้อีก	[ ]	[ ]

	ครั้งที่ 1 ไม่	ครั้งที่ 2 ไม่
2. การตรวจและทดสอบเพื่อยืนยันสภาวะสมองตาย (tests for brain death)		
2.1 มีการเคลื่อนไหวดังต่อไปนี้หรือไม่		
2.1.1 การเคลื่อนไหวได้เอง	[ ]	[ ]
2.1.2 อาการชัก	[ ]	[ ]
2.2 มีรีเฟลกซ์ของก้านสมองดังนี้หรือไม่		
2.2.1 รีเฟลกซ์ของรูม่านตาต่อแสง(pupillary light reflex)	[ ]	[ ]
2.2.2 รีเฟลกซ์ของกระจกตา(corneal reflex)	[ ]	[ ]
2.2.3 การเคลื่อนไหวของกล้ามเนื้อใบหน้าและลูกตา (motor response within the cranial nerve distribution)	[ ]	[ ]
2.2.4 เวสติบูโลออกคูลาร์รีเฟลกซ์(vestibulo-ocular reflex)	[ ]	[ ]
2.2.5 ออกคูโลเซฟาลิกรีเฟลกซ์(oculocephalic reflex)	[ ]	[ ]
2.2.6 รีเฟลกซ์ของการกลืนและการไอ(gag and cough reflexes)	[ ]	[ ]

2.3 ทดสอบการไม่หายใจเป็นบวก โดยหยุดเครื่องช่วยหายใจนาน .....นาที(ไม่น้อยกว่า 10 นาที)
ตรวจค่า $PaCO_2$ ก่อนหยุดเครื่องช่วยหายใจเท่ากับ.....มิลลิเมตรปรอทเมื่อเวลา.....น.(เวลาที่ส่งตรวจ)
ตรวจค่า $PaCO_2$ หลังหยุดเครื่องช่วยหายใจเท่ากับ.....มิลลิเมตรปรอทเมื่อเวลา.....น.(เวลาที่ส่งตรวจ)

2.4 กรณีไม่สามารถทดสอบการไม่หายใจตามข้อ2.3ได้ มีการตรวจทดสอบยืนยันว่าไม่มีเลือดไหลเวียนเข้าสู่สมองโดยวิธีดังนี้เช่น [ ] cerebral angiogram [ ] Isotope brain scan หรือ [ ] .....

2.5 ผลการตรวจคลื่นไฟฟ้าสมองกรณีผู้ป่วยอายุไม่เกิน 1 ปีและไม่สามารถตรวจตามข้อ 2.4ได้พบว่า

.....

ขอรับรองว่าคณะแพทย์ได้ตรวจผู้ป่วยตามรายการและวัน เวลาดังกล่าวแล้ว มีความเห็นว่าได้เกิดสภาวะสมองตาย (brain death) ในผู้ป่วยรายนี้และแพทย์ได้ออกหนังสือรับรองการตายแล้ว

(1) ลงนาม ..... (2) ลงนาม .....

(.....) (.....)

ตำแหน่ง ..... ตำแหน่ง .....

(3) ลงนาม .....

(.....)

ตำแหน่ง .....

ผู้รับรองการวินิจฉัยสมองตาย และรับรองการตาย

ลงนาม .....

(.....)

ผู้อำนวยการโรงพยาบาลหรือผู้ได้รับมอบหมาย

Physiology change after Brain-death

- Cardiovascular system
- Respiratory system
- Endocrine and Thermoregulatory system
- Musculoskeletal & Hematological management

Cardiovascular change

- **Cardiovascular system** :

  - **Hypertensive autonomic storm (Catecholamine surge)** : Tachycardia, Increased myocardial oxygen consumption, Hypertension >> Myocardial ischemia, cardiac arrhythmia

  - **Hypotensive period** : Hypovolemia, Cardiac dysfunction, and Vasodilation (loss of vascular tone)

Barash, P. G. (2017). Clinical Anesthesia (8th edition). Wolters Kluwer.

Cardiovascular management goals

TABLE 61.3 Donor Management Goals, as Reported by Various Authors

Preset Clinical End Points	Six DMGs*	Eight DMGs†	Ten DMGs‡
Mean arterial pressure (mm Hg)	≥60	60–120	60–100
Central venous pressure (mm Hg)	≤10 (or serum osmolality 285-295 mmol/L)	4–12	4–10
Final sodium (mmol/L)	≤155	≤155	135–160
Pressors	≤1 (1 plus vasopressin to treat DI is acceptable)	≤1 or low dose	≤1 and low dose
PaO_2 (mm Hg) or PaO_2/FiO_2 ratio	$PaO_2 \geq 300$ while on 100% oxygen (or $PaCO_2/FiO_2$ ratio > 3)	Final $PaO_2 > 100$	PaO_2/FiO_2 ratio: >300 on PEEP = 5 cm H_2O
Arterial blood gas: pH	7.25–7.50	7.30–7.50	7.30–7.45
Glucose (mg/dL)		≤150	<150
Urine output (mL/kg/h) in 4 h before procurement		0.5–3.0	1–3
Ejection fraction of left ventricle			>50%
Hemoglobin (mg/dL)			>10

Gropper, M. (Ed.). (2020). Miller's Anesthesia (9th Edition). Elsevier.

Cardiovascular management

- **Cardiovascular management** :

  - **Fluid resuscitation** : Review fluid balance and correct hypovolemia by isotonic balanced salt solution (PPV < 15%, CVP 4-10 mmHg, Urine output 1-3 ml/kg/hr)

  - **Choice of vasopressor** : Vasopressin vs Vasopressors vs Inotropes (Avoid high dose of catecholamine : Norepinephrine > 0.05 mcg/kg/min, Dobutamine/Dopamine > 10 mcg/kg/min)

  - **Cardiac parameter** : CI > 2.4 l/min/m^2, HR 60-120/min, SVR 800-1200 dynes/sec/cm^{-5}

McKeown, D. (2012). Management of the heartbeating brain-dead organ donor. British Journal of Anaesthesia, 108, 96–107.

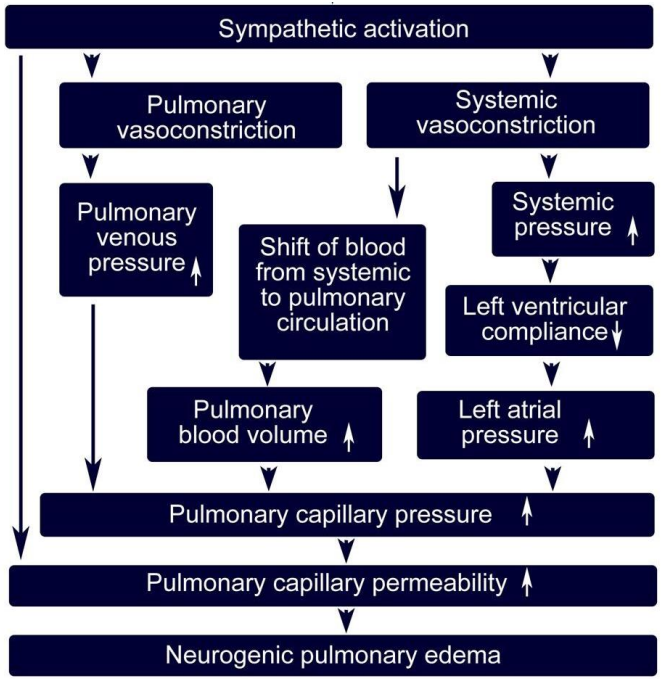
Respiratory change

- **Respiratory system** : Pulmonary edema due to

  - Neurogenic pulmonary edema

  - Catecholamine surge

  - Excessive fluid administration



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Respiratory management goals

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Hemoglobin (mg/dL)			>10

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Respiratory management

- **Respiratory management** :

  - Lung protective strategies (V_T 6-8 ml/kg, PEEP 5 cmH_2O adjusted to allow minimal FiO_2)

  - Respiratory parameter : pH 7.30-7.45, PaO_2 > 100 mmHg, SpO_2 > 95%, $PaCO_2$ 35-40 mmHg

Barash, P. G. (2017). Clinical Anesthesia (8th edition). Wolters Kluwer.

Endocrine and Thermoregulatory change

- **Hormonal change** due to pituitary failure (Posterior & Anterior)

  - Diabetes insipidus -> Hypovolemic hypernatremia

  - Decrease insulin level -> Hyperglycemia

  - Sick euthyroid state

  - Thermoregulatory change (KEEP core temperature > 35°C) : Hyperthermia -> Hypothermia (worsened by lack of shivering, peripheral vasodilation, decrease metabolic rate)

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Endocrine management goals

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Endocrine management

- **Hormonal replacement** :

Hormonal	Dose
Thyroid hormone (Tetraiodothyronine)	20 mcg IV bolus then 10 mcg/hr IV infusion
Vasopressin	1 U IV bolus then 2.4 U/hr IV infusion
Methylprednisolone	15 mg/kg IV q 24 hr

Anthony, A. (2015). Anesthetic considerations in organ procurement surgery: a narrative review. Can J Anesth, 62, 529–539.

Musculoskeletal & Hematological management

- **Require NMBDs** due to residual spinal reflexes

- **Correct coagulopathy** : - If evidence of ongoing bleeding
  - Before harvest operation

- **Correct anemia** : Blood Transfusion for optimal oxygen delivery (Keep Hb > 8-10 mg/dL)

Anthony, A. (2015). Anesthetic considerations in organ procurement surgery: a narrative review. Can J Anesth, 62, 529–539.

Anesthetic consideration in Harvest operation

Table 1 Effects of brain death and recommended anesthetic management by organ system

System	Effects of Brain Death	Recommended Anesthetic Management[6,19,21,26,37,43-46,49,51,52,54,55,59,60]
Cardiac	• Myocardial injury • Loss of vascular tone • Hemodynamic instability • Hypovolemia	• Restore intravascular volume, replacing evaporative and DI urinary losses. • Use vasopressors as necessary to maintain adequate organ perfusion. • Maintain SBP > 100 mmHg, MAP > 70, HR 60-120 beats·min^{-1}.
Pulmonary	• Increased pulmonary capillary permeability • Pulmonary edema	• "Lung-protective" ventilatory strategy: TV 6-8 mL·kg^{-1} of predicted body weight, PEEP 8-10 cm H_2O. • Judicious intravenous fluid; CVP 4-8 (< 10) mmHg.
Endocrine	• Pituitary infarction may lead to diabetes insipidus and obliteration of thyroid axis • Hyperglycemia • Hypernatremia	• Vasopressin to support hemodynamics and control polyuria. • Insulin infusion to maintain serum glucose < 180 mg·dL^{-1} • Consider hormone replacement—thyroxine or T3 infusion, corticosteroids
Hematologic	• Coagulopathy, which may progress to disseminated intravascular coagulation	• Transfuse for hemoglobin < 7 or 8 g·dL^{-1} for optimal oxygen delivery to organs. • Correct coagulopathy with clotting factors or platelets if evidence of ongoing bleeding.
Musculoskeletal	• Reflex somatic movements mediated by spinal reflexes	• Skeletal muscle paralysis.

Anthony, A. (2015). Anesthetic considerations in organ procurement surgery: a narrative review. Can J Anesth, 62, 529–539.

Kidney Transplantation

Kidney Transplant

- Matching process
- Preoperative evaluation and preparation
- Intraoperative management
- Postoperative management

Matching process

- Blood group matching : ABO matching

- HLA type matching :

    - Six antigen (MCH) at three loci A, B and DR

    - Six antigen match : best outcome

    - Immunosuppression ensures favourable outcome for fully mismatched organs

- Testing donor T cells against recipient serum

    - Final crossmatch : lymphocytotoxicity crossmatch between donor lymphocytes and recipient

Preoperative evaluation and preparation

- ESRD pathophysiology
- Hemodialysis
- Preservation of harvested organ

ESRD pathophysiology

Neurological system	- Uremic encephalopathy - Autonomic neuropathy - Convulsions
Cardiovascular system	- Systemic hypertension - Congestive heart failure (Uremic cardiomyopathy, Fluid overload) - Cardiac dysrhythmia (Hyperkalemia, Hypocalcemia) - Coronary artery disease (Accelerated atherosclerosis)
Pulmonary system	- Basal lung atelectasis - Rt. Shift of O2-Hb dissociation curve - Pulmonary edema, Pleural effusion - Pulmonary HT (in AVF hemodialysis) - Hyperventilation

ESRD pathophysiology

Gastrointestinal system	- Delayed gastric emptying time (Uremic gastropathy) - Nausea and vomiting - Peptic ulcer disease, Gastrointestinal bleeding
Hematological system	- Anemia (Decreased erythropoietin production, Reduced RBC life span) - Platelet Dysfunction (Qualitative) - Residual anticoagulant effect (From hemodialysis) - Hypercoagulable state
Endocrine system	- Altered temperature regulation - Glucose intolerance (Altered exogenous insulin requirement) - Secondary hyperparathyroidism

ESRD pathophysiology

Fluid and electrolyte change	- Hypervolemia - Hyperkalemia, Hypocalcemia, Hypermagnesemia, Hyperphosphatemia - Metabolic acidosis
Musculoskeletal system	- Renal osteodystrophy - Osteomalacia
Dialysis related Problem	- Hypovolemia - Systemic Anticoagulation - Dialysis Dementia - Dialysis Disequilibrium Syndrome

Hemodialysis

- Routine dialysis should be avoided in the 24 hours prior to transplantation.
  (Related with delayed graft function)

- If dialysis needs to be done within 24 hours of the operation, It is best to avoid overzealous.

Yao, F.-S. F. (2021). Yao & Artusio's Anesthesiology (Ninth edition). Wolters Kluwer.

Preservation of Harvest organ

- **Cold ischemia time (CIT)**

  - Initiation of cold preservation of donor organ to restoration of warm circulation in the organ recipient
  - Lower CIT improve graft function and survival
  - For cadaveric graft safety > 24hr, potentially > 36hr

- **Warm Ischemic Time (WIT)**

  - Begins when the kidney is placed in the recipient, and terminates when the vascular anastomosis is complete and perfusion by the recipient begins.
  - Incidence ATN increases with its duration

Yao, F.-S. F. (2021). Yao & Artusio's Anesthesiology (Ninth edition). Wolters Kluwer.

Preoperative preparation

- **Choice of Anesthesia** : General anesthesia (Consider RSI) > Neuraxial anesthesia

- **Monitoring** : Standard monitoring ± Central line
  - C-line : Help ensuring adequate hydration during anesthesia
  - A-line : For advance comorbid condition requires close BP monitoring or acid-base status
  - Glucose monitoring : Tight Glucose control 80 – 110 mg% (For less graft rejection)
  - Urine output

- Strictly aseptic technique

- New equipments and drugs including sodalime

Yao, F.-S. F. (2021). Yao & Artusio's Anesthesiology (Ninth edition). Wolters Kluwer.

Intraoperative management

	Use	Caution
IV induction	Propofol Thiopental	Etomidate
RSI	Rocuronium Succinylcholine	
NMBD	Cis-atracurium Atracurium	Pancuronium Sugammadex
Volatile anesthetic	Desflurane Isoflurane	Sevoflurane Enflurane
Opioids	Fentanyl Remifentanil	Morphine

Yao, F.-S. F. (2021). Yao & Artusio's Anesthesiology (Ninth edition). Wolters Kluwer.

Intraoperative management

- **Optimize cardiac output and renal blood flow.**
  - Volume expansion : Isotonic balanced-salt crystalloid
  - SBP : 130-160 mmHg
  - CVP : 10-14 mmHg
  - Mean PA pressure: 18-20 mmHg

- **Vasopressor** : Dopamine, Ephedrine > Norepinephrine

- **Immediate postreperfusion hypotension**
  - 25% of CO to renal graft, Vasoactive mediator
  - Partial systemic absorption of vasodilators that injected to vessels grafts (e.g. papaverine, verapamil)

Yao, F.-S. F. (2021). Yao & Artusio's Anesthesiology (Ninth edition). Wolters Kluwer.

Intraoperative management

- **Promote early diuresis and protection against ischemic injury**

  - 20% Mannitol : 200 to 250 ml immediately before reperfusion
  Improve renal perfusion pressure , acts as a free radical scavenger,
  decreased incidence of impaired renal function immediately after transplant

  - Furosemide role is controversial : Two large RCTs did not show any benefit of furosemide on the recovery from renal failure in patients with oliguria

- Extubation and transfers to high-dependency unit

Yao, F.-S. F. (2021). Yao & Artusio's Anesthesiology (Ninth edition). Wolters Kluwer.

Postoperative management

- Supplemental O_2
- Avoid hypotension and hypovolemia
- Strict monitoring of urine output
  - Decrease strongly suggests mechanical impingement of graft , vessel or ureter
  - Sudden decrease in urine output may require surgical re-exploration
- Nephrotoxic agents should be avoided
- Postoperative pain is usually mild to moderate.

Yao, F.-S. F. (2021). Yao & Artusio's Anesthesiology (Ninth edition). Wolters Kluwer.

Liver Transplantation

Liver Transplant

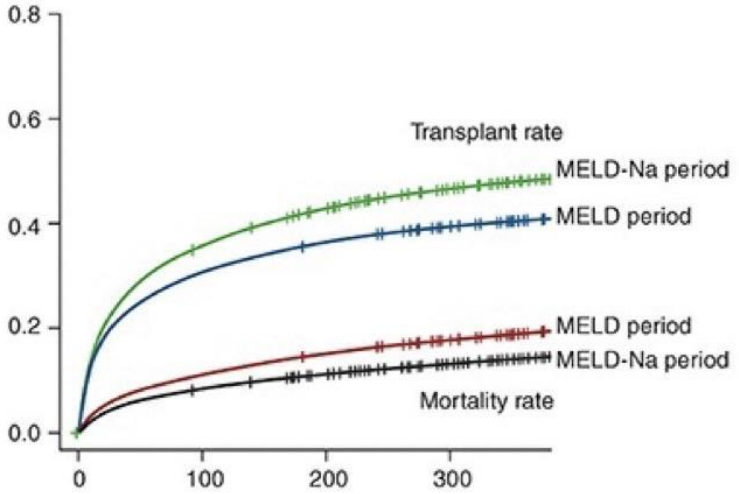
- Matching Process
- Preoperative evaluation and preparation
- Intraoperative management
- Postoperative management

Liver Transplant

- **MELD Score** (Model For End-Stage Liver Disease) has been validated as predictor of survival in patients with ESLD

- MELD score = 3.78 x ln[serum bilirubin (mg/dL)] + 11.2 x ln[INR] + 9.57 x ln[serum creatinine (mg/dL)] + 6.43.

- MELD-Na score = MELD - Na - [0.025 x MELD x (140 – Na)] +140

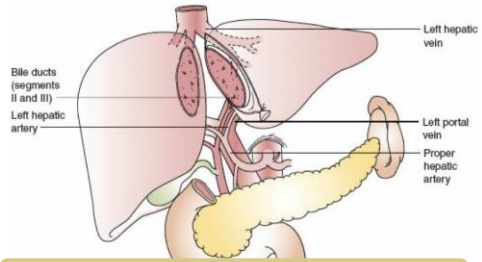


If MELD > 17, Liver transplantation would be consider.

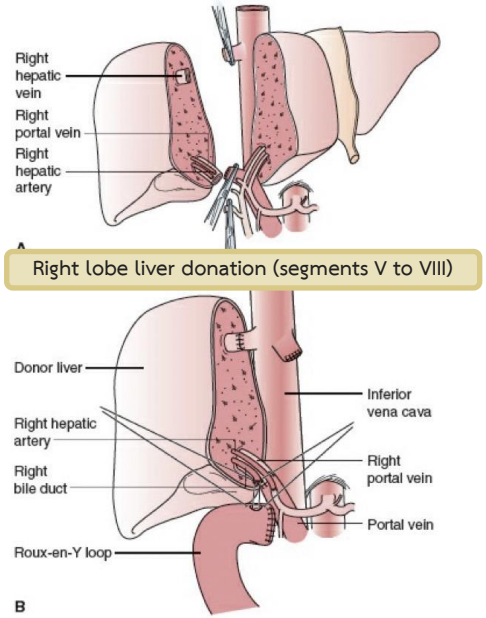
Yao, F.-S. F. (2021). Yao & Artusio's Anesthesiology (Ninth edition). Wolters Kluwer.

Liver Transplant

- Liver grafts : Living donors, Cadaveric donor



Left liver lobe donation (segments II and III)



Right lobe liver donation (segments V to VIII)

Residual Liver volume of the donor must be greater than 35% of original volume to prevent "Small for size"

Barash, P. G. (2017). Clinical Anesthesia (8th edition). Wolters Kluwer.

Liver Transplant

- Matching Process

  - Only ABP crossmatch, no need for HLA match

- Ischemic time for cadaveric donor is 6 – 12 hours

Yao, F.-S. F. (2021). Yao & Artusio's Anesthesiology (Ninth edition). Wolters Kluwer.

ESLD pathophysiology

Cardiovascular system	- "Hyperdynamic Circulation" : Low SVR, Tachycardia, Elevate cardiac output, Low arterial blood pressure - Autonomic dysfunction - Cirrhotic cardiomyopathy
Renal system	- Hepatorenal syndrome - Hyponatremia

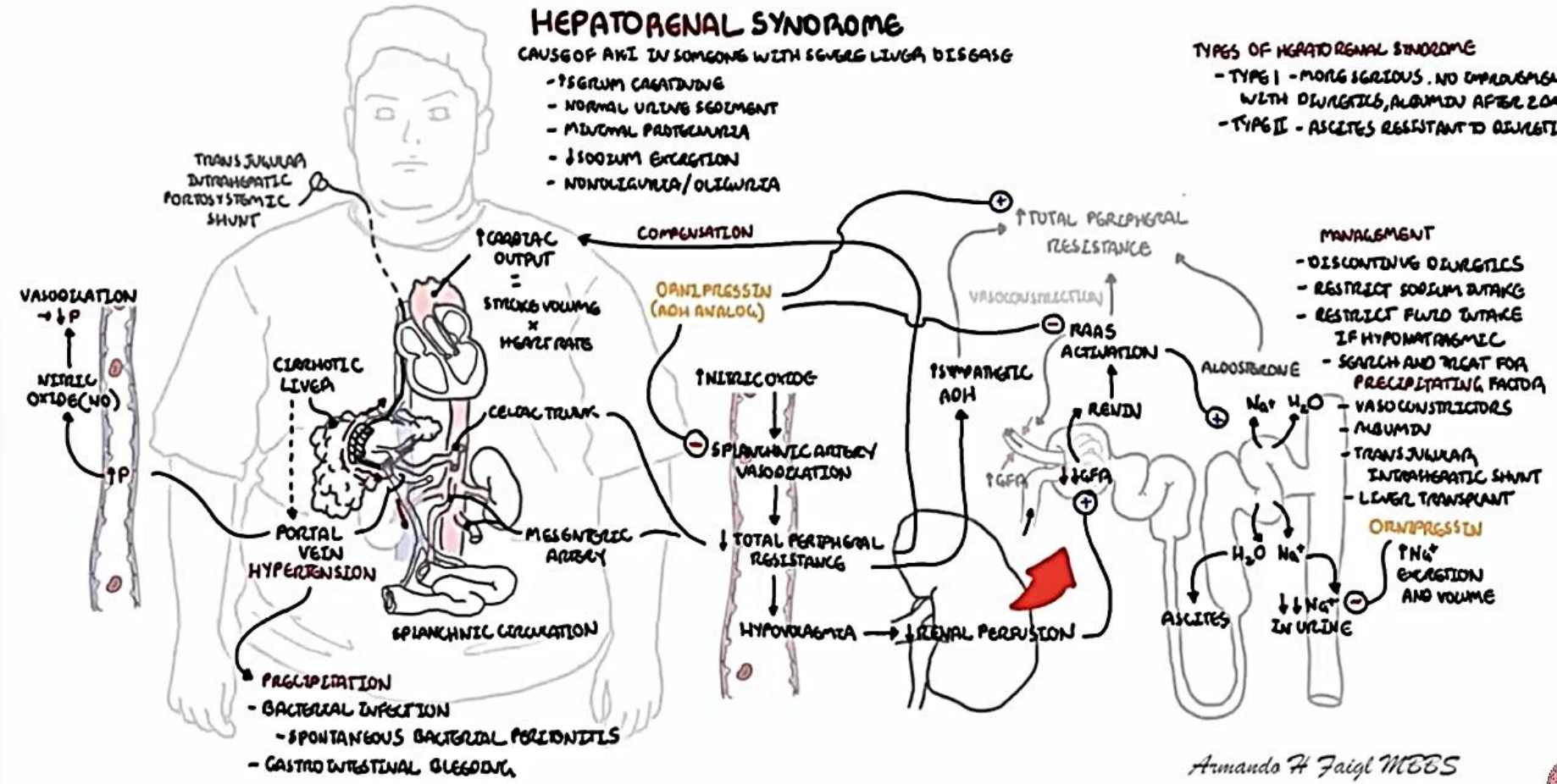
Barash, P. G. (2017). Clinical Anesthesia (8th edition). Wolters Kluwer.

Yao, F.-S. F. (2021). Yao & Artusio's Anesthesiology (Ninth edition). Wolters Kluwer.

HEPATORENAL SYNDROME

CAUSE OF AKI IN SOMEONE WITH SEVERE LIVER DISEASE
- ↑SERUM CREATININE
- NORMAL URINE SEDIMENT
- MINIMAL PROTEINURIA
- ↓SODIUM EXCRETION
- NONOLIGURIA/OLIGURIA

TYPES OF HEPATORENAL SYNDROME
- TYPE I - MORE SERIOUS. NO IMPROVEMENT WITH DIURETICS, ALBUMIN AFTER 2 DAYS
- TYPE II - ASCITES RESISTANT TO DIURETICS

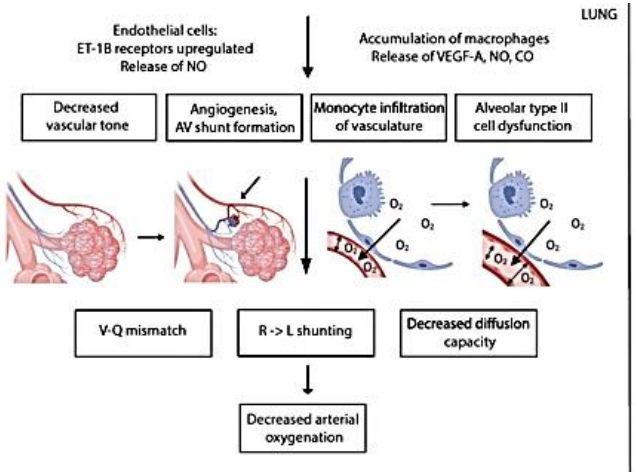


MANAGEMENT
- DISCONTINUE DIURETICS
- RESTRICT SODIUM INTAKE
- RESTRICT FLUID INTAKE IF HYPONATRAEMIC
- SEARCH AND TREAT FOR PRECIPITATING FACTOR
  - VASOCONSTRICTORS
  - ALBUMIN
  - TRANSJUGULAR INTRAHEPATIC SHUNT
  - LIVER TRANSPLANT

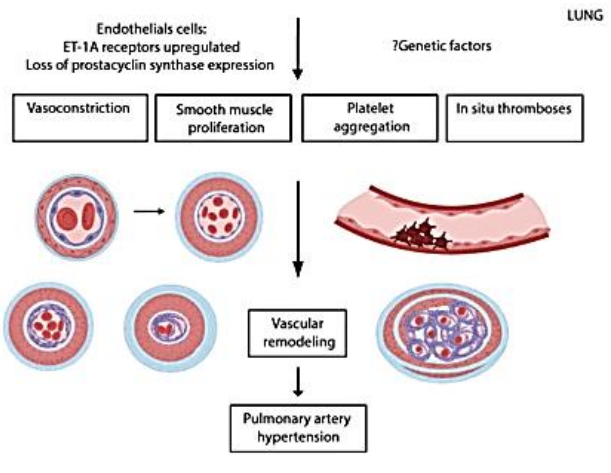
Armando H Faigl MBBS

ESLD pathophysiology

Pulmonary system	- Hepatopulmonary syndrome - Portopulmonary hypertension - Respiratory alkalosis



Hepatopulmonary syndrome



Portopulmonary hypertension

ESLD pathophysiology

Hepatopulmonary syndrome	Portopulmonary hypertension
PaO2 < 80 mmHg (A-a gradient > 15 mmHg)	Mean PAP 25 mmHg at rest or 30 mmHg during exercise PVR > 240 dyn/s/cm-5
Intrapulmonary vascular dilation (Prominent at basal lung “Orthodeoxia”)	Vasoconstriction, Vascular remodeling
-	Moderate to severe PHT (Systolic PA pressure > 50 mmHg) need right heart catheterization
Improved after transplant	Unpredictable resolution after transplant

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ESLD pathophysiology

Hematological system	- Decreased synthesis of coagulation factors - Decreased synthesis of Thrombopoietin - Impaired fibrinolytic mechanism - Hypersplenism

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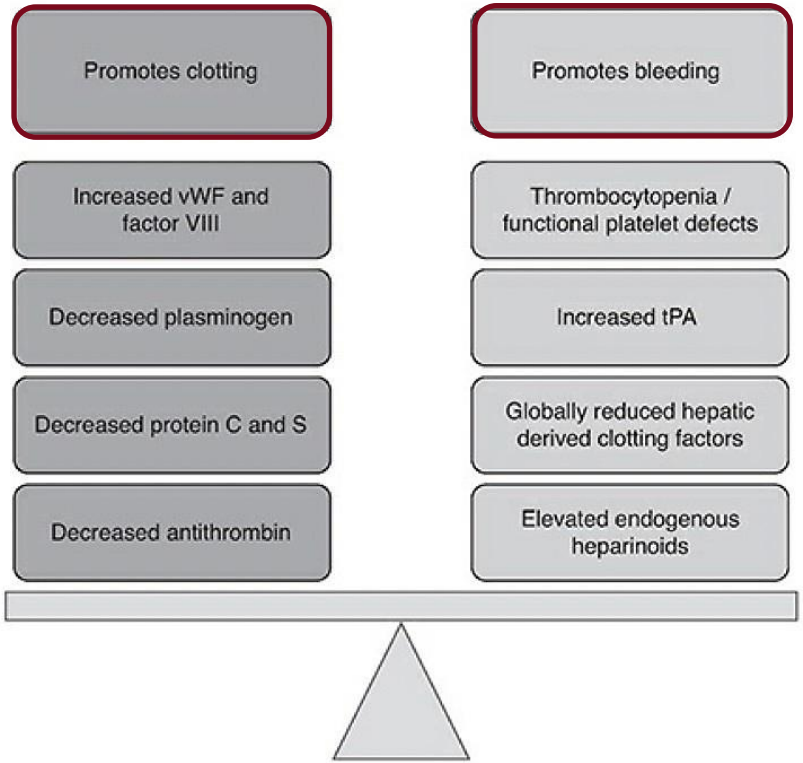
ESLD pathophysiology



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ESLD pathophysiology

Neurological system	- Hepatic encephalopathy
Gastrointestinal system	- Delayed gastric emptying time - Ascites - Gastrointestinal bleeding from varices
Other system	- Increased volume of distribution of drug - Decrease citrate metabolism

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Preoperative preparation

- **Choice of Anesthesia** : General anesthesia (Consider RSI)

- **Monitoring** : Standard monitoring
  - C-line : For CVP measurement, Drug administration
  - A-line : For continuous blood pressure monitoring and blood sampling (Peripheral)

  (Femoral arterial catheter may be consider for central aortic blood pressure)
  - Pulmonary artery catheter and TEE may be consider in significant cardiac dysfunction

- **Prepare for massive bleeding**
  - Two large-bore (9 French)
  - Rapid infusion system (At least 500 ml/min)
  - Blood components

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Preoperative preparation

- **Correct coagulation defects :** INR < 1.5, Platelet > 50,000, Fibrinogen level > 150 mg/dL
  (Platelet transfusion is associated with worse graft and patient survival)

- **Prevention of Renal dysfunction :**
  - SBP prophylaxis (3rd generation cephalosporin)
  - Intravenous albumin
  - Relieve splenic vasodilation (Terlipressin, norepinephrine, octreotide)
  - Adequate volume replacement

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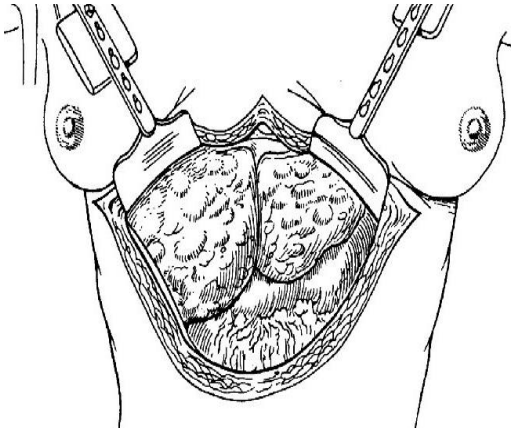
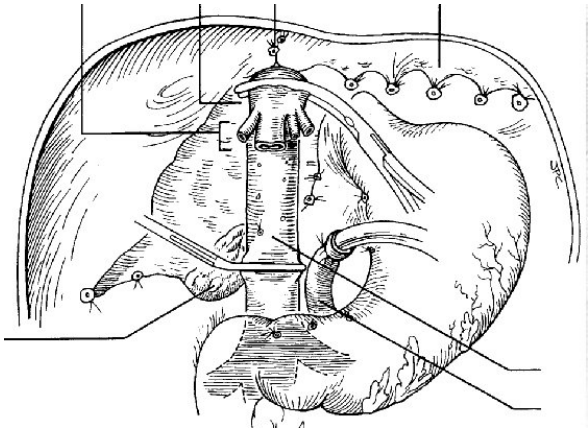
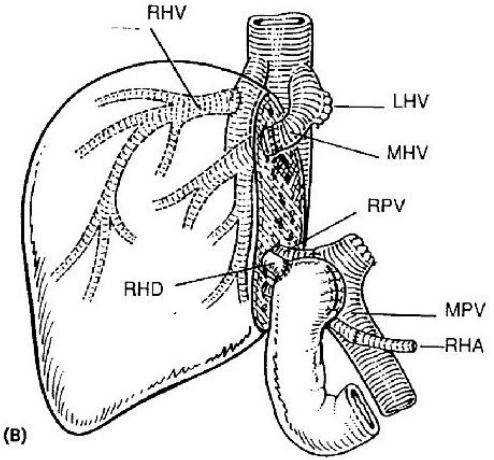
Intraoperative management







Preanhepatic phase

Induction of anesthesia to clamping of hepatic artery

Anhepatic phase

Removal of diseased liver to reperfusion of the new liver

Neohepatic phase

After declamp portal vein (reperfusion of the new liver)

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Preanhepatic phase (Dissection phase)

- **Acute decompression of ascites**

  - Large volume (> 5L) drainage of ascites -> Replace with albumin 6-8 g/L of ascites drained.

- **Hemorrhage**

  - Blood component replacement

- **Citrate toxicity (Hypocalcemia)**

- **Hypothermia**

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Anhepatic phase

- **Complete cava cross-clamping** : Venous return decrease by 50-60%
  - Fluid loading and vasopressors
  - Surgical technique : Piggyback technique

- **Absence of liver metabolic function** : Hypocalcemia, Acidosis, Gluconeogenesis

- **Atelectasis (Retraction on diaphragm)**

- **Hypothermia**

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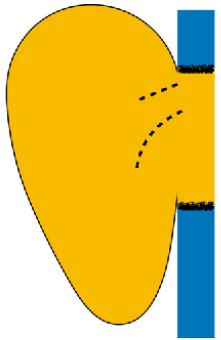
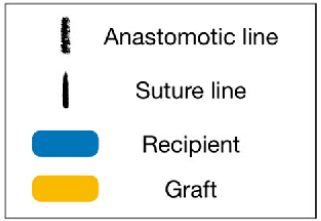
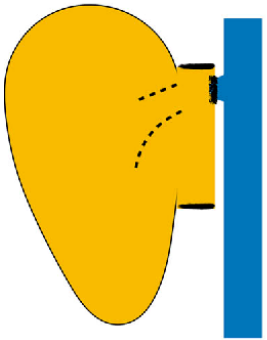
Anhepatic phase

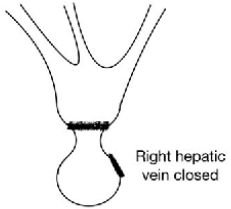


Standard end-to-end anastomosis





Original piggyback



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Neohepatic phase (Reperfusion)

- **Preparation of reperfusion**
  - Sodium bicarbonate 25-50 mEq (Counter acid loads from graft)
  - $CaCl_2$ 500-1,000 mg at the time of reperfusion (Counter Hyperkalemia)
  - Prepare Lidocaine, Atropine, Norepinephrine (In case of ventricular dysrhythmia, Bradyarrhythmia, Hypotension)

- **Hemodynamic change**
  - Caval reperfusion is usually hemodynamic stable
  - Portal vein reperfusion often results in hemodynamic instability
  - Hepatic artery unclamping is usually hemodynamically uncomplicated.

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Neohepatic phase (Reperfusion)

- **Postreperfusion syndrome**

  - A sustained 30% decrease in mean arterial blood pressure for more than 1 minute during the first 5 minutes after reperfusion

  - Hemodynamic instability, characterized by a decrease in blood pressure, heart rate, systemic vascular resistance, stroke volume index, and an increase in pulmonary arterial pressures.

  - Desaturated blood from the obstructed portal circulation, inflammatory mediators such as interleukin-6 (IL-6) and tumor necrosis factor-α (TNF-α), potassium, protons, and cold components are released into the systemic circulation.

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Neohepatic phase (Reperfusion)

- **Postreperfusion complication**

  - LV diastolic dysfunction

  - Microemboli and RV dysfunction, Intracardiac emboli

- **Keep INR 1.5 – 2, Hct 25-27% (Avoid over correct -> Hyperviscosity, Thrombosis)**

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Neohepatic phase (Reperfusion)

- **Sign of graft function :**

  - Decrease calcium requirement

  - Improve acidosis

  - Decrease cardiac output and increase SVR

  - Bile output

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Postoperative management

- Early extubation
- Hemodynamic and metabolic control
- Glucose control < 150 mg% (> 200 mg% associated with graft rejection and mortality)
- Hepatic graft function
- Pain control

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Management of Transplant patient for non-transplant surgery

Management of Transplant patient for non-transplant surgery

- Preoperative evaluation and preparation
- Intraoperative consideration
- Specific anesthetic consideration

Preoperative evaluation and preparation

- Graft function and rejection
- Immunosuppressive drugs
- Function of other organs
- Risk of infection

Graft function and rejection

- Patients who present with signs of acute rejection or infection may benefit from delay of surgery to optimize their status.

- Allograft rejection may occur at any time during the post-transplant period, especially when discontinuing the use of immunosuppressants.

- Immunosuppressive drugs should be continue to the time of surgery.

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Graft function and rejection

Organ	Signs of graft rejection
Heart	Bradycardia, Atrial fibrillation, Dyspnea, Orthopnea
Lung	PFT : Decrease in FEV1, VC, TLC ABG : Increase A-a gradient CXR : Perihilar infiltration
Kidney	Oliguria, Uremic symptoms, Hypertension
Liver	Elevate LFT, Jaundice, Edema

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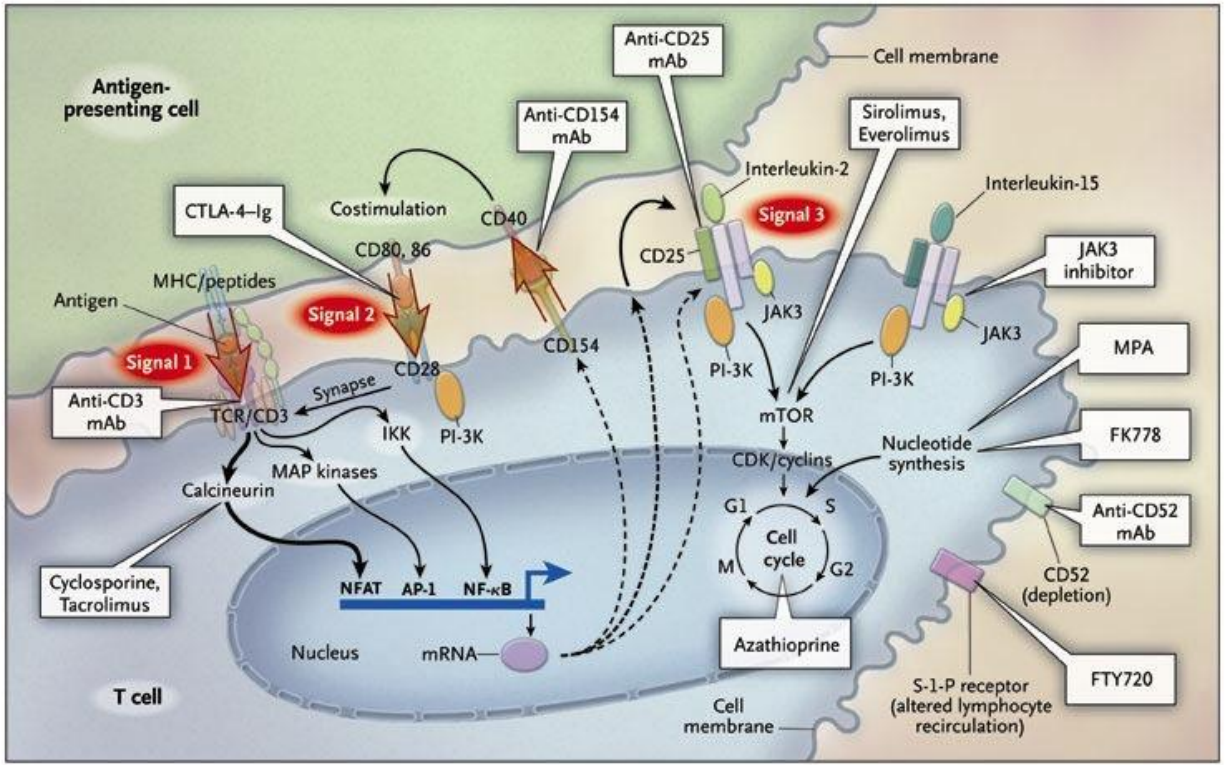
Immunosuppressive drug

- Calcineurin inhibitors
- Corticosteroid
- T-cell inhibitors
- Nucleic acid inhibitors
- mTOR inhibitors



Immunosuppressive drug

Immunosuppressive agent	Example	Adverse effects
Calcineurin inhibitors	Cyclosporine, Tacrolimus (Tacrolimus is CYP450 3A4 inducer)	Nephrotoxicity, Neurotoxicity, Gingival hyperplasia (Cyclosporine), Hypertension, Dyslipidemia, Ischemic vascular disease, Diabetes militus
Corticosteroids	Prednisolone, Dexamethasone, Hydrocortisone	Hyperglycemia, Osteoporosis, Adrenal insufficiency, Hypertension, Dyslipidemia, Diabetes, Weight gain (Cushingoid features), GI ulceration

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Immunosuppressive drug

Immunosuppressive agent	Example	Adverse effects
T-cell inhibitors	Antithymocyte globulin (ATG), Basiliximab, Daclizumab	Anaphylaxis, Severe serum sickness, Severe cytopenia, GI disturbance
Nucleic acid inhibitors	Azathioprine, Mycophenolate mofetil	Myelosuppression, Neutropenia, Anemia, GI disturbance
mTOR inhibitors	Sirolimus	Venous thromboembolism, Impaired wound healing, Cytopenia

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Function of other organs

- Dysfunction of the transplanted organ
- Immunosuppressive therapy
- Underlying disease

Risk of infection

- Continue prophylaxis antimicrobial, antifungal, antiviral drugs as prescribe.

- Prophylaxis with broad spectrum antibiotic should be administered 1 hour before surgical incision.

Operation	Recommended antibiotic prophylaxis
Cardiothoracic surgery	Cefazolin, cefuroxime, or cefamandole. If patient has a β-lactam allergy: vancomycin or clindamycin
Vascular surgery	Cefazolin or cefuroxime. If patient has a β-lactam allergy: vancomycin with or without gentamycin, or clindamycin
Colon surgery	Oral: neomycin plus erythromycin base, or neomycin plus metronidazole. Parenteral: cefoxitin or cefotetan, or cefazolin plus metronidazole
Hip or knee arthroplasty	Cefazolin or cefuroxime. If the patient has a β-lactam allergy: vancomycin or clindamycin
Vaginal or abdominal hysterectomy	Cefazolin, cefotetan, cefoxitin or cefuroxime

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Intraoperative consideration

- **Choice of anesthesia :** No specific contraindication

- **Monitoring :** Consider from surgical, patient and anesthetic aspects
  - Strictly aseptic technique for invasive monitoring
  - Do as minimal as possible (Risk of infection)

- **Airway management :** Prefer Oral intubation > Nasal intubation (Risk of infection by nasal flora)
  - Risk of difficult intubation in Post-transplant lymphoproliferative disease
  - Extubation as early as possible (Prevent nosocomial or ventilator-associated pneumonia)

- **Blood products :** Leukocyte-depleted blood products

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General anesthesia

Drugs	Recommendation
Intravenous	Guided by patient's hemodynamic status, cardiovascular effects, PK of drugs - Etomidate : may have clinical significance in patients who already have adrenal suppression as a result of exogenous corticosteroid use.
Inhalation	All inhaled anesthetics have been used in transplanted patients with success. - N_2O : potential risk of bone marrow suppression, increase PVR, and the potential for altered immunologic response (Not clear adverse effects)
NMBDs	Can be use safety
Opioid	Can be use safety
NSAID	Should be avoid (Nephrotoxicity, GI hemorrhage, Hepatic dysfunction)

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Regional anesthesia

- **Risk of Bleeding**

  - Necessary to perform a total blood count to exclude bone marrow suppression, especially thrombocytopenia, and coagulation tests (PT, INR, APTT, and fibrinogen).

- **Risk of infection** : Strictly aseptic technique

- Prepared for the risk of hypotension because of preexisting autonomic neuropathy and cardiac denervation in this population.

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Specific anesthetic consideration

Heart transplant

- **Denervated Heart :**
  - Lack of neural regulating mechanism
  - No sensory, sympathetic and parasympathetic innervation
  - Intact alpha/beta adrenergic receptors
  - Intact coronary autoregulation

- Increase Baseline HR to 90-110 bpm (Loss of vagal tone)

- Silent MI should be aware (Sensory denervation)

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Heart transplant

- **Cardiac output** : Preload Dependent (Beware in neuraxial anesthesia)
  - Important to prevent hypovolemia and maintain a sufficient systolic pressure
  - Invasive monitoring should be consider when warranted by clinical status or surgical procedure.

- **Transplants heart** : Cannot respond to
  - Indirect acting agents e.g. Ephedrine, Ketamine
  - Peripheral stimulation e.g. Carotid massage, Valsalva maneuver, Laryngoscopy
  - Atropine has no effect on a transplant heart

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Heart transplant

Desired effects	Drugs
Inotropic and Chronotropic	Epinephrine, Norepinephrine, Isoproterenol, Dobutamine
Inotropic vasodilator	Milrinone, Levosimendan
Treat Bradycardia	Epinephrine, Isoproterenol
Treat Tachyarrhythmia	Amiodarone, Verapamil

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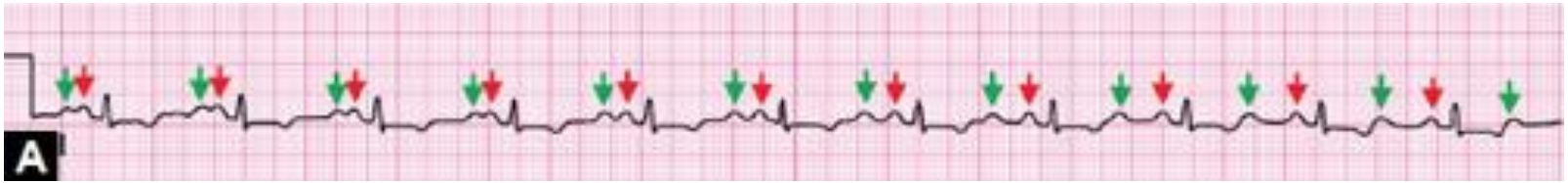
Heart transplant

Medication/class	Mechanism of action	Post-heart transplant considerations
Adenosine	Slows conduction time through atrioventricular node	• Exaggerated sensitivity
Atropine	Blocks acetylcholine at parasympathetic sites	• Not effective in the denervated heart
Beta-adrenergic drugs (eg, dobutamine, epinephrine)	Stimulates beta-adrenergic receptors	• Exaggerated sensitivity due to an increase in beta-receptor density
Beta-blockers	Inhibition of beta-adrenergic receptors	• Use with caution due to reliance on circulating catecholamines and existing blunted heart rate during exercise
Calcium channel blockers	Inhibits calcium ion from entering select voltage-sensitive areas of vascular smooth muscle and myocardium	• Attenuated electrophysiologic response • Nondihydropyridine calcium channel blockers may decrease the metabolism of tacrolimus
Digoxin	Direct suppression of the atrioventricular node, enhanced vagal tone, positive inotropic effect	• Inotropic effect intact • Likely ineffective for AF or supraventricular tachycardia
Direct oral anticoagulants	Direct thrombin inhibitor, factor Xa inhibitor	• Calcineurin inhibitors (CNIs) act as substrates of P-gp, which increases direct oral anticoagulants' concentration • They are a substrate of the P-gp and compete with CNIs, which may increase CNI concentration • There are no specific labelled drug-drug interactions with direct oral anticoagulants and CNIs • Consider contacting hematologist and measuring direct oral anticoagulant-specific anticoagulation test • Rivaroxaban and apixaban are also substrates of CYP3A4, drug-drug interaction with antifungals and other post-transplant medications

Heart transplant



- **Monitoring** : Standard monitoring
  - ECG : 5-lead ECG with ST analysis, 2 P-wave ECG (Biatrial)
  - Invasive monitoring, PAC, TEE may be consider in myocardial dysfunction and ischemia

- **Pacemaker** : Confirm mode and proper function

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Lung transplant

- **Preoperative** : Chest X-ray, Spirometry (R/O Chronic rejection or infection)

- **Denervated Lungs** : Below tracheal anastomosis
  - Lack of cough reflex : Retention of secretion, Silent aspiration
  - Risk of bronchoconstriction and pneumonia

- Alter lymphatic drainage may cause interstitial fluid accumulation. (Pulmonary edema)

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Kidney transplant

- Normal Creatinine BUT GFR and effective plasma flow can be significant lower than healthy patient.
- Beware of prolonged drug action and excretion
- Avoid nephrotoxic drugs
- Maintain intravascular volume during perioperative management. (For graft function)

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Liver transplant

- **Multiorgan dysfunction in ESLD gradually improve :**
  - Recovery of drug metabolism improve immediately after reperfusion of graft
  - Hyperdynamic circulation and cardiac performance improved in month.
  - V/Q mismatch improve in first month.
  - Patients with true shunts may be require more time to improve.

- **Maintain hepatic blood flow and avoid increase splanchnic vascular resistance**
  - Avoid hypoxia, hypercarbia, light anesthesia, excessive PEEP

- **Beware of Hepatic artery thrombosis** (Avoid overtransfusion KEEP Hct ~28%)

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Take home message

Take home message

TABLE 61.3 Donor Management Goals, as Reported by Various Authors

Preset Clinical End Points	Six DMGs*	Eight DMGs†	Ten DMGs‡
Mean arterial pressure (mm Hg)	≥60	60–120	60–100
Central venous pressure (mm Hg)	≤10 (or serum osmolality 285-295 mmol/L)	4–12	4–10
Final sodium (mmol/L)	≤155	≤155	135–160
Pressors	≤1 (1 plus vasopressin to treat DI is acceptable)	≤1 or low dose	≤1 and low dose
PaO_2 (mm Hg) or PaO_2/FiO_2 ratio	$PaO_2 \geq 300$ while on 100% oxygen (or $PaCO_2/FiO_2$ ratio > 3)	Final $PaO_2 > 100$	PaO_2/FiO_2 ratio: >300 on PEEP = 5 cm H_2O
Arterial blood gas: pH	7.25–7.50	7.30–7.50	7.30–7.45
Glucose (mg/dL)		≤150	<150
Urine output (mL/kg/h) in 4 h before procurement		0.5–3.0	1–3
Ejection fraction of left ventricle			>50%
Hemoglobin (mg/dL)			>10

Take home message

- **Renal Transplant** : Promote renal perfusion
  - Volume expansion : Isotonic balanced-salt crystalloid
  - SBP : 130-160 mmHg
  - CVP : 10-14 mmHg
  - Mean PA pressure: 18-20 mmHg

- **Liver Transplant** :
  - Preanhepatic phase : Acute decompression of ascites, Hemorrhage
  - Anhepatic phase : Complete cava cross-clamping, Absence of liver metabolic function
  - Neohepatic phase : Preparation of reperfusion, Hemodynamic change

Take home message

- **Management of Transplant patient for non-transplant surgery**

  Preoperative phase : Graft function and rejection, Immunosuppressive drugs, Risk of infection

  Intraoperative phase : Choice of anesthesia, Monitoring, Consideration for specific organ recipients.

  Postoperative phase : Adequate pain control, continue immunosuppressive drugs and infection prophylaxis

Thank you