

Vanderbilt University Department of Anesthesiology

Center for Evidence-Based Anesthesia

Liver Transplant**Enhanced Recovery after Surgery Pathway**

Category: *Perioperative Management*

Guidelines applicable to: Liver Transplant patients with MELD score \leq 25

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I. Target Population**a. Included CPT codes: 47135**

- b. Hepatobiliary Transplant Surgeons, including Drs Geevarghese, Gorden, Johnson, Karp, Magliocca, Montenovo, Mouch, Rauf, Rizzari.
- c. Indications – adult, low risk liver transplant patients (those with MELD \leq 25 on day of surgery) having surgery at Vanderbilt University Hospital
 - i. Intra-operative interventions can apply to all liver transplants.
 - ii. Pre-operative & post-operative interventions will apply only to those with MELD \leq 25.

II. Goal of Clinical Pathway

- a. Reduce ICU Length of Stay (to ~1 day)
- b. Reduce Overall Length of Stay (to ~4 days)

III. Preoperative Interventions –

- a. Candidate selection process identifies which patients will be selected to proceed with transplant, by Hepatology and Transplant Surgery Team
- b. Specific pre-operative optimization evaluation and treatment goals:
 - i. Diabetes & Cardiac Risk Stratification:
 - 1. Check A1c & Lipid Panel routinely.
 - 2. Coronary CT Screen
 - 3. Optimizing DM management to include medication regimen guidance
 - ii. Nutrition:
 - 1. Patients identified with malnutrition are referred to Transplant nutritionist for follow up telehealth appointment in ~ 6weeks
 - 2. Individualized nutrition plan depending on goals (e.g. malnutrition, obesity/weight loss).

3. RD completes nutrition education and discharge nutrition plan.
 4. Post-transplant follow-up happens only when nutrition problems identified. Patients with malnutrition and/or on home tube feeding are referred to outpatient RD for follow-up.
- iii. Nutrition Lab Screening: Vitamins A, D, E, B12 and Folate
1. *Pre-operative treatment initiated if indicated, by Hepatologist*
- iv. Sarcopenia & Frailty Assessment as per Liver Transplant Team standard process for **Management of Sarcopenia and Frailty in Liver Transplant Candidates**, including:
1. Six minute walk test (6MWT) will be performed at the same time as pulmonary function test ordered for transplant evaluation.
 2. Patients who fail to walk for more than 300 meter in 6 minutes (8) will be deemed as frail and referral to the Physical Medicine & Rehabilitation Vanderbilt Dayani Center clinic would be indicated.
 3. 2 minutes distance will be collected as well since it is expected to be an early surrogate of response to therapy.
 4. Liver Frailty Index to be documented (when available in eStar):
<https://liverfrailtyindex.ucsf.edu/>
- v. Referral to Physical Medicine and Rehabilitation for Physical Therapy evaluation and treatment, by Hepatologist
1. Referral to Dayani for PT Eval & Treat - Comments: Prehab
 2. Dayani PT evaluation includes: strength, endurance, gait, functional status evaluation and treatment
- vi. Bone Density Screening
- vii. Psychiatric Evaluation
1. Patients weaned off benzodiazepines by time of transplant
 2. Patients weaned off opioids by time of transplant
- viii. Patients will be provided with a thorough education during pre-op education with the Transplant Coordinator team that will review the basic principles of the procedure, as well as preoperative surgical instructions and provide Transplant folder to patient and family.
- c. *Other Referrals – As determined by Hepatologist*

IV. Pre-operative Interventions- Admission & Day of Surgery

- a. Pre-op Day of Surgery Orders placed by Liver Transplant Surgery team to include:
- i. Antibiotics: Ampicillin/Sulbactam. If PCN allergy- levofloxacin/Vancomycin.
 - ii. VTE prophylaxis with SCDs (no chemoprophylaxis)
 - iii. Labs include: Type & Screen, BMP, PTT, Fibrinogen, HIV, Hep C, Hep B, CMV
 - iv. Activation of Blood Bank
 - v. CT Scan (PRN)
 - vi. EKG
 - vii. CXR

V. Intraoperative Interventions –

a. Place Oral Gastric Tube - unless contraindicated based on patient-factors

b. Normothermia Strategies:

i. Warming: 3 bear huggers placed: upper, mid and lower body bear huggers standard.

ii. Monitoring: temp foley or esophageal temp probe

c. Medications Administered by Intra-op Anesthesia Team:

i. Methylprednisolone

d. PONV Prevention Strategies:

i. In compliance with MPOG ASPIRE PONV Prophylaxis and Center for Evidence Based Anesthesia [Post-operative nausea and vomiting guidelines](#)

ii. Based upon number of risk factors (Figure 2), consider the following anti-emetics:

1. Propofol infusion

2. **Ondansetron:** 4mg IV given prior to emergence if extubating in OR

3. Methylprednisolone administered as part of immunosuppression so no dexamethasone recommended, but may be used as part of truncal block.

4. No Scopolamine patch recommended

PONV risk factors include the following:¹

- Female Sex
- History of PONV or motion sickness
- Non-smoker
- Younger age
- General anesthetic (as compared to regional anesthetic)
- Use of volatile anesthetics and nitrous oxide
- Postoperative opioids
- Duration of anesthesia
- Type of surgery (cholecystectomy, laparoscopic, gynecological)
- Menstrual cycle
- Level of anesthesiologist's experience
- Perioperative fasting

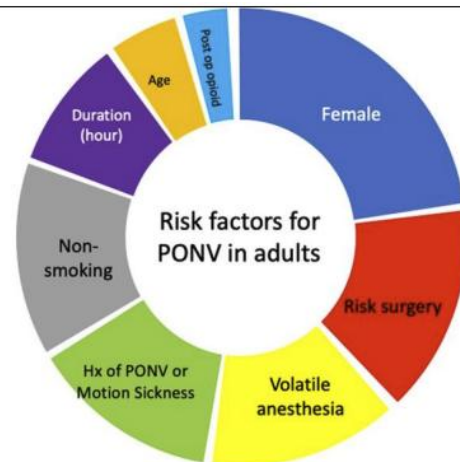
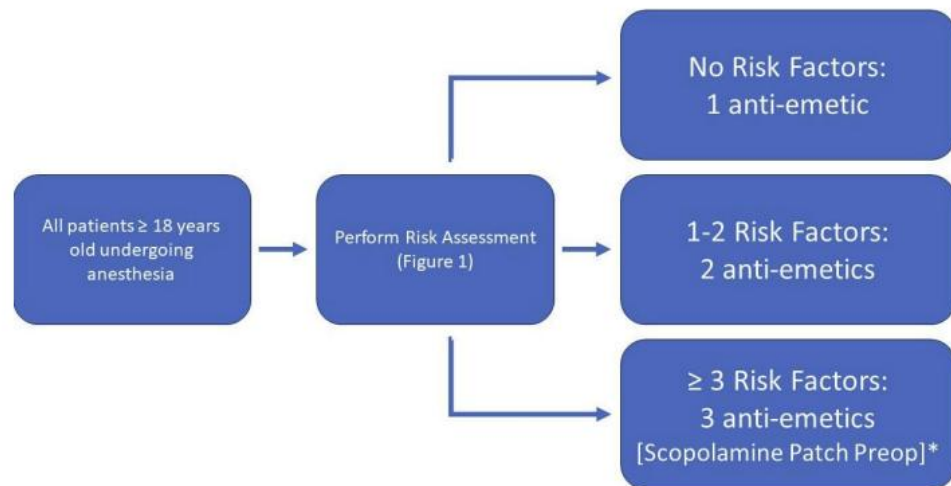


Figure 1. PONV Risk Factors. The size of each segment is proportional to the odds ratios of PONV associated with each risk factor.⁶

Figure 2. PONV Treatment Algorithm. This approach is consistent with the Michigan Perioperative Outcomes Group (MPOG) PONV-5 Measure: PONV Prophylaxis: Adults. *Scopolamine patch should be used for ≥ 3 PONV risk factors barring contraindications.



e. Blood Management Strategies:

- i. Viscoelastic testing in combination with standard coagulation parameters are recommended
- ii. Utilize TEG manager system in epic to guide clinical decision making

f. Glycemic Control Strategies:

- i. Pre-op glucose measured (via BMP) on all cases
- ii. intra-op hourly ABGs, and insulin infusion to goal glucose level between 140 and 180.

g. Goal-Directed Fluid Therapy & Hemodynamic Management Strategies:

- i. Titrate fluids and pressors to CVP Goal < 10. Goal: No sustained CVP > 10 for more than 15 minutes.
- ii. Utilize Norepinephrine and vasopressin as indicated.
- iii. Compliance in line with MPOG ASPIRE MAP Goals (See below)

h. Opioid Sparing & Regional Anesthesia Strategies:

- i. No Opioid minimization goal. Avoid Lidocaine and Ketamine in this population.
- ii. **In-Room Anesthesia** team to consider placement of pre-emergence External Oblique Intercostal (EOI) blocks to assist with post-operative analgesic control, in the patients with MELD \leq 25.

i. Transition to ICU:

- i. **For MELD \leq 25 patients ONLY-** may consider extubating in OR, only after discussing with ICU attending.
- ii. Patient factors to consider:
 1. no encephalopathy at baseline & baseline neuro status.
 2. no major vasopressor requirement & stable hemodynamics
 3. Downtrending Lactate; stable coags

j. Global Intra-op Care Guidelines: Surgical Site Infection Reduction: 'NO BUGS' Management Strategy [Outcome: SSI]

1. **Normothermia:** Population specific strategies above.

- a. Goal core temp >36.0°C
 - b. Standard Methods: active use of warmed blankets on entry to OR; forced air warming blankets used from entry through procedure; warm all IV Fluids (give no IV in preop); maintain room temperature at 68-72°F at all times
 - c. Maintenance of normothermia beginning in the holding room with forced air warmer
 2. **Oxygenation/Tidal volume**
 - a. FiO2 ≥ 0.3 with TV 8mL/kg (IBW) plus PEEP ≥6 cm H2O throughout case
 - b. Then nasal cannula in PACU to maintain SaO2 100%
 3. **Antibiotics**
 - a. Proper drug, proper dose, proper timing (<1 hour before incision, <2h for vancomycin/quinolones), and proper re-dosing strategy
 - b. See antibiotic dosing chart in VPIMS. Call OR Pharmacy w/ questions (2-4897)
 4. **Mild underventilation to normocapnia**
 - a. Goal: ETCO2 >38 mmHg, except for contraindications, such as high ICP, Pulm HTN, etc.
 5. **Glucose control**
 - a. Refer to [VUMC Perioperative Glucose Management Protocol](#) for full assessment and management details (P.Henson 2022), target range for blood glucose is 140-180 mg/dL.
 - b. Assessment: Check fasting blood glucose level on all patients in pre-op holding. If diabetic, check glucose q1hr Intraop; if non-diabetic, and > 140mg/dL preop, check glucose q1hr intraop.
 6. **Site prep**
 - a. No shaving if possible, and careful use of clippers and vacuum attachment when shaving is needed (common in Neurosurgical cases)
 - b. Keystone CVL Protocol for site prep on all lines; use CHG prep
 - c. Use Chloraprep on all CVC and a-line insertion sites
 - d. Use Chloraprep or Duraprep for surgical site
 - e. Scrub the hub - for accessing all CVLs and PIVs
- k. **Perioperative Metrics for Anesthesia: [MPOG ASPIRE MEASURES](#)**
As a component of any perioperative pathway or care standardization, providing perioperative anesthesia care in compliance with MPOG ASPIRE Measures is considered best practice. Anesthesia Provider adherence to the following metrics will be reported via the ASPIRE Task Force. Full text and references are available at [MPOG ASPIRE MEASURES](#)
1. **Blood Pressure Goals & Metrics:**
 - a. BP-01- <https://spec.mpog.org/Spec/Public/11>
Goal: Hypotension avoidance, (MAP >55mmHG throughout case).
 - b. BP-02- <https://spec.mpog.org/Spec/Public/12>
Goal: Regular monitoring, (≤10-minute gap in measurement interval).
 - c. BP-03- <https://spec.mpog.org/Spec/Public/34>
Goal: Hypotension avoidance, (MAP >65mmHG throughout case).

2. **Glucose Management Goals:** For all patients with and without diagnosis of diabetes, the following metrics represent the minimum threshold of provider compliance expected.

- Strategies: Refer to VUMC CEBA [Perioperative Glucose Management Protocol](#).
- [GLU-09- Hyperglycemic management, intraop](#)
 - Goal: intra-operatively, all Glucoses > 180 receive insulin or recheck within 90 minutes.
- [GLU-10- Hyperglycemic management, periop](#)
 - Goal: Perioperatively, all glucose> 180 receive insulin or recheck within 90 minutes.
- [GLU-11- Hyperglycemia treatment, periop](#)
 - Goal: Perioperatively, all glucoses > 180 receive administration of insulin within 90 minutes
- [GLU-12- Hypoglycemic management, intraop](#)
 - Goal: intra-operatively, all glucoses < 70 receive glucose or dextrose or recheck within 30 minutes.
- [GLU-13- Hypoglycemic management, periop](#)
 - Goal: Perioperatively, all glucoses < 70 receive glucose or dextrose, or recheck within 30 minutes.

3. **Neuromuscular Blockade Monitoring & Reversal:**

- Goals: From Anesthesia Start to earliest extubation:
 1. Documentation of a Train of Four count (1, 2, 3, or 4), sustained tetany, or TOF ratio provided by acceleromyography AFTER last dose or stopping of infusion of neuromuscular blocker and before earliest extubation. Note: A Train of Four value of '0' is accepted for cases in which Sugammadex is administered for reversal. NMB-01- <https://spec.mpog.org/Spec/Public/1>
 2. Administration of Neostigmine or Sugammadex before extubation for cases with non-depolarizing neuromuscular blockade. NMB-02- <https://spec.mpog.org/Spec/Public/2>

4. **Prevention of nausea & vomiting:**

- a. PONV-05- <https://spec.mpog.org/Spec/Public/53>
 - i. At least two prophylactic pharmacologic antiemetic agents of different classes administered preoperatively or intraoperatively for patients with one or two risk factors
 - ii. At least three prophylactic pharmacologic antiemetic agents from different classes preoperatively or intraoperatively for patients with three or more risk factors
- b. PONV-03 and 03b- <https://spec.mpog.org/Spec/Public/33>
 - i. Goal: Patient does not report nausea, have an emesis event or receive an antiemetic during the immediate postoperative period PACU to 6hrs post op (excludes patients going straight to ICU).
- c. Strategies:
 - i. Immediate Postoperative Nausea and vomiting (PONV) prophylaxis (Intra-op and PACU) – to be ordered by in-room anesthesiologist
 - ii. # of prophylactic agents should be greater than or equal to # of Apfel risk factors
 - iii. Avoid/minimize sedating anti-emetics in elderly, medically fragile patients, or OSA patients.

- iv. See Center for Evidence Based Anesthesia [Post-Operative Nausea and Vomiting Guidelines](#):
 - 1. Post-operatively in PACU, additional agents may be used.
- 5. **Pulmonary:**
 - a. PUL-01- <https://spec.mpog.org/Spec/Public/4>
 - i. Median tidal volume < 10 ml/ kg predicted body weight
 - b. PUL-03- <https://spec.mpog.org/Spec/Public/30>
 - i. Median PEEP \geq 2 cm H₂O during ventilation (Assuming values less than 2 cm H₂O is equivalent to no PEEP administered)
- 6. **Temperature:** See also Surgical Site Infection Reduction: 'NO BUGS' Management above.
 - a. TEMP-01- Thermoregulation vigilance, active warming <https://spec.mpog.org/Spec/Public/19>
 - i. Documentation of an active warming device applied (forced air warmers, increasing room temp, and fluid warmers should be used).
 - b. TEMP-02- Thermoregulation monitoring, core temp <https://spec.mpog.org/Spec/Public/20>
 - i. At least one core temperature documented between Anesthesia Start and Patient out of Room.
 - c. TEMP-03- perioperative hypothermia <https://spec.mpog.org/Spec/Public/21>
 - i. At least one body temperature measurement equal to or greater than 36 degrees Celsius (or 96.8 degrees Fahrenheit) achieved within the 30 minutes immediately before or the 15 minutes immediately after anesthesia end time.
- 7. **Transfer of Care:**
 - a. TOC-01- <https://spec.mpog.org/Spec/Public/29> Intra-operative handoff
 - b. TOC-02- <https://spec.mpog.org/Spec/Public/22> In-room to PACU handoff
 - c. TOC-03- <https://spec.mpog.org/Spec/Public/26> OR to ICU handoff.
 - d. See also our [Institutional OR-to-ICU Handoff Modules](#) on the Learning Exchange

VI. Postoperative Interventions – SICU

a. Follow SICU Liver Transplant Pathway (see appendix), with the following exceptions:

b. Labwork Monitoring:

i. Upon Arrival to SICU:

- 1. ABG
- 2. Lactate
- 3. CBC
- 4. BMP with Mg, Ca, Phos
- 5. LFTs
- 6. INR
- 7. Fibrinogen

ii. POD#0 (every 8hrs x24hrs):

1. ABG
 2. Lactate
 3. CBC
 4. BMP with Mg, Ca, Phos
 5. LFTs
 6. INR
 7. Fibrinogen
- iii. POD#1 (every 12hrs X24hrs):**
1. CBC
 2. BMP with Mg, Ca, Phos
 3. LFTs
 4. INR
- iv. POD#2-hospital discharge (every AM):**
1. CBC
 2. BMP with Mg, Ca, Phos
 3. LFTs
- c. ERAS Pathway Caveats:**
- i. Transfusion thresholds:**
 1. Maintain Hct \geq 25, INR $<$ 2, plts $>$ 50, fibrinogen $>$ 150
 2. Unless surgical concerns for bleeding, plan to relax parameters after 24 hrs
 - ii. VTE Prophylaxis:** No chemical DVT prophylaxis until:
 1. platelets $>$ 50 and approved by liver transplant team
 2. but may start if plt $<$ 50 and stable*
 3. Start 81 mg on for hepatic artery thrombosis, plt $>$ 50, or sooner if stable. (typically by POD 1-2)
 4. Subcutaneous heparin at prophylaxis dose by POD 2-3 typically, but dependent on patient and clinical concern for bleeding
 - iii. Analgesic Regimen:**
 1. Propofol & Fentanyl infusion- only when intubated, off when extubated
 2. Acetaminophen as soon as extubated: ordered to start 650mg q8H on POD1 at 0600.
 3. start Robaxin by POD0 (PO as soon as extubated).
 4. Opioids: Oral Opioids - with escalating PO regimen; before use of IV dilaudid
 5. Only escalated to IV dilaudid if needed, and off by POD 3
 6. Lidocaine patches (only for escalation).
 7. use of low dose gabapentin, only for escalation to get off IV opioids, or if home use (limited use due to risk for sedation and high AKI rate)
 8. avoid all NSAIDs
 - iv. Glycemic Control:**
 1. ERAS Patients on “Escalated Range” of insulin management, and on [SICU Low Risk Glycemic Control Protocol](#)
 2. Glucose Goal Range: 140-180

3. Insulin Infusion: Transition off infusion, once insulin infusion at less than 4u/hr
4. Goal: no insulin infusion by POD1. Initiate appropriate insulin coverage based on BG range.

v. GI/Diet Progression:

1. Advance diet by POD 1 to Transplant diet, unless:
 - a. patient requires a swallow evaluation
 - b. or if patient has a Roux-en-Y (pt has NG tube): advance diet on POD2, after removal of NG Tube.
2. Order Boost Glucose Control when diet initiated.
3. Antiemetics; IV ondansetron PRN
4. SICU orders stress ulcer prophylaxis and bowel regimen

vi. Ambulation/Mobilization:

1. OOB to chair by POD1.
2. should ambulate as early as able (NOT dependent on PT evaluation).

vii. Physical/Occupational Therapy:

1. All patients need order for PT/OT evaluation in by 0730 POD1 (or reach out to therapist to ensure they can add to that day's list) to evaluate functional status and mobilize.
2. Use rehab pager on weekend for new- ERAS liver transplant patient that needs to be seen.

viii. Lines/Drains Management:

1. Foley removed POD 1 before noon- Liver Transplant team will place order for removal
 - a. Hourly output documented while foley in place, then every 4 hours.
2. MAC removed POD1 after transfusion phase
3. Arterial line removed by POD1, and off vasopressors.
4. 2nd CL- double lumen, removed POD2, if peripheral IV is in place.
5. Surgical Team takes surgical dressing down on POD1

ix. Transition out of SICU Criteria:

1. Hemodynamic stability
2. Stable O2 requirement
3. Able to clear secretions
4. Discontinuation of invasive monitoring
5. Non-combative/cooperative
6. Off insulin infusion

VII. Postoperative Interventions- Step-down Unit

a. Continue Lab work Monitoring:

i. POD2-hospital discharge (every AM):

1. CBC
2. BMP with Mg, Ca, Phos
3. LFTs

b. Lines/Drains:

- i. lateral drain out on POD2 if output OK- quality of output is assessed- sanguinous vs serosanguinous vs bilious
 - ii. medial drain out by POD3-4 at time of discharge, pending biliary leak concerns
 - c. **Continue patient mobilization, expanding ambulation goals to**
 - i. Patient to ambulate as tolerated, with assistance as indicated. Goal for TID ambulation by POD3.
 - d. **Discharge Criteria:**
 - e. **Discharge Prescriptions Provided by Pharmacy:**
 - i. Analgesic Regimen:
 1. continue 5-10 days of multimodal agents that patients are using at discharge
 2. 3 days of PRN opioid
 3. Acetaminophen
 4. Methocarbamol
 5. Lidocaine, etc
 - ii. **Insulin**
 - iii. **Immunosuppression**

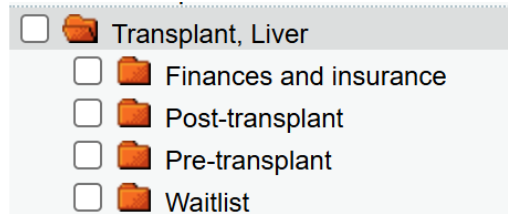
VIII. Post-Discharge Interventions:

- a. Post-discharge laboratory monitoring: on Monday-Wednesday-Friday for 30 days post-op
- b. Follow up appointments weekly for 30 days post-op
- c. Hepatologists will initiate Statin therapy by 6 months post-transplant, if indicated by pre-op CAD risk stratification

IX. Patient/Family Education

- a. Pre- and Post- Transplant Education provided by Transplant Coordinator Team
 - i. [Transplant Education Content](#)
- b. Patient education on glucose monitoring and insulin management will be provided by Post-Transplant Coordinators prior to discharge, and Pharmacist on POD2 and day of discharge.
 - i. ENGLISH
 1. Brochure: https://cdn.staywell.com/custom_content/fde559b7-9819-46d0-9212-d16a903678ab.pdf
 2. Video: <https://share.vidyard.com/watch/jPdut9tCS7rPCiR7PzcL2K>
 - ii. SPANISH
 1. Brochure: https://cdn.staywell.com/custom_content/92f5c8d2-b920-41f1-9fdd-7ebf02a1be57.pdf
 2. Video: <https://share.vidyard.com/watch/NjDnrvK872wRYtPRrzh1h7>
 - iii. ARABIC
 1. Brochure: https://cdn.staywell.com/custom_content/8c4ad70c-b1e4-4a9d-b9cc-f9d85a0569dc.pdf
 2. Video: [\(After Your Transplant: How to Manage Your Blood Sugar\) بعد زراعتك للكبد: كيفية ضبط مستوى السكر في د](#)

- iv. This content is available on Krames on FHIR and in the Liver Transplant Folder



- c. Insulin and Glucose monitor can be ordered from outpatient pharmacy for patient education.

X. Evidence Summary & References

- a. [Evidence Summary Liver Transplant ERAS 2025.xlsx](#)
 b. **References**

1. Brustia R, Monsel A, Skurzak S, et al. Guidelines for Perioperative Care for Liver Transplantation: Enhanced Recovery after Surgery (ERAS) Recommendations. *Transplantation*. 2022;106(3). doi:10.1097/TP.0000000000003808
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4. Jin B, Gu Y, Xi S, Liu X, Wu X, Li G. Application of enhanced recovery after surgery following liver transplantation. *World J Surg Oncol*. 2023;21(1). doi:10.1186/s12957-023-03139-x
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6. Pollok JM, Tinguely P, Berenguer M, et al. Enhanced recovery for liver transplantation: recommendations from the 2022 International Liver Transplantation Society consensus conference. *Lancet Gastroenterol Hepatol*. 2023;8(1). doi:10.1016/S2468-1253(22)00268-0

XI. Appendix

- a. *SICU Liver Transplant Pathway: Current version-* [SICU Liver Transplant Pathway.pdf](#)
 b. [SICU Patient Management Guidelines](#)

