	แนวทางปฏิบัติ **เรื่อง: การระงับความรู้สึกเพื่อทำผ่าตัด Ventricular Assist Devices Placement**	**หน้า :** 1 / 10 **รหัสเอกสาร :** AS-03-4-001-01 **ทบทวนครั้งที่ :** - **วันที่ทบทวน :** -
ชื่อหน่วยงาน : สาขาวิสัญญีหัวใจและทรวงอก ภาควิชาวิสัญญีวิทยา		**วันที่อนุมัติ :** 22-06-2563
ผู้ตรวจสอบ : คณะกรรมการฝ่ายวิชาการ ภาควิชาวิสัญญีวิทยา		**ผู้อนุมัติ : หัวหน้าภาควิชาวิสัญญีวิทยา**

1. วัตถุประสงค์

1.1 เพื่อเป็นแนวทางปฏิบัติแก่ทีมวิสัญญี ในการระงับความรู้สึกผู้ป่วยที่มารับการใส่ Ventricular Assist Devices (VADs) แบบระยะยาว (Long Term Assist Devices)

1.2 เพื่อการป้องกัน การวินิจฉัย และการแก้ไข ภาวะแทรกซ้อนหรือปัญหาที่อาจเกิดขึ้นจากการระงับความรู้สึกในผู้ป่วยกลุ่มนี้ (โดยเฉพาะในช่วงหลังผ่าตัด) ดังต่อไปนี้

- Bleeding
- Cardiac failure
- Coagulopathy
- Mechanical failure
- Infection
- ARDS
- Multiple organ failure (MODs)

2. ขอบข่าย

2.1 ผู้ป่วยทุกรายที่มารับการระงับความรู้สึกเพื่อใส่ Ventricular Assist Devices แบบระยะยาวในโรงพยาบาลศิริราช

3. ความรับผิดชอบ

3.1 อาจารย์วิสัญญีแพทย์

3.2 แพทย์ต่อยอดสาขาวิสัญญีหัวใจ หลอดเลือดใหญ่และทรวงอก

3.3 แพทย์ประจำบ้านวิสัญญี

3.4 วิสัญญีพยาบาล

4. คำจำกัดความ

4.1 ไม่มี

5. เอกสารอ้างอิง

5.1 Gaunt A. Anaesthesia for cardiothoracic transplantation and ventricular assist devices. Anaesthesia and Intensive Care Medicine. 2006;9:317-20.

5.2 Heath MJS, Dickstein ML. Perioperative management of the left ventricular assist device recipient. Progress in Cardiovascular Diseases. 2000;43:47-54.

5.3 Mets B. Anesthesia for left ventricular assist device placement. J Cardiothorac Vasc Anesth. 2000;14:316-26.

5.4 Nusmeier NA, Probert CB, Hirsch D, Cooper JR jr, Gregoric ID, Myers TJ, et al. Anesthetic management for implantation of the Javik 2000TM left ventricular assist system. Anesth Analg 2003;97:964-71.

5.5 Stainback RF, Estep JD, Agler DA, Birks EJ, Bremer M, Hung J, et al. Echocardiography in the Management of Patients with Left Ventricular Assist Devices: Recommendations from the American Society of Echocardiography. J Am Soc Echocardiogr. 2015;28(8):853-909.

5.6 Albert C. Perrino STR. Tranesophageal Echocardiography. Tranesophageal Echocardiography. Tranesophageal Echocardiography for Coronary Revascularization. 3rd ed. Philadephia: Wolters Kluwer Health/Lippincott Williams & Wilkins; 2014. p. 315-21.

6. **รายละเอียด**

Indications for long-term mechanical circulatory support (e.g. VADs) include:

- New York Heart Association functional class IIIB—IV and Ejection fraction <_25% and
- At least one of the following criteria:
  - INTERMACS 2-4
  - Inotrope dependence
  - Progressive end-organ dysfunction
  - Peak VO2 < 12 ml/kg/min
  - Temporary mechanical circulatory support dependence

It is recommended that reversible causes of heart failure be ruled out. No transplant candidate.

6.1 **Goals of anesthesia management**

6.1.1 Ensure unconsciousness

6.1.2 Maintain cardiac stability

6.1.3 Maintain adequacy of organ perfusion

6.1.4 Ensure proper VAD management

6.1.5 Prevent infection

6.1.6 Correct coagulopathy

6.2 **Preoperative assessment**

6.2.1 Cardiac status and cause of heart failure or indication of VADs placement

6.2.2 Intracardiac device management (e.g. AICD, Pacemaker)

6.2.3 Contraindications for intraoperative transesophageal echocardiography

6.2.4 Neurologic function (cognitive function, level of consciousness, etc.)

6.2.5 Pulmonary function (e.g. SpO2, ABG)

6.2.6 Renal function & hepatic function as well as coagulation status

6.2.7 Psychological status

6.2.8 History of previous anesthesia and surgery particularly redo open heart surgery

6.2.9 Other routine pre-anesthesia evaluation: airway, line access, allergies

6.3 **Patient preparation**:

Patient will be inform about anesthesia care, risk/benefit including written-informed consent obtained.

6.3.1 Investigations

6.3.1.1 CBC, Urinalysis

6.3.1.2 Blood chemistries: blood glucose, BUN/Creatine, Electrolytes, Liver function test include coagulogram

6.3.1.3 Blood/Sputum/Urine cultures (if indicated)

6.3.1.4 Chest X-ray

6.3.1.5 Electrocardiography (ECG)

6.3.1.6 Echocardiography

6.3.2 Current medications & support

6.3.2.1 Review preoperative medications, mechanical hemodynamic support (if being used)

6.3.2.2 Ensure continuous infusion of all importance medications

6.3.2.3 Ensure proper mechanical circulatory device functions during transportation

6.3.2.4 Appropriate antibiotics be given prior surgery

6.3.3 IV Fluids & Blood components

6.3.3.1 Crystalloids and Colloids as individual needs

6.3.3.2 Blood components included PRC, FFP, Platelet and Cryoprecipitate

6.4 **Room preparation**

6.4.1 Equipment

6.4.1.1 Anesthesia machine checked: follow basic safety guidelines

6.4.1.2 Airway devices, suction etc.

6.4.1.3 Warming devices: water-warmer blanket, air-forced warmer, fluid/blood warming devices etc.

6.4.1.4 Rapid fluid infusion devices, autologous blood recovery unit (e.g. cell saver)

6.4.1.5 Two large-bore peripheral lines, one arterial line, double-lumen catheter, PA catheter with cardiac output (CO) measurement & set up

6.4.1.6 Infusion & syringe pumps as needed.

6.4.1.7 TEE machine

6.4.1.8 Defibrillator with transcutaneous pacing patch

6.4.2 Medications

6.4.2.1 Cardiostable induction agent preferred (e.g. etomidate), narcotics, sedatives, muscle relaxant and inhalation agent

6.4.2.2 Heparin and Protamine

6.4.2.3 Antifibrinoytics: e.g. Tranexamic acid

6.4.2.4 Inotropics and vasoactive agents

6.4.2.5 Pulmonary vasodilators (inhaled nitric oxide, prostacyclin analogues)

6.4.2.6 Antibiotics

6.4.3 Monitoring

6.4.3.1 NIBP, ECG, SpO2, EtCO2, temperature

6.4.3.2 Airway pressure, minute ventilation

6.4.3.3 Arterial line, CVP, PAP, CO (particularly right sided CO post VAD placement)

6.4.3.4 ABG, hematocrit, electrolytes, ACT, Blood sugar (as indicated), and thromboelastogram (as indicated)

6.4.3.5 Consider depth of anesthesia monitoring (e.g. processed EEG) and cerebral oximetry

6.4.3.6 Transesophageal echocardiography

6.4.4 Position

Supine (except for the Jarvik 2000 Heart™: 30-45 degree right lateral decubitus position)

6.5 **Intraoperative management**

6.5.1 Induction phase

6.5.1.1 Hemodynamically stable induction agents preferred e.g.: etomidate, midazolam, fentanyl/sufentanil, or ketamine

6.5.1.2 Small incremental dose of induction agents given due to slow circulation time & reduced volume of distribution

6.5.1.3 Pre-induction invasive hemodynamic monitoring

6.5.2 Intubation phase

6.5.2.1 Pre-oxygenation prior induction and intubation may be necessary to avoid desaturation that is significant in this group of patients.

6.5.2.2 Muscle relaxants: depend on individual preference but both liver and renal impairments should be considered.

6.5.2.3 If possible full stomach would be concerned, rapid sequence intubation (RSI) should be performed. Anyway, this might result in hypoventilation or apnea which may be hazardous due to hypercarbia and hypoxia induced pulmonary hypertension. Then intermittent ventilation while maintaining cricoid pressure might be a feasible alternative to minimize the chance of pulmonary aspiration and those insults.

6.5.3 Maintenance phase

6.5.3.1 Maintain level of anesthesia to avoid awareness with volatile anesthetic agent or intravenous anesthetics, good relaxation and adequate control of autonomic response.

6.5.3.2 Maintain inotropic and vasoactive agents as preoperative period.

6.5.3.3 Avoid both hypo- and hyper-ventilation because hypercarbia may cause pulmonary hypertension whereas overventilation and hypocarbia decreases venous return and circulating catecholamines.

6.5.3.4 Consider anti-fibrinolytic agents to minimize blood loss as Institute protocol (Tranexamic acid, Aminocaproic acid)

6.5.3.5 Ensure full heparinization prior and during CPB. Administer protamine after CPB.

6.5.3.6 Post CPB: the combination of milrinone/dobutamine for inotropy and norepinephrine for supporting of SVR are highly effective in supporting

LVAD circulation. RV failure is the common after LVAD implantation, therefore measures to support the RV and to reduce PVR (inhaled NO, prostacyclin analogues) should be considered prior to separation of CPB.

6.5.3.7 Blood, FFP, Platelets and Cryoprecipitate as indicated.

6.5.3.8 TEE is the key monitoring to optimize intraoperative hemodynamics and to assist LVAD implantation: Appendix 1.

6.5.4 Surgery concept

6.5.4.1 Operative technique is subject to device-specific features as well as to the individual surgeon and institutional preference. The use of cardiopulmonary bypass should be considered. However, implantation of VADs on extracorporeal life support or off-pump implantation may be used.

6.5.4.2 Inflow cannula is placed into the left ventricle (LVADs). Confirming the inflow cannula position with TEE is recommended.

6.5.4.3 Outflow cannula is placed into the ascending aorta (LVADs).

6.6 **Postoperative implications**

6.6.1 Possible complications:

6.6.1.1 Bleeding and coagulopathy

- Significant bleeding or reoperation could occur after VAD implantation.
- Causes include preoperative hepatic dysfunction, preoperative and intraoperative anticoagulation, contact-activation of coagulation cascades by CPB circuit and VAD, and postoperative anticoagulation.
- Measures to reduce bleeding: ceasing preoperative anticoagulant and correction of coagulopathy, administration of antifibrinolytic, maintaining normothermia, and avoiding hypertension. Blood product administration guided by clinical and laboratory parameters should be considered.
- In general, a postoperative international normalized ratio is targeted at 2.0 and 3.0. Device-specific anticoagulation protocols should be utilized.

6.6.1.2 Right ventricular failure

- RV failure is defined as a CVP greater than 18 mmHg and a cardiac index less than 2.0 L/min/m2 in the absence of elevated LA pressure.

Cardiac tamponade, ventricular arrhythmia and pneumothorax should be ruled out. (INTERMACS definition).

- Regular echocardiographic scans should be considered to monitor the RV.
- Inhaled NO or prostacyclin and phosphoesterase-5 inhibitors may be considered to prevent RV failure after LVAD implantation.

6.6.1.3 Mechanical failure

6.6.1.4 Infection

6.6.1.5 ARDs

6.6.1.6 Multiple organ failure (MODs)

6.6.2 General ICU care include Pain control: as postoperative ICU protocol

7. **ภาคผนวก**

Appendix 1. Echocardiography in the management of patients with left ventricular assist devices:

1. Preimplantation TTE/TEE

a. Left ventricle and interventricular septum
   i. Small LV size, particularly with increased LV trabeculation
   ii. LV thrombus
   iii. LV apical aneurysm
   iv. Ventricular septal defect
   v. LV dysfunction

b. Right ventricle
   i. RV dilatation
   ii. RV systolic dysfunction: RV ejection fraction, RV fractional area change (FAC), tricuspid annular-plane systolic excursion (TAPSE) and RV free-wall peak longitudinal strain

c. Atria, interatrial septum, and inferior vena cava
   i. Left atrial appendage thrombus
   ii. PFO or atrial septal defect

d. Valvular abnormalities
   i. Any prosthetic valve (especially mechanical MV and AV)
   ii. > mild AR, ≥ moderated MS
   iii. ≥ moderate TR or > mild TS
   iv. > mild PS, ≥ moderate PR

e. Other
   i. Any congenital heart disease esp. PFO or interatrial communications
   ii. Aortic pathology: aneurysm, dissection, atheroma, coarctation
   iii. Mobile mass lesion
   iv. Other shunts: patent ductus arteriosus, intrapulmonary
   v. Acute endocarditis, Mobile mass lesion (or other active infection) is an absolute contraindication for MCS-device implantation

2. Perioperative TEE exam preimplantation

Goal: to confirm previous finding and to detect unexpected abnormal finding before and after LVAD implantation

a. LV size and systolic function, assess for thrombus
b. LA size and LA appendage for thrombus
c. RV size, systolic function and catheters/leads
d. RA size, assess for thrombus, catheters/leads
e. Interatrial septum: detailed 2D, color Doppler, IV saline contrast (red flag: PFO/ASD)
f. Systemic Veins: assess SVC and IVC
g. Aortic valve (red flags > mild AR and prosthetic valve)
h. Mitral valve (red flags ≥ moderate MS, prosthetic mitral valve)
i. Pulmonary valve (red flags > mild PS, ≥ moderate PR)
j. Pulmonary trunk (red flags congenital anomaly, [PDA, pulmonary atresia or aneurysm])
k. Tricuspid valve TR, RVSP, (red flags ≥ moderate TR, > mild TS, prosthetic valve)
l. Pericardium screen for effusion and constrictive physiology
m. Aorta root, ascending, arch and descending thoracic aorta screen of aneurysm, congenital anomaly, dissection or complex atheroma at each level

3. Perioperative TEE during LVAD implantation

Goal monitor for intracardiac; rule out shunt; confirm devices and native heart function

a. Pump type
b. Pump speed
c. Intracardiac air; left-sided chambers and aortic root during removal from CPB
d. LV size inflow-cannula position and flow velocities, septal position [red flags small LV (Over pumping or RV failure), right to left septal shift, large LV (obstruct or inadequate pump flows)]
e. Inflow cannula position: 2D and 3D assess for possible malposition
f. Inflow cannula flow: spectral and color Doppler appropriate positioned inflow cannula lies near or within the LV apex and directed toward to mitral inflow (red flags: abnormal flow pattern/high/low velocities, especially after sternal closure)
g. LA: assess LA appendage
h. RV size and function (red flags sign of RV dysfunction)
i. RA size, assess for thrombus, catheters/leads
j. Interatrial septum: repeat IV saline agitation test and color Doppler evaluation of IAS (red flags PFO/ASD)
k. Systemic veins IVC and SVC
l. Pulmonary veins
m. Aortic valve degree of AV opening and degree if AR (red flags > mild AR)
n. Mitral valve exclude inflow-cannula interference with submitral apparatus; assess MR
o. Pulmonary valve: assess PR, measure RVOT stroke volume if able
p. Tricuspid valve: assess TR severity (red flags $\geq$ moderate TR) , RVSP if not severe TR
q. Pericardium screen for pericardial effusion/hematoma
r. Aorta exclude iatrogenic dissection outflow graft to aorta anastomosis; assess patency/flow by color and spectral Doppler (when able) (red flags kink apparatus turbulent flow/velocity > 2m/sec, particularly after sternal closure)

4. Perioperative TEE during initial LVAD Activation and speed Optimization

a. Annotate pump speed and device name on the screen

5. Post LVAD implantation checks

a. De-airing, both intracardiac and device

b. Re-evaluation of PFO/ASD
c. The presence of mitral regurgitation should be reduced if not may indicate the poor positioning of inflow cannula
d. Decompression of LV
e. Septal position should be neutral, right shift indicates inadequate emptying. Left shift can result from excessive decompression due to excessive pump speeds
f. Doppler interrogation of cannulas
g. Aortic valve opening
h. Right ventricular failure

6. Rule out cardiac tamponade Troubleshooting: problems and LVAD optimization

a. Suction event: a condition in which a segment of LV myocardium partially occludes the inflow cannula and reduces pump inflow, quickly corrected by lowering the pump speed
b. Important of aortic valve opening and aortic regurgitation
c. Sign of LVAD dysfunction