Non-operating room anesthesia

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General Principles

General Principles

- Nonoperating room anesthesia (NORA) refers to anesthesia that is provided at any location remote from the traditional operating room.

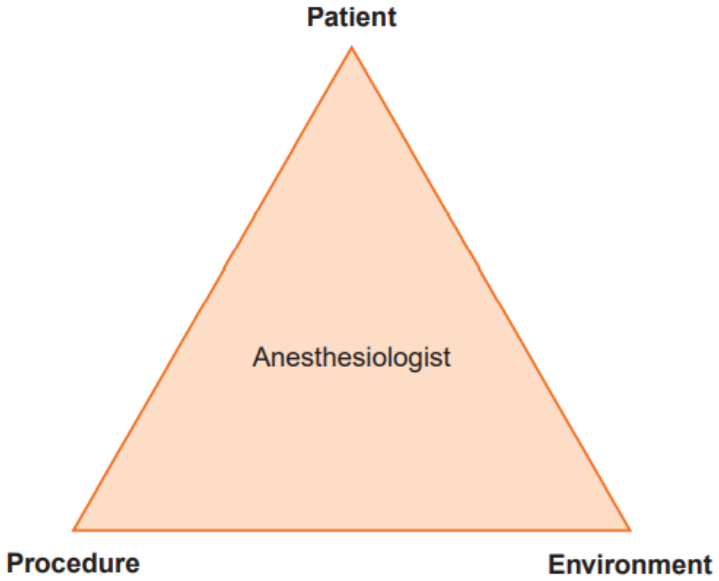
- NORA accounts for about 30% of anesthesia case, the highest rate of increase being in gastroenterological procedures.

NORA-specific challenges

NORA-specific challenges
Remote location far from pharmacy and supplies
Noisy environments
Limited workspace, small procedure room
Inadequate lighting
Minimal temperature regulation
Electrical / magnetic interference
Older, possibly unfamiliar equipment
Lack of skilled anesthesia support staff
Limited patient access during procedures
Inadequate power supply
Radiation safety

Challenges relevant to NORA and OR anesthesia
Supply of equipment
Appropriate monitoring devices
Inadequate support staff
Patient-related illness
More cases after normal working hours
Increased percentage of “emergency” procedures

Three-step approach to NORA



Patients

- Ages :
  - Tend to be older (above 50 years) : higher ASA status (especially cardiologic, gastroenterologic and radiologic procedures)
  - Pediatrics (below 10 years) : need for sedation or anesthesia for diagnostic or therapeutic procedures.

- More likely to receive monitored anesthesia care (MAC) or sedation

- Preanesthetic assessment and care, Anesthetic plan with appropriate levels of monitoring, Appropriate post-anesthesia care is important.

Patients factors requiring sedation and anesthesia

- Claustrophobia, anxiety and panic disorders
- Cerebral palsy, developmental delay and learning difficulties
- Seizure disorders, movement disorders and muscular contractures
- Pain, both related to the procedure and other causes
- Acute trauma with unstable cardiovascular, respiratory, or neurologic function
- Raised intracranial pressure
- Significant comorbidity and patient frailty (ASA grades III, IV)
- Child age, especially children <10 yrs

Procedures

- The anesthesiologist must understand the nature of the procedure, including
  - The position of the patient.
  - How painful the procedure will be.
  - How long it will last.

- Discussions with the proceduralist must include contingencies for emergencies and adverse outcomes.

Common NORA procedures

Radiologic imaging	Computed tomography (CT)
	Magnetic resonance imaging (MRI)
	Positron emission tomography (PET)
Diagnostic and therapeutic interventional radiology	Various vascular imaging, stenting, and embolization procedures
	Radiofrequency ablation (RFA)
	Transjugular intrahepatic portosystemic shunt (TIPS)
Diagnostic and therapeutic interventional neuroradiology	Occlusive ("closing") procedures
	• Embolization of cerebral aneurysm/AVM/vascular tumors
	Opening procedures
	• Angioplasty/stenting/thrombolysis in stroke cerebral atherosclerosis or cerebral vasospasm
Radiotherapy	Radiation therapy
	Intraoperative radiotherapy
Diagnostic and therapeutic interventional cardiology	
Cardiac catheterization laboratory	Diagnostic cardiac catheterization
	Percutaneous coronary interventions (PCI)
	Interventional techniques for management of structural heart disease (Transcatheter aortic valve implantation [TAVI])
	Placement of left ventricular cardiac assist devices for hemodynamic support
Electrophysiology laboratory (EPL)	Electrophysiology studies and radiofrequency ablation
	Implantation of biventricular pacing systems and cardioverter defibrillators
Other Procedures	Cardioversion and Transesophageal echocardiography
Diagnostic and therapeutic interventional gastroenterology	Upper gastroenterology endoscopy
	Esophageal dilatation or stenting
	Percutaneous endoscopic gastrostomy tube placement
	Endoscopic retrograde cholangiopancreatography (ERCP)
	Colonoscopy
	Liver biopsy
Psychiatry	Electroconvulsive therapy (ECT)
Dentistry	Dental extractions
	Restorative dentistry

Environment

- The American Society of Anesthesiologists (ASA) has developed standards for NORA.
- Prior to the anesthetic, the presence and proper functioning of all equipment needed for safe patient care must be established.
- The location of immediately available resuscitation equipment should be noted.
- Protocols developed with the local staff for dealing with emergencies, including cardiopulmonary resuscitation and the management of anaphylaxis.

ASA standards for NORA locations

1. Oxygen-reliable source and full backup E-cylinder
2. Suction-adequate and reliable
3. Scavenging system if inhalational agents are administered
4. Anesthetic equipment
   - Backup self-inflating bag capable of delivering at least 90% oxygen by positive-pressure ventilation
   - Adequate anesthetic drugs and supplies
   - Anesthesia machine with equivalent function to those in the operating rooms and maintained to the same standards
   - Adequate monitoring equipment to allow adherence to the ASA standards for basic monitoring[4]
5. Electrical outlets
   - Sufficient for anesthesia machine and monitors
   - Isolated electrical power or ground fault circuit interrupters if "wet location"
6. Adequate illumination of patient, anesthesia machine, and monitoring equipment

   Battery-operated backup light source
7. Sufficient space for:
   - Personnel and equipment
   - Easy and expeditious access to patient, anesthesia machine, and monitoring equipment
8. Resuscitation equipment immediately available
   - Defibrillator/emergency drugs/cardiopulmonary resuscitation equipment
9. Adequately trained staff to support the anesthesiologist and a reliable means of two-way communication
10. All building and safety codes and facility standards should be observed
11. Postanesthesia care facilities
    - Adequately trained staff to provide postanesthesia care
    - Appropriate equipment to allow safe transport to main postanesthesia care unit

Environment

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Patient safety in NORA

Adverse events

- NORA procedures appear to have a lower incidence of both minor and major complications and mortality than OR procedures.
- The gastroenterology suite, cardiac laboratory, and the emergency department are sites where adverse events are likely to occur and elderly, medically complex patients have been determined to be more at risk.
- Respiratory depression secondary to oversedation was the most common type of adverse event.
- Capnography provides an early monitor of impending respiratory depression during sedation and is recommended.

Complications of Nonoperating Room Anesthesia

- Minor complications

  - Postoperative nausea and vomiting
  - Inadequate postoperative pain control
  - Hemodynamic instability
  - Minor neurologic complications such as postdural puncture headache
  - Minor respiratory complication
  - Complications related to central/intravenous lines
  - Need for opioid reversal

Complications of Nonoperating Room Anesthesia

- Major complications

  - Unintended patient awareness
  - Anaphylaxis
  - Need for upgrade of care
  - Serious hemodynamic instability
  - Respiratory complication
  - Need for resuscitation
  - Vascular access-related complications
  - Wrong patient/wrong site
  - Fall of burn

Preprocedural checklists and patient transfer

- The use of checklists and pre and postprocedural team briefings should be adopted in NOR sites.
- During transport the sick and unstable patient should be accompanied by skilled personnel to evaluate, monitor, and support the patient's medical condition.
- Adequate supplies of oxygen must be available for the transfer. A manual self-inflating bag is essential in the event of ventilator failure.
- Infusion pumps and portable monitors should have adequate battery power for transit.

Preprocedural checklists and patient transfer

- The transport team should carry spare anesthetic and emergency drugs, equipment for intubation or reintubation, portable suction, and if the patient's condition requires, a portable defibrillator.

- It is vital to notify the destination area that the patient is in transit, so that appropriate preparations to receive the patient can be made in advance.

- It is also useful to send personnel ahead to secure the elevators to prevent delays during transfer.

Sedation and anesthesia

Sedation and anesthesia

- Anesthesia exists along a continuum and the transition from minimal sedation to general anesthesia is not clear-cut.

- As sedation deepens, it is important to recognize the progressive blunting and loss of airway reflexes and patency, together with depression of spontaneous ventilation and cardiovascular function.

- Services must be immediately available to rescue a patient from a deeper than intended level of sedation or general anesthesia.

Sedation and anesthesia

Description	***Minimal Sedation***	***Moderate Sedation/Analgesia***	***Deep Sedation/Analgesia***	***General Anesthesia***
Responsiveness	Normal response to verbal stimulation	Purposeful response to verbal or tactile stimulation	Purposeful response following repeated or painful stimulation	No response even with painful stimulus
Airway	Unaffected	No intervention required	Intervention may be required	Intervention often required
Spontaneous Ventilation	Unaffected	Adequate	Maybe inadequate	Frequently inadequate
Cardiovascular Function	Unaffected	Usually maintained	Usually maintained	May be impaired

Environmental consideration for NORA

X-rays and Fluoroscopy

- X-rays are produced when electrons are accelerated through a high voltage in a vacuum tube and collide with a metal target.

- Fluoroscopy is a technique used to obtain real-time moving images of the internal structures. The patient is positioned between the x-ray source and a fluorescent screen.

- Fluoroscopy is widely and increasingly used in NOR locations including interventional radiology, cardiac catheterization, and electrophysiologic procedures and in the gastroenterology suite.

X-rays and Fluoroscopy

- Large, C-shaped, mobile fluoroscopy devices (C-arms) are used to provide images in multiple dimensions.

- The C-arm moves back and forth around the patient during the procedure :
  - Taking up large amounts of space
  - Limiting access to the patient
  - Serving as a means of dislodging intravenous lines and endotracheal tubes.

Hazards of Ionizing radiation

- The effects of ionizing radiation on biologic tissues are classified as

  - Deterministic (dose related causing cell death and tissue damage)

  - Stochastic (the development of cancer from direct DNA ionization or the creation of hydroxyl radicals from x-ray interactions with water molecules)

- Patient exposure to radiation during imaging and treatment varies depending on the type of procedure as well as patient- and operator-related factors.

Common terms used in radiation exposure

Term	Units	Definition	Notes
Exposure	Roentgen (R)	Quantity of X-radiation or gamma radiation required to produce an amount of ionization	Measurements may be in exposure rate, i.e., amount of exposure per unit time e.g., fluoroscopy is measured in R/min
Absorbed dose	Rad (radiation absorbed dose) or Gray	Amount of ionizing radiation absorbed by the body	Depends on exposure to X-ray beam and the tissue type
Dose equivalent	Sievert (Sv)	Absorbed dose multiplied by a radiation quality factor specific for the type of radiation	Measures the "harmfulness" of any radiation-absorbed dose
Effective dose	Sievert (Sv)	Dose equivalent to the entire body caused by irradiating only a localized area. Calculated by multiplying the dose equivalent by a weighting factor specific for the irradiated organ	Takes into account the differing radiosensitivity of different organs Estimate of cancer risk

Characteristics of External Exposure Doses

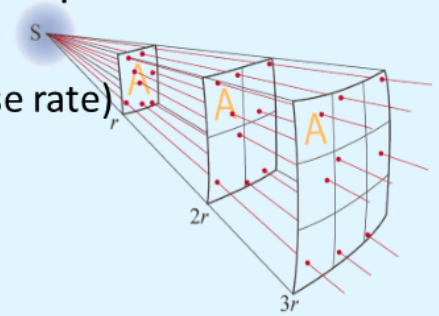
1) **Distance**: Dose rates are inversely proportional to the distance squared.

$$I = \frac{k}{r^2}$$

I : Radiation intensity (dose rate)

r : Distance

k : Constant



2) **Time**: Doses are proportional to the time of exposure provided the dose rates are the same.

(Total) dose (microsieverts) =

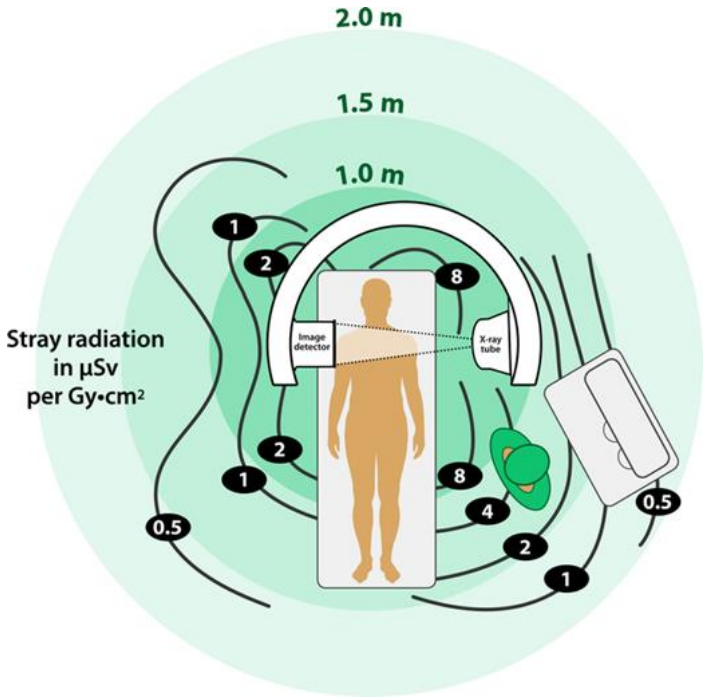
Dose rate (microsieverts/h) × Time

Hazards of Ionizing radiation

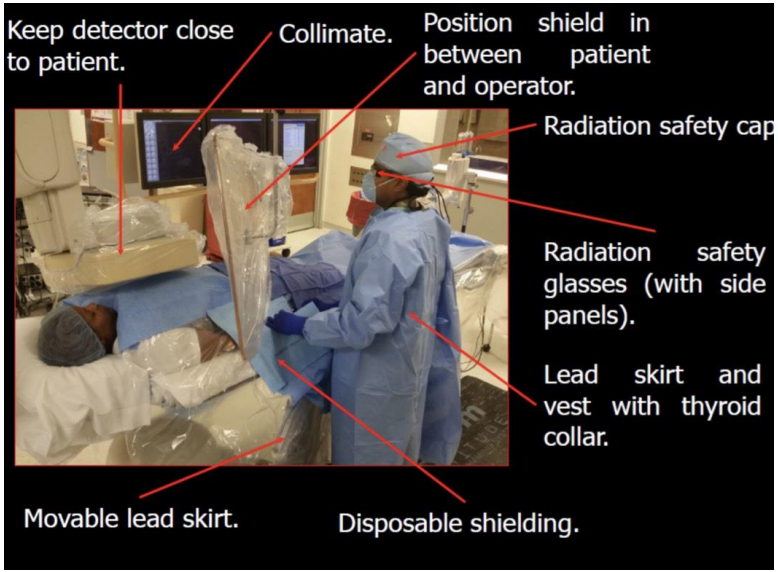
- National Council on Radiation Protection and Measurements (NCRP) recommends

  - Occupational limit of 50 mSv in any 1 year

  - Lifetime limit of 10 mSv multiplied by the individual's age in years.



Hazards of Ionizing radiation



- Radiation can be minimized by

  - Limiting the time of exposure to radiation

  - Increasing the distance from the source of radiation

  - Using protective shielding : Lead aprons, thyroid shields, and leaded eyeglasses

Intravenous contrast agents

- Intravenous contrast agents are commonly used in radiologic and MRI to enhance vascular imaging.

- Radiologic contrast media are iodinated compounds classified according to their osmolarity, ionicity, and the number of benzene rings.

  - Nonionic contrast agents cause less discomfort on injection and have a lower incidence of adverse reactions.

- MRI contrast agents are also divided into ionic and nonionic compounds. They are chelated metal complexes containing gadolinium, iron, or manganese.

Renal adverse reaction

- Contrast agents are eliminated via the kidneys, and contrast-induced nephropathy (CIN) associated with their use is estimated to account for nearly 10% of hospital-acquired acute renal failure.

- CIN is defined as an increase in serum creatinine of 0.5 mg/dL or a 25% increase from the baseline within 48 to 72 hours after iodinated contrast medium administration.

- Risk factors : Chronic kidney disease, history of renal disease, prior renal surgery, proteinuria, diabetes mellitus, hypertension, gout, and use of nephrotoxic drugs.

Prevention for renal adverse reaction

- Adequate hydration, maintaining a good urine output, and using sodium bicarbonate infusions to improve elimination of the contrast agent.

- Avoid Nephrotoxic medications such as nonsteroidal anti-inflammatory drugs, aminoglycosides, and diuretics should be avoided for 24 to 48 hours before and after the use of intravenous contrast agents.

- The efficacy of N-acetylcysteine and other agents such as fenoldopam, dopamine, calcium-channel blockers, atrial natriuretic peptide, and L-arginine in mitigating CIN has not been proven.

Hypersensitivity reactions

- Hypersensitivity reactions to contrast media are divided into immediate (<1 hour) and nonimmediate (>1 hour) reactions.
- Reactions to gadolinium-based contrast agents used for MRI are less frequent than to iodinated contrast agents.
- Fatal hypersensitivity reactions may occur in about 1 per 100,000 contrast administrations.
- Risk factors : allergic history to contrast agents, urticaria, history of previous allergy to drugs other than contrast agents, contrast agent concentration > 70%, age <50 years old, and a total contrast agent dose >65 g.

Hypersensitivity reactions

Immediate Reactions	Nonimmediate Reactions
Pruritus	Pruritus
Urticaria	Exanthema (mostly macular or maculopapular drug eruption)
Angioedema/facial edema	Urticaria, angioedema
Abdominal pain, nausea, diarrhea	Erythema multiforme minor
Rhinitis (sneezing, rhinorrhea)	Fixed drug eruption
Hoarseness, cough	Stevens–Johnson syndrome
Dyspnea (bronchospasm, laryngeal edema)	Toxic epidermal necrolysis
Respiratory arrest	Graft-versus-host reaction
Hypotension, cardiovascular shock	Drug-related eosinophilia with systemic symptoms (DRESS)
Cardiac arrest	Symmetrical drug-related intertriginous and flexural exanthema (SDRIFE)
	Vasculitis

Hypersensitivity reactions

- Treatment of severe hypersensitivity reactions includes

  - Discontinuing the causative agent

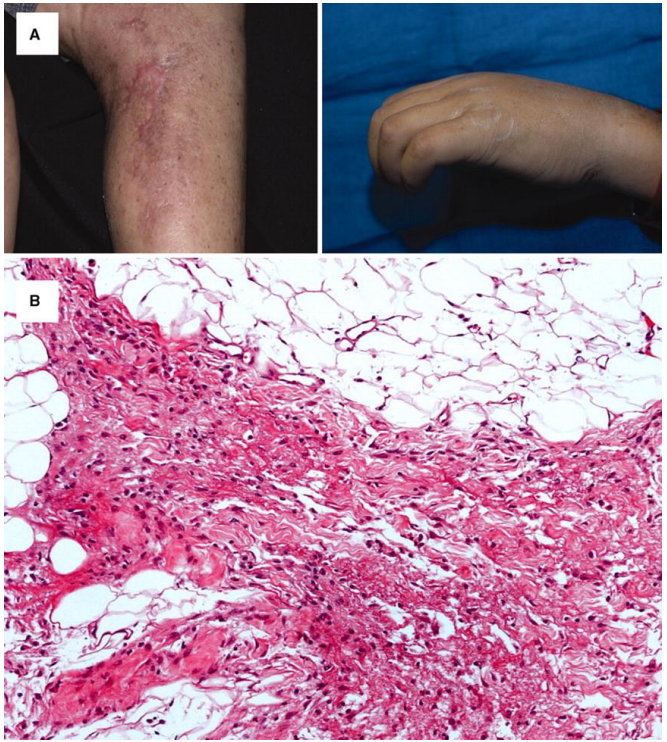
  - Supportive therapy, oxygen, intubating the trachea

  - Cardiovascular support with fluids, vasopressors, and inotropes

  - If required, bronchodilators

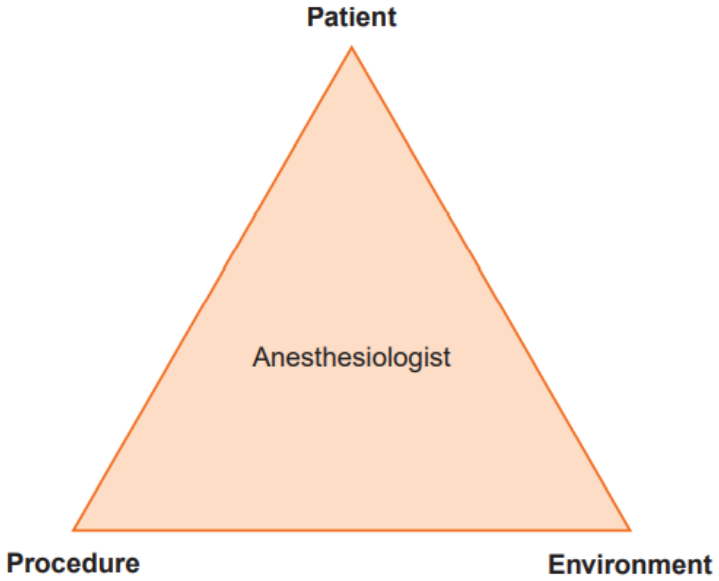
Hypersensitivity reactions

- Gadolinium-containing compounds have been associated with nephrogenic systemic fibrosis (NSF), a disease manifesting fibrosis of the skin and internal organs with some similarities to scleroderma in patients with renal insufficiency



Specific Nonoperating room procedures

Three-step approach to NORA



1. Computed Tomography (CT)

Computed Tomography (CT)

- Computed tomography (CT) scanners obtain a cross-sectional image in a few seconds, and spiral scanners can image a slice of the body in less than 1 second, minimizing problems with motion artifacts.

- The procedure is painless and most adults do not require sedation or anesthesia.

- Contrast agents for CT imaging may be administered orally and the anesthesiologist needs to be aware of the possibility of a full stomach.

CT : Anesthetic consideration

- The Patient :

  - Pediatrics
  - Adults (uncooperative, panic, paranoids, can't lay down, abnormal movement, severe illness, fail sedation)

- The Procedure :

  - Duration : Short (Diagnosis), Long (Intervention e.g. RFA, Abscess drainage)
  - Pain : Painless (Diagnosis), Mild (Intervention)
  - Other : Contrast media (CIN, allergy, pain, high pressure injector)

CT : Anesthetic consideration

- The Environment :

  - Monitor
  - Stretcher
  - Inadequate light
  - Setting for induction and intubation
  - Narrow space
  - Distance patient : Long breathing circuit
  - IV line : Long extension tube, Large bore IV for contrast injection
  - Radiation exposure : Protective equipment

CT : Anesthetic consideration

- Anesthetic technique : GA VS Sedation (beware presence of full stomach)
  - Patient condition
  - Procedure : Breath holding, duration, intervention

- General anesthesia
  - Airway : ETT, LMA
  - Maintenance : Inhalation, TIVA

- Sedation
  - Intermittent bolus vs Continuous infusion
  - Drugs : Propofol, Dexmedetomidine, Midazolam, Fentanyl, Ketamine
  - Depth of sedation

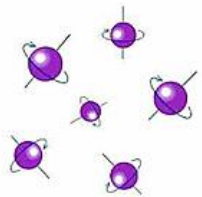
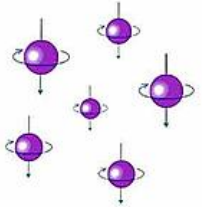
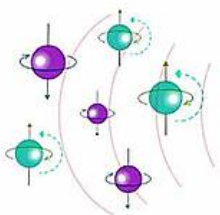
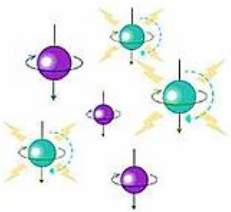
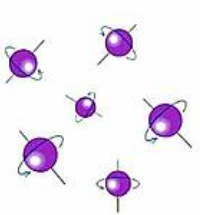
CT : Anesthetic consideration

General anesthesia	Sedation
Invasive (Need of ETT or LMA)	Less invasive
Risk of post-op respiratory complication	Risk of airway obstruction
More delayed awakening	More rapid awakening
Lower failure rate	Higher failure rate
Higher cost	Lower cost

2. Magnetic resonance imaging (MRI)

Magnetic resonance imaging (MRI)

- Magnetic resonance imaging (MRI) is a medical imaging technique used in radiology to form pictures by using strong magnetic fields, magnetic field gradients, and radio waves to generate images of the organs in the body.

MRI-generated magnetic field OFF	MRI-generated magnetic field ON	MRI-generated radio wave frequency pulse ON	MRI-generated radio wave frequency pulse OFF	MRI-generated magnetic field OFF
1 	2 	3 	4 	5 
Under normal circumstances, hydrogen protons in the body spin along their individual axes in random alignment.	When the body is placed in a strong magnetic field, such as that generated by MRI, the protons' axes all line up.	Radio wave frequency (RF) pulses are then transmitted to the area of examination, causing deflection of the magnetic vector of unmatched protons.	RF pulses are terminated, causing the magnetic vector of deflected protons to realign with the MRI-generated magnetic field. This emits a radio wave signal that can be captured by receiver coils in the MRI scanner and transformed into images.	Removing the body from the MRI-generated magnetic field allows the magnetic vectors of the hydrogen protons to return to their resting state.

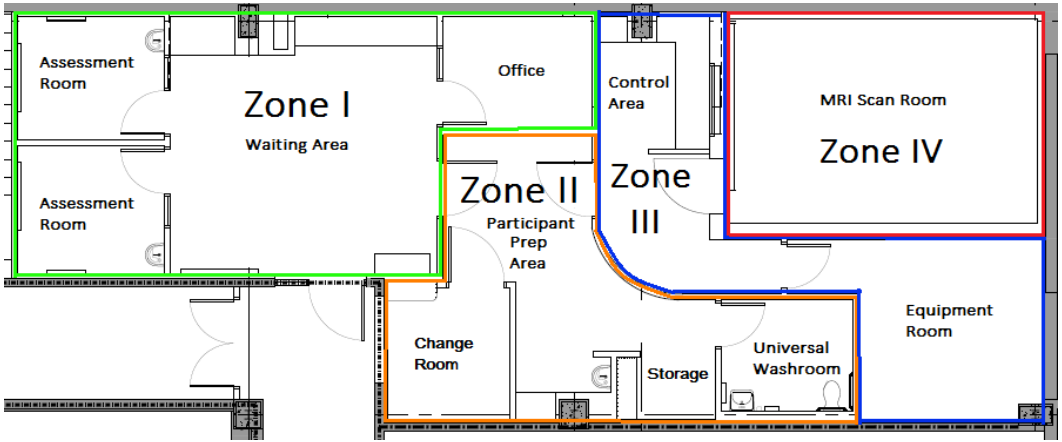
MRI Anesthetic team

- Magnetic Hazard
- MRI zone & Gauss line
- Equipment precaution and MRI-compatible equipment
- Safely respond to code blue situations in zone III and IV

Hazards of MRI

- MRI is devoid of the risks related to ionizing radiation.
- Peripheral nerve stimulation (PNS) has been reported in biologic tissues exposed to radiofrequencies greater than 60 Hz. PNS results in sensory phenomena ranging from mild tingling to intolerable pain.
- MRI workers may experience transient vertigo-related symptoms and a metallic taste in the mouth when working in high (>3 T) magnetic fields. (MRI for medical propose 1.5–3T)
- Considerable noise (99 dB – 140 dB)

MRI zone & Gauss line



- Zone 1 : General public
- Zone 2 : Unscreened MRI patient
- Zone 3 : Screened MRI patient and personal
- Zone 2 : Screened MRI patient under direct supervision of trained MR personal

MRI zone & Gauss line

- The 5 gauss line is the safety line drawn around the perimeter of the main magnet of the MRI scanner, specifying the distance at which the stray magnetic field is equivalent to 5 gauss (0.5 mT).

- < 5 gauss : considered 'safe' levels of static magnetic field exposure for the general public.

- > 5 gauss : - Risk of cardiac pacemakers and other implanted electronic device malfunction
  - Ferromagnetic materials may become projectile

Equipment precaution and Patient screening

- Implanted devices — e.g. CIED, nerve stimulators, deep brain stimulators, cochlear implants, surgical clips, prosthetic heart valve
- Imbedded foreign bodies — e.g. Tattoos, orbital iron filling
- Ferromagnetic items (Iron, nickel, cobalt) — e.g. Stethoscopes, laryngoscope, pens, wallets, watches, hair clips, coin, credit card, glasses, cell phones

Non-ferromagnetic items (Aluminum, Titanium, Copper, Silver, Gold, Stainless steel)

MRI-compatible equipment

- The most common metal used for MRI compatible equipment or tools is titanium. Titanium is an excellent material to make MRI-safe products because it’s lightweight and strong, in addition to being nonmagnetic.

- Anesthetic machine
- Monitors
- Infusion pump
- Stethoscope
- Laryngoscope

Code blue situations in zone III and IV

- 1. The anesthesiologist and technologist will immediately remove the patient form the magnetic field while companion staff will alert the appropriate emergency team.
- 2. During the emergency event, the MRI technologist will supervise admission to the MRI suite. The MRI technologist will decide who is granted entry.
- 3. Make sure the scan room door is closed prior to the arrival of the code team.
- 4. Begin the CPR protocol according to ACLS guideline.

MRI : Anesthetic consideration

- The Patient :

  - Pediatrics
  - Adults (uncooperative, claustrophobia, panic, paranoids, can't lay down, abnormal movement, severe illness, fail sedation)

- The Procedure :

  - Duration : Long
  - Pain : Painless, Noise
  - Other : Contrast media (CIN, NSF)

MRI : Anesthetic consideration

- The Environment :

  - MRI compatible equipment
  - Avoid ferromagnetic item
  - Stretcher
  - Inadequate light
  - Setting for induction and intubation
  - Narrow space
  - Distance patient : Long breathing circuit
  - IV line : Long extension tube, Large bore IV for contrast injection

  - Temperature :
    - Heat production : Radiofrequency & Magnetic field
    - Heat loss : Room temperature
  - Noise : Ear plugs + Head phone

MRI : Anesthetic consideration

- Anesthetic technique : GA VS Sedation
  - Patient condition
  - Procedure : Breath holding, duration

- General anesthesia
  - Airway : ETT, LMA
  - Maintenance : Inhalation, TIVA

- Sedation
  - Intermittent bolus vs Continuous infusion
  - Drugs : Propofol, Dexmedetomidine, Midazolam, Fentanyl, Ketamine
  - Depth of sedation

MRI : Anesthetic consideration

General anesthesia	Sedation
Invasive (Need of ETT or LMA)	Less invasive
Risk of post-op respiratory complication	Risk of airway obstruction
More delayed awakening	More rapid awakening
Lower failure rate	Higher failure rate
Higher cost	Lower cost

CT/MRI : Anesthetic consideration

MRI	CT
Ferromagnetic effect	Radiation exposure
MRI compatible equipment	-
Patient screening	-
Patient distance	Patient distance
Environment	Environment
Temperature	-
Noise	-
Contrast (IV)	Contrast (IV, Oral, Rectal)
Long duration	Short duration

3. Interventional Neuroradiology (INR)

Interventional Neuroradiology (INR)

- Interventional neuroradiology is a subspecialty of interventional radiology which involves using medical imaging tests in diagnosing and treating diseases of the central nervous system, head, neck and spine.

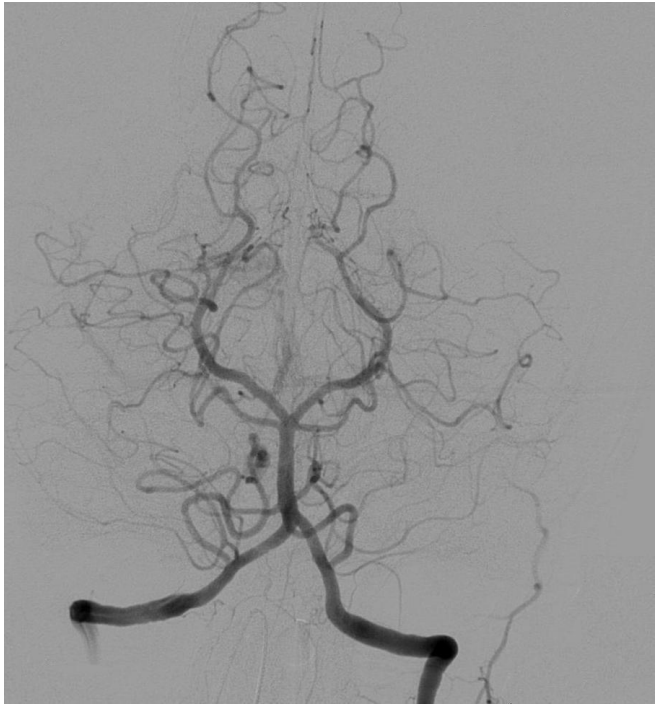
- Diagnosis procedure : Angiography

- Occlusive (“Closing”) procedure : Embolization of cerebral aneurysm, AVM, vascular tumor

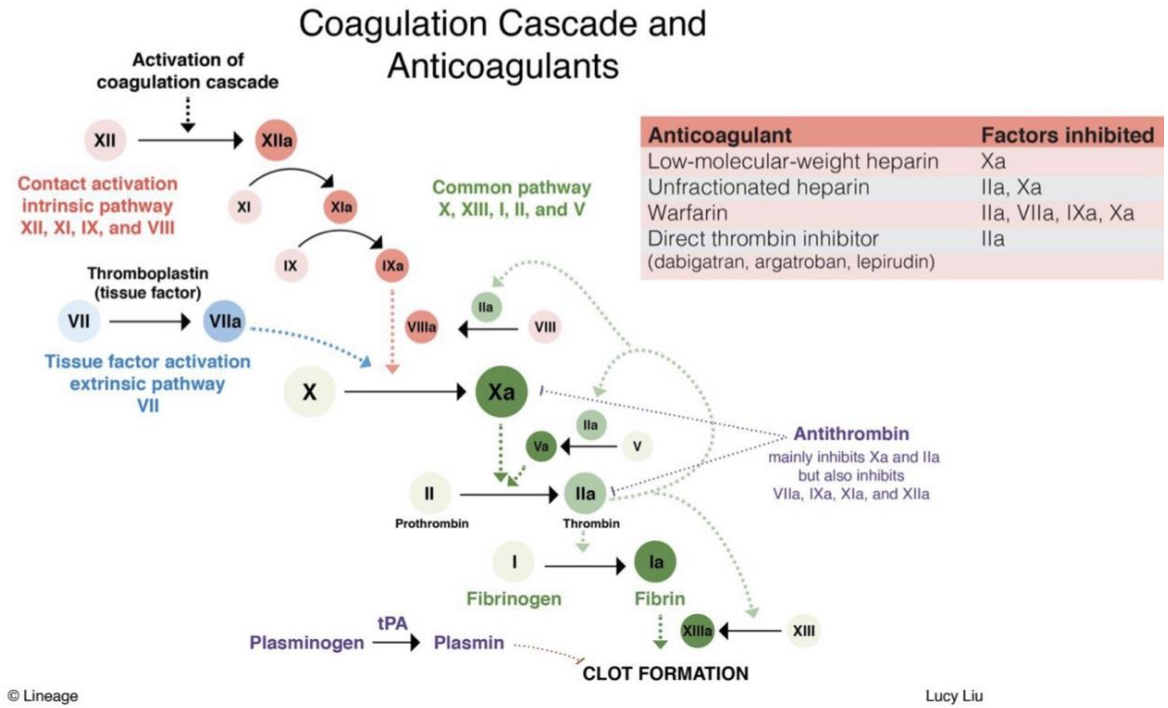
- “Opening” procedure : Angioplasty, Stenting, Thrombolysis in thromboembolic stroke

Angiography

- Coronary angiography is a procedure that uses a special dye (contrast material) and x-rays to see how blood flows through the arteries.
- Use of intravenous contrast
- Anticoagulation is required during and up to 24 hours after interventional neuroradiology for preventing thromboembolic events.



Anticoagulation



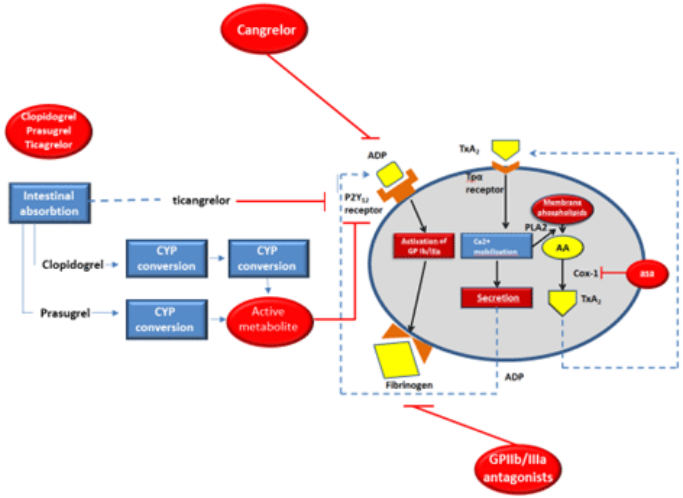
Anticoagulation

- Heparin
  - Intravenous heparin 3,000-5,000 U (approximately 50-70 IU/kg)
  - Keep activated clotting time (ACT) between 2-3 times of patients baseline

- Direct Thrombin inhibitors
  - Lepirudin, Bivalirudin, Argatroban
  - Adverse events : anaphylaxis

Antiplatelet

- Aspirin, Thienopyridine derivatives (Ticlopidine, Clopidogrel), Glycoprotein IIb/IIIa receptors antagonist
- Patients who are expected to receive stents, should be pretreated with antiplatelet agents
- Still controversial in the acute setting



Protamine sulfate

- At the end of the procedure or in case of hemorrhage heparin may be reversed with protamine.

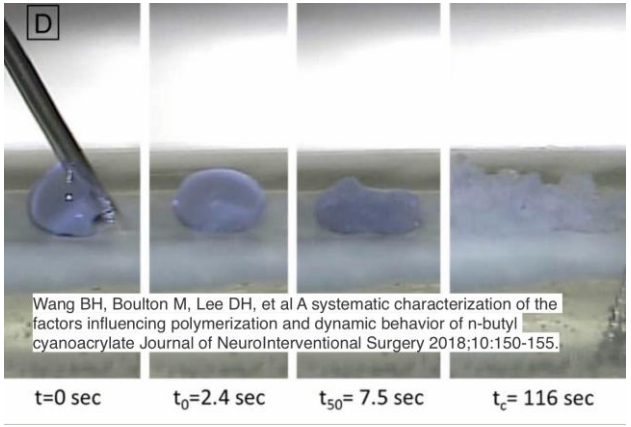
- SE : Allergy, hypotension, bronchospasm

- Beware in History of vasectomy
  Fish allergy
  Protamine insulin-dependent diabetics (e.g. NPH)

Occlusive agent

- Occlusive agents include cyanoacrylates (N-Butyl cyanoacrylate; NBCA) , “Onyx liquid embolic system” (Micro therapeutics Inc., USA)

- Complication : - Acute hemorrhage
  - Brain infarction
  - Pulmonary embolism



INR : Anesthetic consideration

- The Patient :

  - Neurological : Baseline neurological examination

  - Cardiovascular : Baseline BP and cardiovascular reserve

  - Renal function

  - Risk of protamine reaction (History of vasectomy, Fish allergy, Protamine insulin-dependent diabetics

  - Risk of contrast media allergy (Iodine, shellfish allergy)

INR : Anesthetic consideration

- The Procedure :

  - Duration : Short (Diagnosis), Long (Intervention)

  - Pain : Mild

  - Hemodynamic manipulation :
    - Deliberate hypertension : Increase collateral blood flow
      Complication : Myocardial infarction, rupture aneurysm of AVM
    - Deliberate hypotension : Test cerebrovascular reserve during carotid test occlusion
      Slow flow in feeding artery of brain AVM before injecting glue
      Complication : Myocardial infarction, cerebral ischemia

INR : Anesthetic consideration

Table 14.1 **Interventional Neuroradiologic Procedures and Primary Anesthetic Considerations**

Procedure	Possible Anesthetic Considerations
Therapeutic embolization of vascular malformation:	
Intracranial AVM	Deliberate hypotension, postprocedure NPPB
Dural arteriovenous fistula	Existence of venous hypertension; deliberate hypercapnia
Extracranial AVM	Deliberate hypercapnia
Carotid cavernous fistula	Deliberate hypercapnia, postprocedure NPPB
Cerebral aneurysms	Aneurysmal rupture, blood pressure control[*]
Ethanol sclerotherapy of arteriovenous or venous malformations	Brain swelling, airway swelling, hypoxemia, hypoglycemia, intoxication from ethanol, cardiorespiratory arrest
Balloon angioplasty and stenting of occlusive cerebrovascular disease	Cerebral ischemia, deliberate hypertension, concomitant coronary artery disease, bradycardia, hypotension
Balloon angioplasty of cerebral vasospasm secondary to aneurysmal subarachnoid hemorrhage	Cerebral ischemia, blood pressure control[*]
Therapeutic carotid occlusion for giant aneurysms and skull base tumors	Cerebral ischemia, blood pressure control[*]
Thrombolysis of acute thromboembolic stroke	Postprocedure intracranial hemorrhage (NPPB), concomitant coronary artery disease, blood pressure control[*]
Intra-arterial chemotherapy of head and neck tumors	Airway swelling, intracranial hypertension
Embolization for epistaxis	Airway control

INR : Anesthetic consideration

- The Procedure :

  - Management of Intracranial catastrophes

  - Bleeding catastrophes :

  Symptoms : Headache, Nausea, Vomiting,
  Vascular pain

  Signs : Cushing response,
  Extravasation of contrast agent

BOX 14.1 Management of Intracranial Catastrophes[*]

Initial Resuscitation

Communicate with endovascular therapy team. Assess the need for assistance; call for assistance. Secure the airway and ventilate with 100% O_2.

Determine whether the problem is hemorrhagic or occlusive:

Hemorrhagic: Immediate heparin reversal (1 mg protamine for each 100 units of heparin given) and low normal mean arterial pressure.

Occlusive: Deliberate hypertension, titrated to findings of neurologic examination, angiography, or physiologic imaging studies or to clinical context.

Further Resuscitation

$PaCO_2$ manipulation consistent with clinical setting; otherwise normocapnia. Mannitol 0.5 g/kg, rapid IV infusion.

Titrate IV agent to electroencephalographic burst suppression.

Consider ventriculostomy for treatment or monitoring of increased intracranial pressure. Consider anticonvulsant.

INR : Anesthetic consideration

- The Environment :

  - Monitor : Standard vs Invasive
  - Inadequate light
  - Setting for induction and intubation
  - Narrow space
  - Distance patient : Long breathing circuit
  - IV line : Long extension tube
  - Radiation exposure : Protective equipment

INR : Anesthetic consideration

- Anesthetic technique : GA VS Sedation
  - Patient condition
  - Procedure : Breath holding, duration, hemodynamic manipulation

- General anesthesia
  - Airway : ETT, LMA
  - Maintenance : Inhalation, TIVA

- Sedation
  - Intermittent bolus vs Continuous infusion
  - Drugs : Propofol, Dexmedetomidine, Midazolam, Fentanyl
  - Depth of sedation

INR : Anesthetic consideration

General anesthesia	Sedation
Minimize motion artifacts (Improve the quality of images)	Minimal invasive
Reduce catheter-induced complication	Rapid recovery
Secure airway	Unsecure airway
Control ventilation and hemodynamic	
Avoid N_2O : Risk of air emboli	Avoid nasopharyngeal airway (Risk of bleeding)

INR : Anesthetic consideration

- Post-operative : Monitor sign of hemodynamic instability or neurological deterioration

  - Cerebral hemorrhage form normal perfusion breakthrough

  - Cerebral hyperemia (Triad : Unilateral headache, seizure, neurological deficit)

  - Cerebral ischemia

Need neuromuscular blockage reversal for observe neurological deficit

4. Interventional Cardiology

Interventional Cardiology

- Interventional cardiology is a branch of cardiology that deals specifically with the catheter based treatment of structural heart diseases. Divided into 2 major procedures :

- Electrophysiology procedures

- Cardiac catheterization procedures

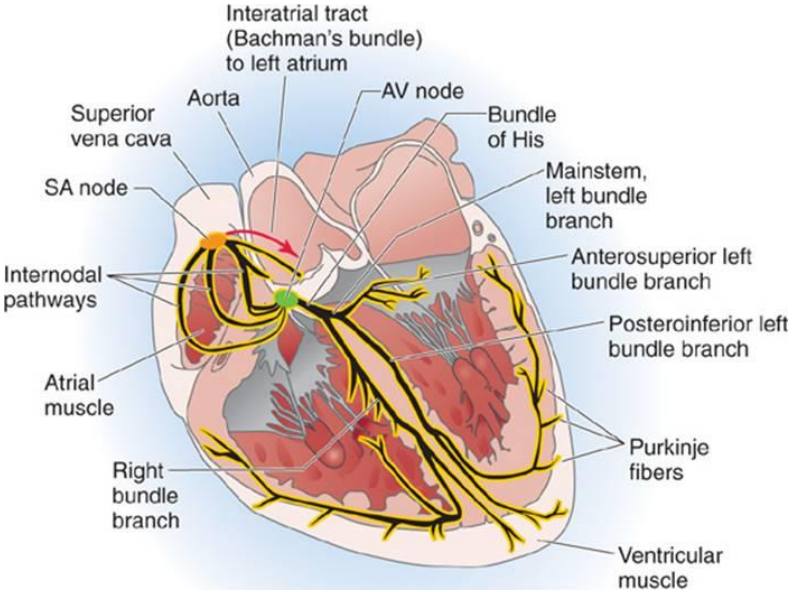
Interventional Cardiology

- Electrophysiology procedures :

  1. Electrophysiology studies

  2. Atrial and ventricular ablation procedures

  3. Implantation and removal of cardioverter-defibrillator and pacing devices



Interventional Cardiology

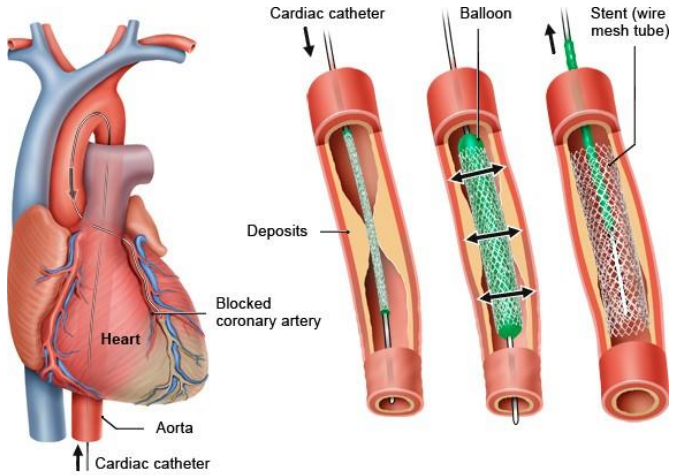
- Cardiac catheterization procedures:

  1. Diagnostic cardiac catheterizations and coronary interventions

  2. Peripheral vascular diagnostic and therapeutic procedures

  3. Implantation of intra-aortic balloon pumps (IABPs) and percutaneous left ventricular assist devices

  4. Amelioration of structural heart disease by the placement of intracardiac device



Interventional Cardiology : Anesthetic consideration

- The Patient :

  - Cardiovascular : Baseline BP, cardiovascular reserve, pathologic and physiologic change of cardiac disease

  - Renal function

  - Other comorbidities

  - Risk of protamine reaction (History of vasectomy, Fish allergy, Protamine insulin-dependent diabetics

  - Risk of contrast media allergy (Iodine, shellfish allergy)

Interventional Cardiology : Anesthetic consideration

- The Procedure :

  - Duration : Short (Diagnosis), Long (Intervention)

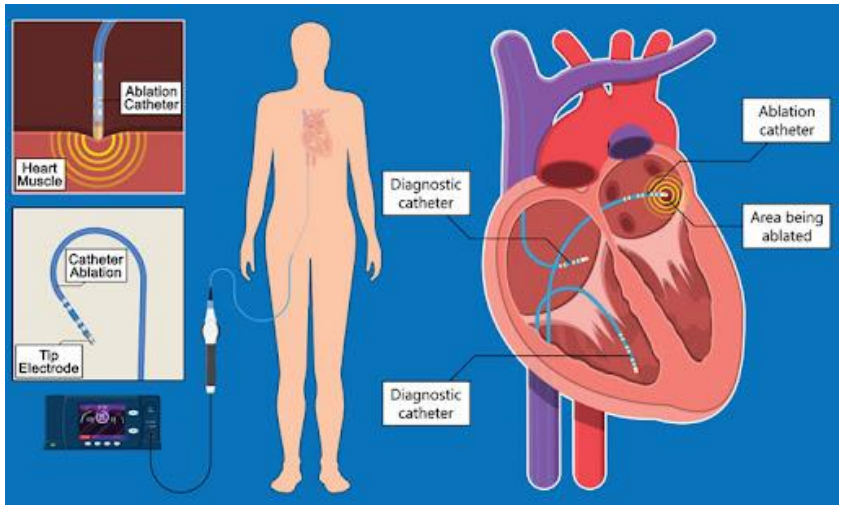
  - Pain : Mild

  - Anticipate and management in physiological change during a procedures.

  - It’s important to understand the tempo and framework of procedures.

Electrophysiology studies

- Electrophysiology studies is performed to analyze the electrical or rhythm function of the heart. The heart's rhythm function is what affects the heart rate and heartbeat.
- These abnormalities can be identified with diagnostic electrophysiology studies, which are usually undertaken in conjunction with a therapeutic procedure to either treat a specific arrhythmia or place a device.

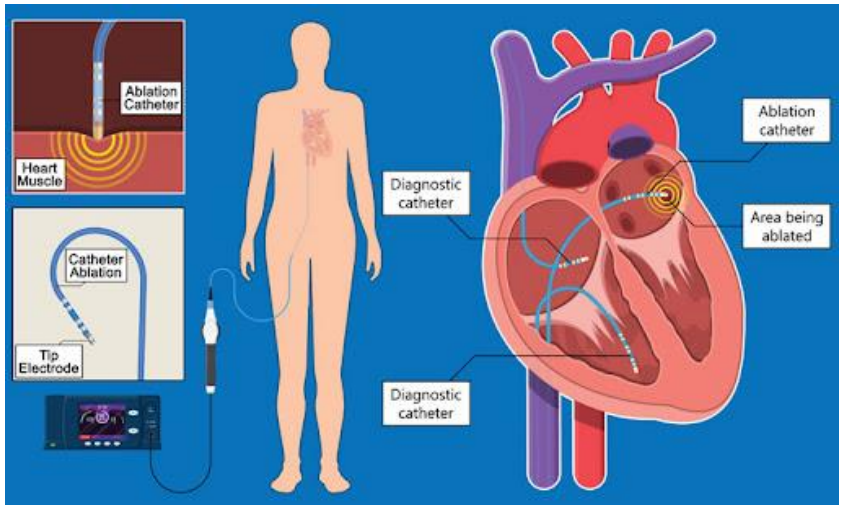


- For these studies, sedation with benzodiazepines and short-acting opioids is usually sufficient.
- Drugs that may affect inducibility of certain arrhythmias should be avoided.

Catheter ablation

- During ablation procedures, catheters are placed throughout the cardiac chambers and programmed stimulation is performed from different sites to induce tachyarrhythmias.

- Complex mapping techniques localize the source of the arrhythmia to identify the exact intracardiac location to which the energy must be applied.



Catheter ablation

- **Sedation :**

  - Preferred as arrhythmias can be suppressed with general anesthesia.

  - Longer procedures may be challenging to conduct with monitored anesthesia care as undersedation may result in back pain and patient movement.

  - Oversedation may result in snoring or partial airway obstruction with resultant swinging of the intraatrial septum making transseptal catheter placement difficult.

Catheter ablation

- **General anesthesia :**

  - May be required for optimal procedural conditions and patient comfort.

  - Paralysis should be avoided during ablation so that phrenic nerve stimulation and activity can be used as an alert to avoid its injury. (Curare cleft can be observe in capnography)

  - The esophageal temperature should be monitored for conductive heat transfer to the esophagus, which can result in esophageal injury

  - Radiofrequency ablation may require irrigation, which can result in the administration of a substantial amount of fluid to the patient over the duration of the case.

Catheter ablation

- **General anesthesia :**

  - High flow jet ventilation (HFJV) : Eliminate cardiac translation in the thoracic cavity due to tidal ventilation > Near static field > Reduce the potential for catheter instability. (particularly in atrial fibrillation ablations because sustained contact between the catheter and the area around the pulmonary veins is often required.)

  - Hypercarbia refractory to adjustments in jet ventilation settings may require a transition back to traditional ventilation.

  - Due to the unpredictable delivery of volatile anesthetic with HFJV, total intravenous anesthetic techniques are typically necessary.

Catheter ablation

- **Other consideration :**

  - Beta-agonist (e.g. Isoproterenol) may be requested by interventionist to induce arrhythemia.

- **Complication :**

  - Cardiac arrhythmia : Close communication with cardiologist, electrical cardioversion

  - Cardiac tamponade : Reversal of heparin, placement of catheter for drainage

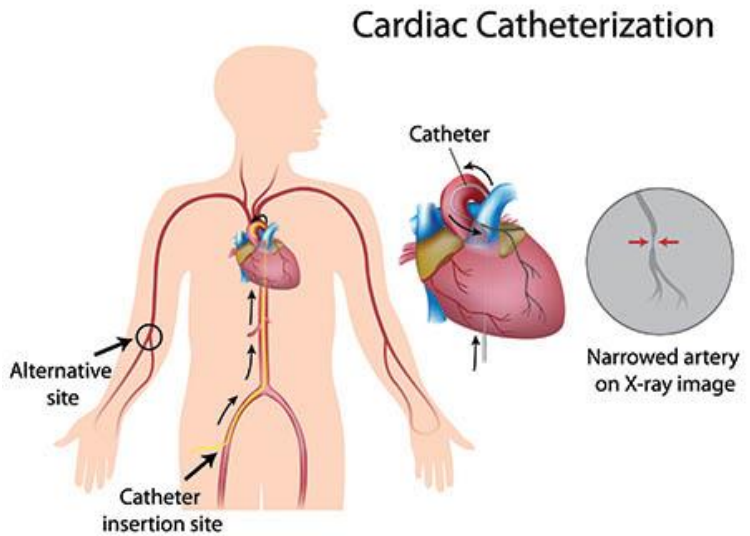
Cardiac catheterization

- Cardiac catheterization is a procedure used to diagnose and treat certain cardiovascular conditions.

  - Diagnosis : Visualize structures and function of heart (e.g. congenital heart defect, coronary angiography)

  - Interventional : Valvuloplasty, Septal defect closure, Percutaneous coronary intervention (PCI)

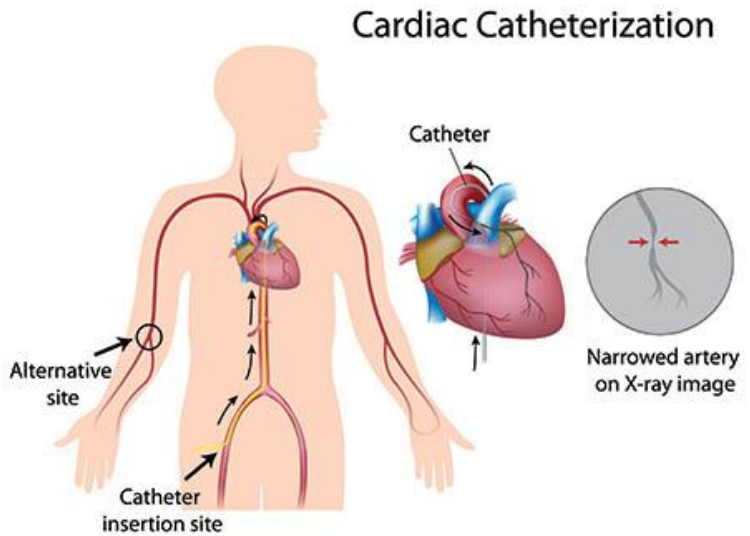
- Choice of anesthesia is depended on patient's condition and surgical procedures.



Cardiac catheterization

- For some patients, It is important to communicate with interventionist for acceptable O_2sat and FiO_2 during the procedure.

- Surveillance and be ready to treat emergency situation during the procedure.



Interventional Cardiology : Anesthetic consideration

- The Environment :

  - Monitor : Standard vs Invasive
  - Inadequate light
  - Setting for induction and intubation
  - Narrow space
  - Secure IV line
  - Preparation of electro-cardioversion
  - Radiation exposure : Protective equipment

5. Electroconvulsive therapy (ECT)

Electroconvulsive therapy (ECT)

- Electroconvulsive therapy (ECT) has had an important role in the management of depression, mania, and affective disorders.

- Typically it is performed three times a week for 6 to 12 treatments, followed by weekly or monthly maintenance therapy to prevent relapses.

Physiologic change during ECT

- **Cardiovascular system :** Secondary to activation of the autonomic nervous system

  - **Initial parasympathetic discharge** lasting 10–15 s. : bradycardia, hypotension, or even asystole.

  - **Sympathetic discharge** : Hypertension, Tachycardia, Cardiac arrhythmia, Increase myocardial oxygen consumption

- **Neurological system :** Increase cerebral oxygen consumption, blood flow, and intracranial pressure

ECT : Anesthetic consideration

Anesthetic Requirements	Comments
Amnesia	With induction agent of choice
Airway management	Usually with bag–mask ventilation, although the laryngeal mask has been used with success[122]
Moderate hypocapnia	Improves the quality and duration of seizures[123]
Protection of the teeth and tongue during the seizure	Using a soft bite block
Prevention of seizure-related injuries (fractures and dislocations)	Small doses of muscle relaxant, e.g., succinic choline (0.75–1.5 mg/kg) are most commonly used unless there are contraindications
Control of hemodynamic responses	Labetalol; esmolol; and the calcium channel antagonists nifedipine, diltiazem, and nicardipine all attenuate the hemodynamic responses to ECT. Dexmedetomidine (1 µg/kg administered over 10 minutes just before induction of anesthesia) has been shown to be effective in controlling blood pressure without affecting seizure duration.[124]
Control or prevention of the parasympathetic effects of ECT (salivation, transient bradycardia, and asystole)	Can be prevented with glycopyrrolate or atropine
Analgesia to relieve postseizure myalgia	Ketorolac 15–30 mg is effective in younger patients Acetaminophen or aspirin may be used in older patients or where NSAIDs are contraindicated

A blood pressure cuff is applied to an extremity and inflated before muscle relaxant is administered to monitor the seizure.

ECT : Anesthetic consideration

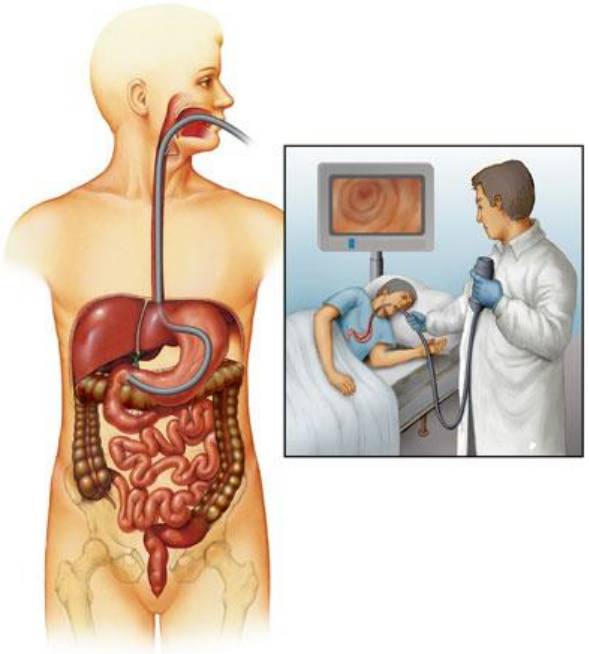
Induction agent	Seizure quality	Advantages	Disadvantages
Propofol 0.75–2.5 mg kg^{-1}	Shortest duration (weighted mean difference however only 9 s)[5]	Improved CVS stability; less PONV; quicker emergence[9]	Pain on injection
Etomidate[10] 0.15–0.3 mg kg^{-1}	Duration prolonged; may reduce seizure threshold[11]	Resistant seizures	Hyperdynamic response more pronounced compared with propofol; increased PONV Longer emergence time
Methohexital 0.5–1.5 mg kg^{-1} (supplemented with narcotic *vs* single agent)	'Gold standard'	Long history of use	Reduced availability; increasing lack of familiarity with use
Thiopental 2–5 mg kg^{-1}	Duration reduced; better than propofol[12]		Need to reconstitute; increased dysrhythmias
Ketamine 0.7–2.8 mg kg^{-1}	Unclear—reduced[13] and prolonged in different studies	Resistant seizures	Emergence phenomena; reduced CVS stability, and increased ICP
Sevoflurane 6–8% inspired concentration for induction. Thereafter 1–2 MAC	Comparable with thiopental;[14] reduced seizure duration compared with methohexital[15]	Difficult venous access; reduces uterine contraction in pregnancy	Extra equipment required; more time-consuming

6. Gastroenterology

Gastroenterology

- Procedures commonly performed in the gastrointestinal (GI) endoscopy suite are :

  - Esophagogastroduodenoscopy (EGD)
  - Esophageal dilatation or stenting
  - Colonoscopy
  - Endoscopic retrograde cholangiopancreatography (ERCP)
  - Liver biopsy



Take home message

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Thank you