- Examination of upper airway for potentially obstructive lesions (i.e., Kaposi sarcoma)

Induction

- Chronic respiratory injury due to repeated lung infections may cause rapid desaturation.
- Hypotension due to decreased myocardial reserve and/or relative hypovolemia.
- Decreased drug requirements secondary to decreased plasma proteins.

Maintenance

- Increased inspired O_2 may be required due to chronic lung infections.
- Decreased myocardial reserve may require careful selection and titration of anesthetic agents or local or regional anesthesia for peripheral procedures.
- Preemptive pain management may protect against additional immune suppression.

Extubation

- Due to weakness and drug-drug interactions, return of strength should be carefully evaluated.

Adjuvants

- Transplantation and anticancer drug interactions need to be considered (e.g., cyclosporine and barbiturates, narcotics, muscle relaxants); bleomycin and O_2 administration.

Postoperative Period

- Respiratory adequacy should be carefully followed and may require ICU monitoring.
- Maintain careful antisepsis procedures for extended periods.

Anticipated Problems/Concerns

- Greatest intraop risk to these pts is infection; therefore strict hygienic practices are required.
- General state of nutrition, recurrent infections, and the underlying cause of the immune suppression all tend to generally decrease respiratory reserve and cardiovascular stability.
- Risk of transmission of drug-resistant pathogenic microbial agents to medical personnel (needlestick or respiratory [e.g., drug-resistant tuberculosis]). Follow CDC recommendations if exposed

Implantable Cardioverter-Defibrillators

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Epidemiology

- In USA, more than 300,000 people have an ICD and more than 180,000 ICDs are implanted annually, based on CMS registry data.
- Given current implant and survival rates, nearly 700,000 people in USA may have an ICD by the year 2020.
- ICD implant is indicated for any-cause cardiomyopathy with EF ≤35% and without evidence of dysrhythmia; thus some pts undergo ICD implantation for "primary prevention."
- All conventional ICDs can provide pacing for bradycardia; some pts are pacing dependent.
- Some ICDs also have atrial, RV, and LV pacing capability for CRT. LV leads can be transvenous in the coronary sinus or epicardial.
- Newer subcutaneous ICDs use a subcutaneous electrode instead of traditional transvenous or epicardial leads. These devices are less invasive but have limited functionality; for example, they have no permanent antibradycardia pacing capability and cannot deliver antitachycardia pacing.
- Premature ICD failure rates might approach 2%. For the ICD pt without evidence of pacing, determining battery function is difficult.*

Risk

- In USA, 450,000 pts/y suffer SCA; 550,000 new cases/y of CHF.
- ICD therapy for SCA, VT, and VF and primary prevention is superior than medical management.
- Associated diseases include cardiomyopathy, CAD, long QT syndrome, arrhythmogenic right ventricular dysplasia, Brugada syndrome, hypertrophic cardiomyopathy, and LV noncompaction. Some ICD pts also have sinus and/or AV node disease.

Perioperative Risks

- Robust data is lacking; however, the presence of an ICD might increase periop risk.
- Inappropriate HVT can induce tachydysrhythmia, injure the myocardium releasing troponin, and is associated with increased mortality.
- Incorrect interpretation of device type (i.e., confusing an ICD for a pacemaker) or events (i.e., pseudomalfunction) during the periop period might lead to pt harm.
- Risk might also be increased in these pts owing to associated disease(s).

Worry About

- EMI on the ICD's ventricular channel resulting in inappropriate HVT including shock(s) and/or antitachycardia pacing. For the pacing-dependent pt, EMI-induced ventricular oversensing with pacing inhibition can also result in asystole
- Intraop increase in ventricular pacing owing to EMI entering a dual chamber ICD and causing atrial lead oversensing and ventricular tracking
- Intraop increases in pacing rates owing to activation of the "exercise sensor," whether due to direct mechanical stimulation (such as preparation of the chest) or pressure on the device (personnel leaning). The cause of this undesirable tachycardia might be mistaken as inadequate anesthetic depth
- Failure to capture (i.e., pacing output without myocardial depolarization) due to inappropriate programmed parameters (i.e., inadequate safety margin), or abrupt increase in pacing threshold from myocardial ischemia/infarction, drug administration, or lyte shifts. Note that any or all chambers can undergo failure to capture with possible hemodynamic derangement, even without apparent outright pacing failure
- Magnet* placement will never change the pacing mode (i.e., produce asynchronous pacing) of an ICD and will change pacing rates only in ICDs from ELA (Sorin, Milan, Italy). Only Boston Scientific (BOS)§ ICDs emit ongoing tones confirming appropriate magnet placement. No ongoing confirmation of magnet placement is available in Medtronic, St Jude Medical§ (SJM), or Biotronik ICD. ICDs from BOS and St. Jude Medical can have their magnet switch disabled by programming. Indeed, some older ICDs from BOS (with the "GDT" or "CPI" x-ray code) can undergo permanent disabling of HVT by magnet placement
- Disabling HVT during central access procedures in the thorax to prevent inappropriate shocks due to guidewire contact with the RV lead. For 6 weeks after lead implant central venous catheterization in the thorax is relatively contraindicated

Overview

- Indications for initial ICD placement: SCA (including spontaneous or induced VT or VF), cardiomyopathy from any cause with LVEF ≤35%, long QT syndrome, arrhythmogenic RV dysplasia, or Brugada syndrome
- Tachydysrhythmia therapy in most conventional ICDs includes ATP, which uses less battery energy and is better tolerated (sometimes not even noticed) by pts. For ICDs programmed to deliver repetitive ATP, shock can be delayed for periods exceeding 1 min, and distinguishing between repetitive ATP on the monitor versus ventricular tachydysrhythmia can be difficult. Some ICDs will deliver ATP while charging, which will not delay shock
- Codes: The North American Society of Pacing and Electrophysiology (NASPE)/British Pacing and Electrophysiology Group (BPEG) generic defibrillator code has four positions. The first position refers to the chamber(s) shocked (A = atrium, V = ventricle, D = both, O = none). The second position refers to the chamber(s) where ATP is programmed (A, V, D, O). The third position identifies the detection method: either heart rate E = electrogram or hemodynamic (H) (although no hemodynamic sensors are currently in clinical use). The fourth position identifies chambers (A, V, D, O) where pacing for bradycardia has been programmed. The most robust form of this code uses only the first three positions and adds the five-position generic pacemaker code. For example, an ICD with anti–atrial fibrillation therapy and CRT might be DDE-DDDRV

Indications and Usual Treatment

- Primary prevention in a pt with LVEF ≤35% (and more than 40 d from an ischemic event or 3 mo from vascular intervention) who is receiving optimal medical therapy and has a reasonable expectation of survival with good functional capacity for >1 y
- Survivors of cardiac arrest presumably due to VT/VF, not associated with reversible factors, such as acute coronary syndrome
- Pts with inducible VT/VF by EP study and no reversible cause
- Treatment for LV cardiomyopathy should include (unless contraindicated) beta-blocker and ACE inhibitor/angiotensin receptor blocker therapy (see the ACC/AHA Heart Failure Guidelines). Many pts will also have statin, aspirin, antiarrhythmic, diuretic, nitrate, and/or digoxin therapy

*Some ICDs allow demonstration of battery function without interrogation:

Assessment Points

System	Effect	Assessment By Hx	PE	Test
CV	Myocardial ischemia LV dysfunction Heart rate (guidelines suggest <80 bpm) Frequency of ICD therapy Need for pacing	Angina symptoms Exercise tolerance, DOE	ECG, pulse S_3, rales	Nuclear imaging ECHO B-type natriuretic peptide ICD interrogation
RESP	Amiodarone toxicity	Exercise tolerance, DOE		SpO_2, CXR, PFTs, ABGs
ENDO	Amiodarone toxicity			TSH, T_4
RENAL	Renal insufficiency		Edema	BUN, Cr
NEURO	CV disease	Stroke, TIAs	Bruits	Carotid duplex
METAB	Reversible VT/VF	Diuretic Chemotherapy (platins)		Serum K^+ and Mg^{2+}

Key References: Rozner MA: Pacemakers and implanted cardioverter-defibrillators. In Miller RD, Eriksson LI, Fleisher LA, et al. editors: *Miller's anesthesia*, ed 7 Philadelphia, PA, 2009, Churchill Livingstone, pp 1387–1409; Schulman PM, Rozner MA, Sera V, Stecker EC: Patient with a pacemaker or implantable cardioverter-defibrillator, *Med Clin North Am* 97:1051–1075, 2013.

Perioperative Implications

Preoperative Preparation

- Prior to an elective procedure, a CIED care team assessment should be obtained. Comprehensive interrogation should be performed within 6 mo prior to scheduled surgery for an ICD and within 3 mo prior for any CRT device. For pts who have received HVT since the last interrogation, or those who are scheduled to undergo hemodynamically challenging surgery, interrogation might be indicated during the periop evaluation. Remaining battery life, tachycardia zones and therapies, pacing behavior, prior dysrhythmia treatment, and magnet behavior should be documented. Many ICDs (even those with dual chamber capability) are programmed to VVI pacing capability; for the pt with intact atria and AV node, periop care must be directed to prevent the sinus rate from falling below the VVI pacing rate because ventricular-only pacing will likely compromise hemodynamics. For the pt with hemodynamically advantageous pacing capability who is chronotropically incompetent or pacing dependent and undergoing a major procedure, consideration should be given to increasing the pacing rate.
- For ventricular multisite pacing (called cardiac resynchronization therapy), assurance that the LV pacing lead is functioning. If placement of a thoracic central venous cannulation is planned in a CRT pt, the position of the LV (coronary sinus) lead on the CXR should be noted because it may be dislodged during CVC insertion.
- Alternate defibrillation (and pacing modality [e.g., transvenous, transcutaneous]) for the pacing-dependent pt should be available. While transesophageal pacing might work as backup, it is contraindicated in any pt with an ICD or those with atrial fibrillation or AV nodal block.
- IV chronotropes (epinephrine, ephedrine).
- Discuss monopolar ESU precautions with surgeon and nursing staff. If monopolar ESU is planned, the ICD should have its HVT suspended for the procedure. Suspending HVT by applying a magnet† is sometimes possible and appropriate; however, it is important to ensure that the magnet mode is active and understand that magnet application can occasionally have unintended and untoward consequences.
- Placement of defibrillation pads should be considered, especially if a pt has been receiving HVT from the ICD.

Monitoring

- Mechanical pulse wave monitoring is required. It can be accomplished with pulse oximeter plethysmogram, any invasive hemodynamic monitoring modality, or Doppler technique.
- ECG monitoring is an ASA requirement, but EMI perturbs the signal, and monitors frequently report incorrect heart rates (both too high and too low).

Induction

- Succinylcholine or etomidate might lead to muscle fasciculation or myoclonus, resulting in pacing inhibition, increased rates, or false VT/VF detection, but these sequela have not been reported for ICDs. Succinylcholine-induced potassium fluxes theoretically can change pacing thresholds.

Maintenance

- Vigilant ECG/pulse monitoring
- Monopolar ESU cautery (i.e., the "Bovie") emits radiofrequency energy, potentially causing EMI, and resulting in inappropriate VT/VF detection (and HVT), as well as transient or permanent changes in ICD function. The most common problem is inhibition of pacing. Prevention includes use of bipolar-only ESU, use of pure unblended monopolar ESU, and placement of the ESU dispersive electrode so that the presumed current path of the ESU does not cross the pulse generator or leads. For all head and neck or contralateral breast surgery, the dispersive electrode can be placed on the shoulder contralateral to the CIED. For ipsilateral breast surgery, the dispersive electrode can be placed on the ipsilateral arm and the wire prepped into the field if needed
- Magnet†: Assuming that the magnet is appropriately placed and that the magnet mode is enabled, placement might be useful to suspend HVT. No ICD provides asynchronous pacing upon magnet application, and, except for ELA (Sorin) ICDs, no ICD will change its pacing rate in response. If interference from the ESU or other equipment creates hemodynamic instability, the use of this equipment should be transiently stopped. If possible the dispersive electrode should be relocated (for abdominal or pelvic surgery the pad could be moved to the other leg). If relocating the return pad is not possible or ineffective the ICD will require reprogramming

Postoperative Period

- Monitoring of mechanical pulse in the postop care unit.
- ICD interrogation/reprogramming required if ICD was reprogrammed preop; advisable if monopolar ESU used, any problems noted, or cardioversion/defibrillation has taken place.
- Some pts require pacing programming changes to optimize postop hemodynamics. These changes might include increasing the pacing rate, disabling battery saving features, and adjusting the AV delay.

Anticipated Problems/Concerns

- Inappropriate delivery of HVT, which typically occurs without warning and might be missed by intraop personnel
- Intraop failure to pace, most likely related to EMI from monopolar electrosurgery
- Periop pacing and sensing threshold changes
- Risks related to associated medical problems
- Iatrogenic misadventures resulting from misunderstanding of ICD pacing behavior
- BOS‡ ICDs will emit beeps if the magnet switch is enabled and the magnet is appropriately placed. A constant tone indicates that the ICD is disabled. No tone indicates magnet switch deactivation or a dead battery.
- ELA (Sorin) ICDs will change pacing rate to 90 bpm if battery is okay, 80 if elective replacement. However, the pt rate must be <90 (80) to observe this function. No change indicates battery or other failure.
- Medtronic ICDs will emit a tone for at least 15 sec when the magnet switch (nonprogrammable) is activated, even briefly, by a magnet. A warbling tone indicates a problem with the ICD, and no tone indicates a nonfunctioning device. Note that this tone cannot be used to verify appropriate placement of a magnet.

† MAGNET CAUTION: A magnet will never change the pacing mode of an ICD. Only ICDs from ELA (Sorin) will change pacing rate (to 90 bpm if battery is okay) upon magnet placement. For many ICDs (Boston Scientific‡and St Jude Medical‡), the magnet switch can be programmed "OFF." Only ICDs from Boston Scientific and its previous companies emit ongoing tones that identify correct placement of a magnet (except subcutaneous ICDs, which emit a tone for only 1 min following magnet application). Some older ICDs from Boston Scientific (with the "GDT" or "CPI" x-ray code) can undergo permanent disabling of tachycardia therapy by magnet placement.

‡ Boston Scientific owns the Guidant and CPI brands, and St Jude Medical owns the Pacesetter brand.