Objectives

At the end of this session, the audience member shall be able to:

- Discuss heart anatomy and electrical conduction pathways.
- Explain what the QT interval is anatomically and on the ECG.
- Verbalize the genetic and acquired components of LQTS.
- Have an awareness of the medications that can cause LQTS.

Objectives

- Apply proper treatment to a patient with consequences of LQTS.
- Define what is meant by short QT syndrome.
- Describe the rhythm consequences of short QT syndrome.
- Discuss what type of therapy a patient with short QT syndrome may be undergoing.
The Conduction System

- **Automaticity** - The heart’s ability to initiate an impulse without stimulation from the CNS or hormones
- **Nodal Cells** - “Pacemakers”
- **Conducting Cells** - Allow the stimulus to spread throughout the myocardium

Nodal Cells

- Generate action potentials at regular intervals
  - Sino-atrial (SA), Atrio-ventricular (AV) and Purkinje Fibers
- Conducting cells are connected to normal cardiac muscle cells
- An action potential can reach all the heart’s cells in less than 0.25 seconds

S.A. (sino-atrial) Node

- Located in the R atrium near the entrance of the SVC
- Generates impulses at 60-100/minute
- Depolarizes the right and left atria almost simultaneously

INTERNODAL ATRIAL PATHWAYS

- 3 tracts that run from the SA node through the wall of the right atrium to left atrium and down to the AV node
- Provide depolarization in syncytium so it allows the right and left atrium to contract at the same time

A.V. (atrio-ventricular) node

- Located on the inferior portion of the intra-atrial septum- above the tricuspid valve
- Primary function is to relay electrical impulse from atria to the ventricles
- Allows for a short delay - atrial kick
- Intrinsic firing rate of 40-60/minute
Located at the top of the intraventricular septum
Divides into two branches
Right bundle branch runs along intraventricular septum to R. ventricle branching into Purkinje fibers

Bundle of His divides into a Left anterior fascicle and a Left posterior fascicle
Provide innervation to left ventricle to stimulate the large muscle mass to produce systole
Branch off into the Purkinje fibers

Purkinje Fibers
The last defense against cardiac arrest
Fire at a rate of 20-40/minute
Produce just enough C.O. to sustain minimal oxygenation to brain and heart for a very short period of time
The normal QTc interval varies from approximately 350-480 milliseconds.

About 90% of people have a value between 380 and 440 ms, which is generally the "normal" range.

**QRS Complex**
- Indicates electrical stimulation of the ventricular muscle
- Marks the beginning of mechanical systole

**Q Wave**
- First negative deflection seen after the P-wave
- Represents electrical conduction through the intraventricular septum

**R Wave**
- First positive deflection seen after the P-wave
- Represents electrical conduction moving toward the left ventricle
R Wave
- First negative deflection seen after the R-wave
- Represents electrical conduction through both ventricular walls

S Wave
- Distance between the S-wave of the QRS complex and the beginning of the T-wave
- Represents the beginning of ventricular repolarization

T Wave
- Rounded wave following the QRS complex
- Indicates repolarization of the ventricles
Absolute Refractory Period

- Time when the cardiac cells have been depolarized and cannot be depolarized a second time until the process of repolarization has occurred
- Occurs from the beginning of the QRS to the apex (middle) of the T-wave

Relative Refractory Period

- Extends from the middle of the T-wave to the end of the T-wave
- Time when stimulation may cause premature depolarization of the ventricles
  - ‘R on T’ phenomenon
- Can cause a ventricular malfunction
  - VT/VF, Torsades, SVT
**Sudden Cardiac Death (SCD)**
- Affects 350,000 - 400,000 each year in the U.S. alone
- Only 5% of victims survive
- Causes of SCD may include structural heart disease or a genetic channelopathy

**Features common to the cardiac channelopathies**
- Subjects are outwardly normal, otherwise healthy
- 50% of family members are gene carriers
- Sudden death may be the first symptom
- Misdiagnosis as epilepsy/sudden syncopal episode is common

**Long QT Syndrome**
- Genetic disorder (1:5,000-10,000)
- ECG evidence: QTc interval prolonged
  - Upper limit women
    - 0.46
  - Upper limit men
    - 0.45
- Hallmark arrhythmia: Torsades de Pointes / VF

**LQTS ECG Patterns**
- Circ 1992;85[Suppl I]:I140-I144

**Additional LQTS ECG Patterns**
- Circ 1992;85[Suppl I]:I140-I144

**People at risk of long QT syndrome**
- Children, teenagers and young adults or family members of them
  - unexplained fainting, unexplained near drowning or other accidents, unexplained seizures, or a history of cardiac arrest
- First-degree relatives of people with known long QT syndrome
- People taking medications known to cause prolonged Q-T intervals
- People with low potassium, magnesium or calcium blood levels
  - anorexia nervosa/bulimia
Congenital LQTS

- Congenital LQTS is caused by an abnormality in the gene code for the ion channels.
- Slows the recovery phase of the heartbeat.

Forms of inherited LQTS include:

- Multiple ion channel abnormalities
- The most common ones include LQT1, LQT2, LQT3, LQT4, LQT5
- Classified by the type of channel which causes the LQTS
- Those with LQT3 having the highest risk of life-threatening arrhythmias

Other forms of inherited LQTS include:

- Jervell, Lange-Nielsen Syndrome (autosomal recessive inheritance pattern)
- Both parents are carriers of the abnormal gene (rare), but they may not manifest LQTS
- This syndrome is associated with deafness at birth

- Romano-Ward Syndrome (autosomal dominant inheritance pattern)
- One parent has LQTS and the other parent usually does not.
- Hearing is normal; however the likelihood that children in this family would have LQTS is greater

Ventricular Myocyte Action Potential

Resting membrane potential

Rapid Depolarization

Plateau

Outward potassium

Inward calcium and outward slow potassium

Closure of sodium channels: outward potassium and chloride

Inward sodium

Outward potassium

Repolarization

3 main factors contributing to syncope or SCD

- Exercise (LQT1), especially swimming
- Emotions or emotional stress (LQT2)
- Events occurring during sleep or at rest, slow heart rate during sleep (LQT3)
LQTS: Identification of Risk

- Most common presenting symptom: unexplained syncope
- Syncope on exertion in pediatric patients should be considered malignant until proven otherwise
- History & ECG:
  - Onset and offset of syncopal episode
  - Siblings, or family members with unexplained syncope or sudden death
  - Family history of “seizures” or congenital deafness
  - Prolonged QTc on ECG

Acquired LQTS

- More than 50 common medications can lengthen the Q-T interval in otherwise healthy people
- Causes a form of acquired long QT syndrome known as drug-induced long QT syndrome

Acquired LQTS

- People who develop drug-induced long QT syndrome may also have some subtle genetic defects in their hearts
- More susceptible to disruptions in heart rhythm from taking drugs that cause prolonged Q-T intervals
### Meds of Note
- Amiodarone
- Zithromax
- Celexa/Effexor
- Benadryl
- Pepcid
- Prozac
- Diflucan
- Cerebyx
- Levitra
- Lasix
- Haldol
- Zofran
- Ritalin
- Cipro
- Elavil
- Inapsine
- Paxil
- Phenergan
- Albuterol
- Dopamine
- Dobutamine
- Xopenex
- Oxytocin
- Procainamide
- Brethene
- Neosynephrine
- Primatine Mist

### Other Acquired Causes of LQTS
- Hypokalemia
- Hypomagnesemia
- Hypocalcemia
- Hypothermia
- Myocardial ischemia/infarct
- Bundle branch block
- Raised intracranial pressure

### Meds to be Avoided by Congenital Long QT Patients

### Drugs to Be Avoided by Congenital Long QT Patients

Note: Medications on this list are not reviewed on an ongoing basis to ensure that the available evidence supports their inclusion. Clinicians are encouraged to consult with patients' providers and consider the specific circumstances of the patient before administering any medication.

Disclaimer: The information presented is intended solely for the purpose of providing general information and should not be used as a substitute for medical advice. Clinicians should always consult with patients' providers to determine the appropriate course of action.

11/5/2014
Beta-adrenergic blocking agents are the drugs of choice to treat long QT syndrome:
- Propranolol
- Nadolol
- Metoprolol
- Atenolol

Mexiletine
- LQT3 patients
  Taking this anti-arrhythmic drug in combination with propranolol may help shorten the Q-T interval
- Potassium supplements

Surgical intervention
- Implantation of cardioverter-defibrillator
- Placement of a pacemaker

Patients with long QT syndrome should avoid participation in competitive sports, strenuous exercise, and stress-related emotions.

Short QT Syndrome
- Rare

Related to several mutations affecting the function of ion channels responsible for the currents that generate the cardiac action potential:
  - hyperfunction of the potassium current or
  - hypofunction of the calcium current

Other Short QT causes
- Hypercalcemia
- Digoxin
Short QT ECG Characteristics
- QT < 300msec
- Re-entrant arrhythmias
- No significant QT change with HR changes
- Short ST segment with tall, narrow peaked T-waves in V1-V6

SQTS Characteristics
- Age of presentation ranges from a few months to 60’s
- No specific triggers for episodes that took place at rest, during exercise, or after loud noises
- Excluded in patients without structural heart disease presenting with SCD

SQTS Characteristics
- Symptoms often documented are syncope and palpitations
  - Self-terminating VF episodes were considered the most likely mechanism
  - Atrial fibrillation constitutes one of the main findings of SQTS
    - Taken it into account in the management of young patients with lone atrial fibrillation

Short QT
- Management
  - Pharmacological (small studies)
    - Only quinidine effective in increasing the QTI
  - ICD experience (limited)
    - T wave oversensing/inappropriate shocks