Hybrid Treatment of Inappropriate Sinus Tachycardia

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If we stand tall, it is because we stand tall on the shoulders of the giants who came before us.”

-Yoruba Proverb
Inappropriate Sinus Tachycardia

• Rare cause of sinus tachycardia
• Diagnosis by exclusion
• Unknown etiology
• 15 – 45 years of age
• Female predominance 4:1
• Difficult to make diagnosis
• Difficult to treat effectively
Inappropriate Sinus Tachycardia

Definition

- HR > 100 bpm at rest or with mild exertion, stress, or orthostatic position change
- Average HR > 90 bpm on 24-hr Holter
- Increase HR > 30 bpm after standing
- Normal P-wave morphology on 12-lead ECG
- Exclusion of other causes of tachycardia
- Exclusion of atrial- and AV nodal reentry-tachycardia
Inappropriate Sinus Tachycardia Symptoms

- Palpitations with mild exertion or standing position
- Atypical chest pain
- Fatigue
- Lightheadedness
- Near-syncope, syncope
- Severe tachycardia, paroxysmal or persistent
Inappropriate Sinus Tachycardia Diagnosis

• Rule out other causes of Sinus Tachycardia
• Labs (CBC, TFT, Adrenal, Catecholamines, 24-hr Urine)
• ECG, Holter, TMT, Echo, EP study
• Autonomic Function Tests
  – Baroreflex Sensitivity
  – $\beta$-adrenergic Sensitivity
  – Intrinsic HR
  – $\alpha$-adrenergic Receptor Sensitivity
  – Peripheral Vascular Resistance
  – Quantitative Sudomotor Axon Reflex Test
Inappropriate Sinus Tachycardia

Treatment Options

• Exercise, cardiac rehab
• Hydration, salt intake
• Medical therapy
  – β-blockers, Ca-channel blockers, Amiodarone
  – Fludrocortisone, Midodrine
  – Ivabradine, Clonidine
• A-V Node Ablation and Pacemaker
• Sinus Node Resection
• Sinus Node Ablation
• Sinus Node Modification
Sinus Node Modification for IST

- **Catheter-based (Endocardial)**
  - RF, Cryothermal
    - Waspe: Pacing Clin Electrophysiolog 1994; 16 1569
    - Lee: Circulation 1995; 92: 2919
    - Bai: J Cardiovasc Electrophysiolog 2006; 17: 944
  - Intracardiac Echo-guided
    - Kalman Circulation 1995; 92: 3070
  - Electro-anatomic mapping-guided
    - Marrouche: J Am Coll Cardiol 2002; 39:1046
  - Activation-mapping-guided
    - Man: J Am Coll Cardiol 2000; 35: 457
Atrial Mapping
Endocardial Sinus Node Modification

Results

• Activation-guided RF Ablation (n = 29)
  – Acute reduction in HR = 76%
    • Stepwise caudal progression of EA in 59%
    • Abrupt success in 41%
    • Symptoms recurred (mean 4.4 months) in 27%
  – Long-term symptom-free rate = 66%
    – Man: J Am Coll Cardiol 2000; 35: 451

• 3-D mapping-guided RF Ablation (n = 39)
  – 21% had recurrent IST requiring repeat ablations
    – Marrouche: J Am Coll Cardiol 2002; 39: 1046
Endocardial Sinus Node Modification

Results

• Recurrence of IST or symptoms
  – Symptoms may occur in absence of tachycardia
  – Autonomic dysfunction or POTS
  – Non-IST tachyarrhythmias

• Complications
  – R Phrenic Nerve injury
    • RF or Cryothermal ablations
  – SVC narrowing
  – Bradyarrhythmias requiring permanent pacemaker
  – DVT
Sinus Node Surgery for IST

- **Epicardial Approaches**
  
  - Sternotomy, CPB, Sinus node resection
    - Yee: J Am Coll Cardiol 1984; 3: 400
  
  - Mini-R Thoracotomy, Bipolar RF ablation
    - Kreisel: J Thorac Cardiovasc Surg 2005; 130: 598
  
  - R Thoracoscopy, Microwave Ablation
    - Adrian: Ann Thorac Surg 2007; 83: 300
Hybrid Sinus Node Modification for IST Case Reports

• Combined Endocardial and Epicardial Ablation
  – Unable to complete adequate SNM due to Phrenic N
    • Subxiphoid intrapericardial and transvenous RF
    • Transpericardial with phrenic nerve protection
      – Rubenstein: J Cardiovasc Electrophysiol 2009; 20: 689
Earliest Activation in Sinus Rhythm
Anatomy of the Sinus Node

- Sanchez-Quintana: Heart 2005; 91: 189
Justification for a Hybrid Approach

• Proximity of the Sinus Node to the R Phrenic Nerve

• Myocardial thickness between Sinus Node and endocardium, especially at the Crista Terminalis

• Benefit of 3-D mapping to identify migration of the areas of Earliest Activation during ablation
Hybrid Sinus Node Modification Case Presentations

- 4 pts with medical-refractory IST
- Other causes of tachycardia ruled-out
- Severe, incapacitating symptoms
- Unable to complete catheter-based Sinus Node Modification
  - R Phrenic nerve stimulation with endocardial pacing at mapped site of earliest activation
• 32 F
• Known PFO
• S/P ankle Fx, AVM, S/P embolization of AVM
• Palpitations, lightheaded, syncope x 5
• Resting HR 110 bpm
  – HR to 150 – 160 with mild exertion
• Diagnosed with orthostatic hypotension but no BP change
• Unable to tolerate Midodrine
• Symptoms progressed despite B-blockers and Florinef
• EP study ruled out atrial tachycardia
• Unable to safely ablate Sinus Node due to Phrenic Nerve proximity
LM

• 49 yo F, RN
• S/P D&C c/b unresponsiveness, intubated x 10 days
• Multiple UE DVTs, Neurogenic bladder
• Diagnosed Orthostatic Hypotension
• Midodrine, Florinef, Prednisone
• Sinus tachycardia with any exertion, syncope
• Resting HR 110 bpm
  – HR increases to 150 bpm with mild exercise
• Extensive neurologic W/U
  – No Autonomic dysfunction
  – No Neuropathy nor Myopathy
• Symptoms progressed over 11 months
AB and JW (A.K.A. “The Twins”)

- 28 and 32 yo Females
- Extensive palpitations and syncope
- Resting HR 110 – 120 bpm
  - HR increases to 150 – 160 bpm with standing or walking across room
- Each pt diagnosed with IST independent of each
  - Met on IST Support Group website
  - Became immediate “soul-mates”, now inseperable
- Extreme Type A personalities
  - AB exercises 3x per day and is obsessed with exercise
  - JW has Ehlers-Danlos and S/P very large breast implants
Hybrid Sinus Node Modification
EP Procedure

- R CFV access with 9,8,6 Fr sheaths
  - EP mapping
    - EnSite array balloon catheter (St. Jude Medical) in RA
    - Non-contact electroanatomic mapping of RA
    - Identified sites of Earliest Activation at rest and after infusion of Isoproterenol
  - Mapping-guided Endocardial RF ablation
    - 8 mm EP Therapeutic Unipolar RF catheter (Boston Scientific)
    - Applied sequentially to caudally migrating sites of EA
EnSite Array Balloon Mapping Catheter
EP Therapeutic Radiofrequency Ablation Catheter
Hybrid Sinus Node Modification Surgical Procedure

• R Inframammary Minithoracotomy (4cm)
  – Entered 4th IS
  – Soft-tissue retractor, no rib-spread ing
  – Opened pericardium anterior to Phrenic Nerve
  – 24 Fr Red Rubber catheter placed between SVC/RA and PN
  – Endocardial pacing at 10 mA failed to stimulate diaphragm

• EP Mapping-guided Epicardial Ablation
  – Unipolar Saline-irrigated RF Probe (Estech)
  – 1st and 2nd segments only
  – Correlated endocardial 3-D map with epicardial landmarks
  – Sequentially followed EA more caudally based HR response
Estech Unipolar RF Catheter
Right Phrenic Nerve Protection
Epicardial and Endocardial Radiofrequency Ablation with Phrenic Nerve Protection
Endocardial RF Ablation of Sinus Node
Caudal Migration of the Area of Earliest Activation
Mapping-Guided Epicardial RF Lesion
Sites of Mapping-Guided RF Ablation
Caudal Migration of the Area of Earliest Activation
Post-Ablation Mapping of the Area of Earliest Activation
Can Cardiologists and Surgeons Work Together?
Can’t We All Just Get Along?
Results

• Significant acute HR reduction in all patients
  – Baseline HR = 100 – 110 bpm
  – Isoproterenol infusion HR = 150 – 160 bpm
  – Post-ablation resting HR = 70 – 80
  – Post-ablation HR with Isoproterenol = 90 – 102 bpm
Results

- **LM**
  - DVT R groin requiring thrombolysis/filter
  - Excellent symptom and HR relief with medications
  - 2 months postop, had seizure after Endometrial ablation
    - CT brain normal
    - No arrhythmias

- **KF**
  - Single episode of SVT in hospital postop
  - AVNRT 2:1 block, self-terminating
  - Excellent symptom and HR relief
  - 11 months postop had PICC line in PA – telemetry
    - Junctional rhythm at times with AV dissociation
    - Poor exercise tolerance on TMT
    - PPM 11 months postop
    - LV RF ablation 12 months postop for PVCs
Results

• AB
  – Excellent relief of symptoms and HR immediately
  – Wrote letter POD 7 saying how great she felt
    • Running 3 miles per day

• JW
  – Excellent relief of symptoms and HR
  – Had some postop pain after returning to normal activities, well-controlled
  – Awaiting F/U Holter
Conclusion

• Sinus Node Modification can be performed for highly-selected, medically-refractory patients

• Longer follow-up is required to judge the efficacy of Hybrid Sinus Node Modification

• Several adjuncts can be used to improve safety and efficacy of Sinus Node Modification
  – Accuracy and completeness can be improved with transvenous RA activation mapping, combined with electrical-anatomic guidance
  – A hybrid approach may improve the likelihood of adequate depth of ablation of sinus nodal tissue and decrease the risk of collateral damage

• Careful patient selection and informed consent are critically important in this complex patient population undergoing a procedure with variable results
Thank You From All Your Friends at the Texas Heart Institute