VCU Health
Pauley Heart Center

"Phrenic Nerve Pacing for Central Sleep Apnea"

Richard Shepard, MD
Associate Professor of Medicine, VCU Health Pauley Heart Center

Educational Objectives:
- What are the different treatments for central and obstructive sleep apnea?
- What are cardiac issues associated with sleep apnea?
- What are effective treatments for central sleep apnea?

October 10, 2025

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Central Sleep Apnea and Phrenic Nerve Pacing

Richard K Shepard MD
Associate Professor of Medicine
VCU Pauley Heart Center
VCU Health

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Disclosures

- None to report

- I am an implanter of the Respicardia Remede sleep apnea device but have no financial interest. (now owned by Zoll)
- I participated in the original Pivotal clinical trials for Respicardia.
- I am not a sleep doctor.

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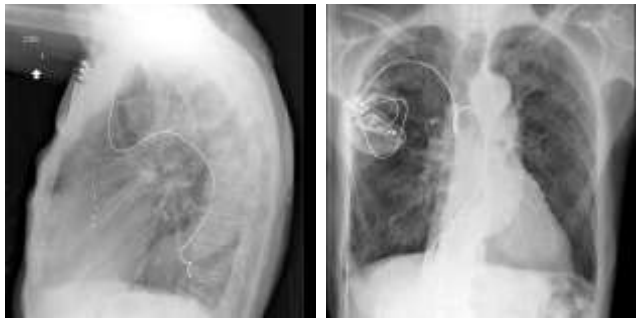
What is this?



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VCU Health
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First remede Phrenic Nerve stimulator implant at VCU health
Done in 2014 as part of Pivotal trial.
Implanters were chosen for expertise in BiV ICD CS lead implantation.

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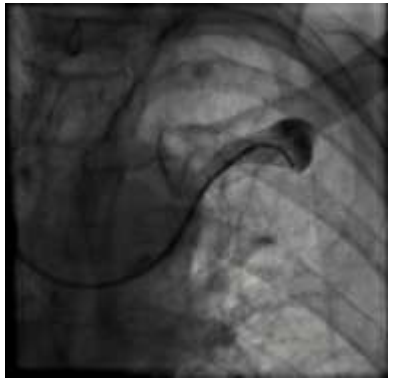

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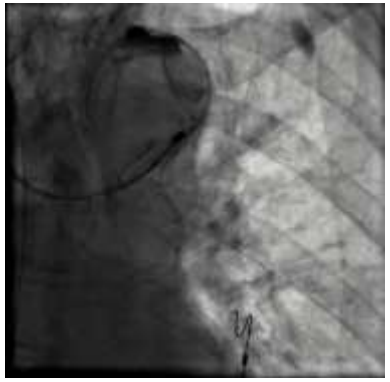

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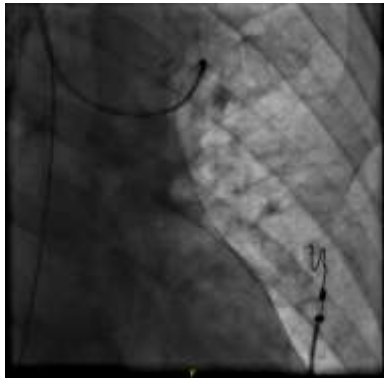

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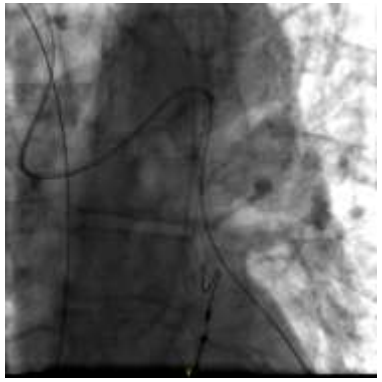

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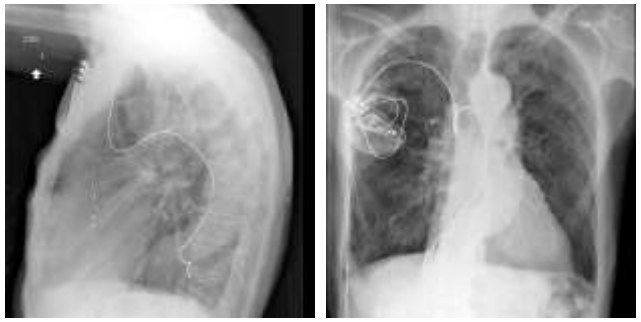

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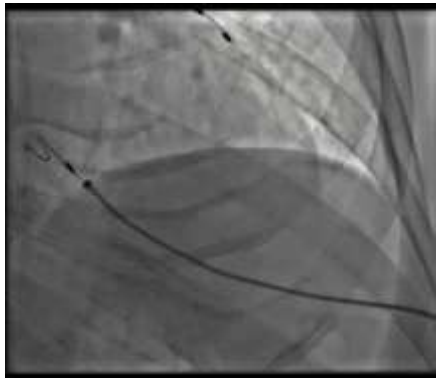

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Outline:

Sleep Apnea

Brief discussion of Obstructive Sleep Apnea

Cardiovascular problems with Sleep Apnea

Central Sleep Apnea and Treatment

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Sleep Apnea: Many cardiovascular effects

Hypoxia and sympathetic activity surges:

Hypertension
Increased preload
Increased afterload

Promotes myocardial ischemia and arrhythmia

Enhances oxidative stress
Endothelial dysfunction
Inflammation
Activates neurohormonal system --> progression of disease

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AHI Apnea-hypopnea Index

- The apnea-hypopnea index is the combined average number of apneas and hypopneas that occur per hour of sleep.
- American Academy of Sleep Medicine categorized as
  - Mild 5 -15 events per hour
  - Moderate 15 -30 events per hour
  - Severe > 30 events per hour

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Table 2—Patients at High Risk for OSA Who Should Be Evaluated for OSA Symptoms

Obesity (BMI > 35)
Congestive heart failure
Atrial fibrillation
Treatment refractory hypertension
Type 2 diabetes
Nocturnal dysrhythmias
Stroke
Pulmonary hypertension
High-risk driving populations
Preoperative for bariatric surgery

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CPAP is very effective for treatment Obstructive Sleep Apnea

It is only effective when used greater than 4 hours per night

29 % to 83% of patients have been non adherent if various studies

Therefore, many surgical options are now available
Which may have led to thought of surgical treatment for CSA

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Operative Techniques in Otolaryngology-Head and Neck Surgery
Volume 23, Issue 3, September 2012, Pages 227-233

Original contribution

Operative technique of upper airway stimulation: an implantable treatment of obstructive sleep apnea

Joachim T. Maurer MD *, Paul Van de Heyning MD, PhD, Ho-Sheng Lin MD *, Jonathon Baskin MD, Clemens Anders MD, Winfried Hohenhorst MD, B. Tucker Woodson MD

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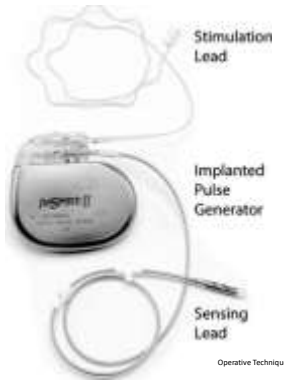

Operative Techniques in Otolaryngology, Vol 23, No 3, September 2012

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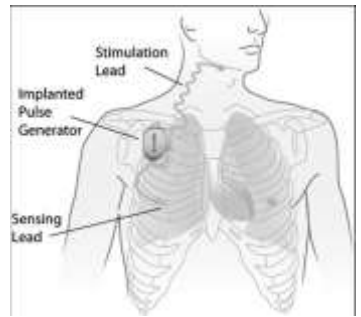

Figure 1. Schematic drawing of the Inspire upper airway stimulation (UAS) system. The implantable pulse generator (IPG) delivers electric pulses through a stimulation lead to the hypoglossal nerve synchronous with respiratory cycles detected by a sensing lead

Operative Techniques in Otolaryngology, Vol 23, No 3, September 2012

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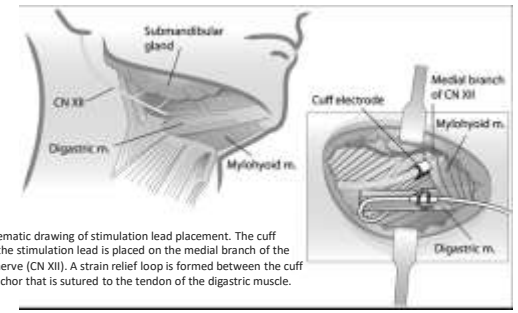

Figure 4. Schematic drawing of stimulation lead placement. The cuff electrode of the stimulation lead is placed on the medial branch of the hypoglossal nerve (CN XII). A strain relief loop is formed between the cuff and a lead anchor that is sutured to the tendon of the digastric muscle.

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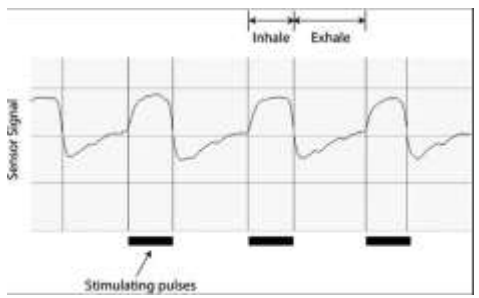

Figure 6. Inspire UAS stimulation timing. Stimulation pulses start when the patient begins to inhale and stop when the patient begins to exhale. The timing of the synchronization can be adjusted by sensing parameters.

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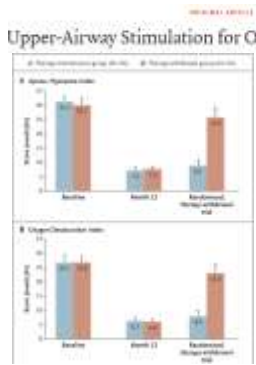

Significant reduction in AHI with Inspire sleep apnea device after 12 months of therapy.
Benefits only remain with maintenance of therapy.

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Central Sleep Apnea in the Cardiovascular Patient Population

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Central Sleep Apnea

- Central sleep apnea results from an ***intermittent neural drive*** to breathe
- Patients with co-morbidities such as heart failure, atrial fibrillation and renal disease are at ***increased risk*** for CSA

Costanzo, et al. J Am Coll Cardiol 2015;65:72–84

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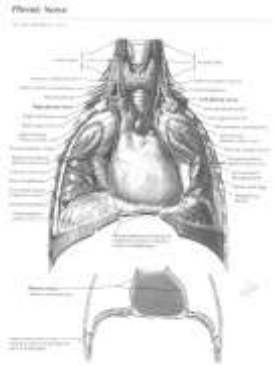
Phrenic Nerve:

C 3 4 5 Keeps the diaphragm alive



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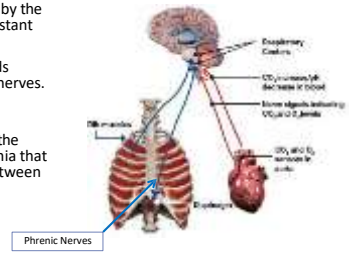
Pathophysiology of Central Sleep Apnea

During sleep, respiration is regulated by the brain whose goal is to maintain a constant blood CO_2

To keep CO_2 regulated, the brain sends signals to the diaphragm via phrenic nerves. These signals control the pattern of breathing

In patients with central sleep apnea, the brain develops a respiratory arrhythmia that manifests as an oscillating pattern between hyperventilation and apnea



Dempsey et al. Physiol Rev 2010;90:47-112
Orr et al. Respirology 2017;22,43-52

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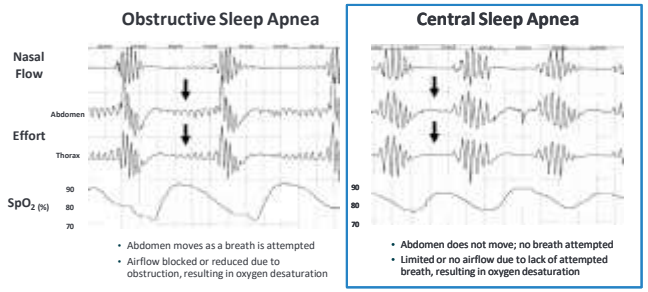
The difference between OSA and CSA is evident in sleep studies



Pham, et al High Alt Med Biol 2017; 18: 11-19

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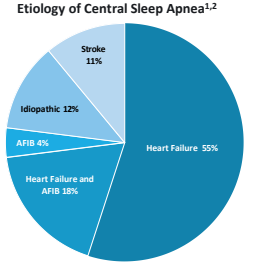
Most patients with CSA also have concomitant cardiovascular conditions



- **Heart Failure**[2,3]
- CSA occurs in 30–50% of patients with heart failure with reduced left ventricular ejection fraction (LVEF) and in 18–30% of HF patients with preserved LVEF
- 70%+ of CSA patients have heart failure and/or reduced left ventricular ejection fraction (LVEF)
- **Atrial Fibrillation**[2,4,5]
- CSA occurs in 10-30% of patients with atrial fibrillation
- 20+% of CSA patients have atrial fibrillation

1. Javaheri and Dempsey, Comprehensive Physiology 2013;3:141-163;
2. Dymedex data on file, 2016.;
3. Bekfani and Abraham, Europace 2016; 18:1123-24;
4. Tung et al. J Am Heart Assoc 2017;6:e004500.DOI: 10.1161/JAHA.116.004500
5. Bitter T, et. al. Disch Arztebl Int. 2009;106(30):164–170.

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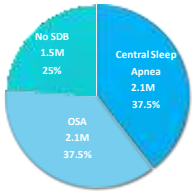
Sleep Disordered Breathing is Common in Heart Failure

Untreated CSA symptoms can overlap HF symptoms



- Many patients with CSA complain of symptoms which may be multifactorial:
  - Fatigue
    - Low cardiac index
    - Medication side-effects
    - Depression
    - Co-existent medical problems
  - Frequent hospitalizations
  - Nocturia
  - Frequent awakenings
- CSA patients often have apneas observed by bed partners
- CSA patients frequently do not snore
- CSA patients frequently are not aware that they have arousals

Roger et al. Circulation 2011;123:e18-209
Oldenburg et al. Eur J Heart Fail;2007;9:251-7

Costanzo et al., JACC 2015; 65(1):72-84
Arzt et al., JACC: Heart Fail 2014; 4(2):116-125

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Untreated CSA causes life altering levels of fatigue as well as increased health risks for heart failure and atrial fibrillation

CSA is due to a loss of neural drive to breathe during sleep[1]

CSA patients undergo **hundreds** of repeated cycles of oxygen desaturation, arousals and surges in sympathetic drive

Nighttime sleep disruptions significantly diminish quality of life[2,3,4,5]

- Severe fatigue
- Excessive daytime sleepiness
- Cognitive impairment
- Depression
- Memory deficits

Untreated CSA significantly increases health risks for these patients

- Significantly higher rates of heart failure and atrial fibrillation[1,6]
- **2x** more likely to have a HF-related readmission within 6 months[7]
- **2x** the mortality rate in HF patients[8]

1. Bekfani and Abraham, Europace 2016; 18:1123-24
2. Dempsey JA. Exp Physiol 2005; 90: 13–24,
3. Javaheri S., Dempsey J.A. Compr Physiol. 2013; 3:141–163
4. Brenner, S., et al. Trends Cardiovasc. Med. 2008; 18, 240–247.
5. Flemons WW, Tsai W. J Allergy Clin Immunol 1997; 99:S750-S756
6. Tung et al. J Am Heart Assoc. 2017; e004500. DOI: 10.1161/JAHA.116.004500.Khayat et al. J Card Fail 2012; 18:534-540.
7. Khayat et al. Eur Heart J 2015; 23:1463-1469.

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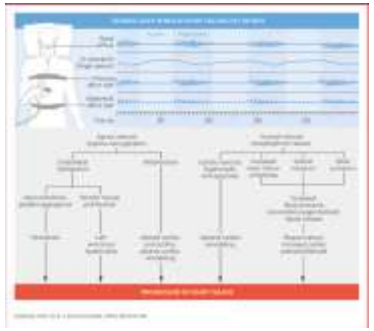

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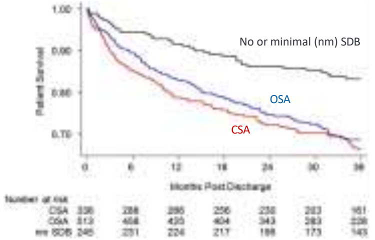
Sleep Disordered Breathing is a Predictor of Mortality in HF Patients

Survival – Heart failure (LVEF< 45%) with CSA patients vs. heart failure with normal breathing in NIH sponsored study



HF combined with CSA is associated with a 2-fold increase in risk of death

Hazard ratios	
CSA vs. no or minimal SDB	**OSA vs. no or minimal SDB**
2.17 $p < 0.001$	**2.00 $p < 0.001$**

Khayat et al. Eur Heart J 2015; 36:1463-9

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Limited Treatment Options for Central Sleep Apnea

CPAP	• Most common CSA treatment • Clinical trials demonstrated improvement in AHI and EF • CANPAP showed no improvement in QoL or M&M and was stopped early for safety • Does not have a FDA approved indication to treat CSA
ASV (Adaptive servo-ventilation)	• Largest randomized study in CSA (SERVE-HF n=1325) • Showed an improvement in AHI but no improvement in QoL • No difference in M&M, but increased cardiovascular mortality in patients with EF < 45% • **Black box warning** and Class III recommendation against use in patients with EF < 45%
Oxygen Therapy	• Small randomized studies show improvement in AHI, but no improvements in arousals or daytime sleepiness • Does not have a FDA approved indication to treat CSA
Medications • Theophylline • Acetazolamide	• Both studied in short (<3 month) studies with < 20 patients • Does not have a FDA approved indication to treat CSA

Aurora et al., SLEEP 2012;35:17-40; Costanzo, et al., JACC 2015; 65: 72-84; Sepehrvand, et al. JACC 2016; 4: 783-790. Bradley TD, et al. N Engl J Med 2005;353:2025-33; Cowie MR et al. New Engl J Med 2015; 373:1095-1105. Aurora et al. J Clin S le ep Med 2016; 12:757-761

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Positive airway pressure (PAP) devices are frequently prescribed for CSA despite limited effectiveness data, as well as compliance and tolerance issues

- Positive airway pressure therapies have been shown to reduce AHI but have not shown improvements in arousals, REM Sleep or quality of life in a randomized clinical trial[1]
- Many patients are unable to tolerate PAP due to a range of challenges:[2]
  - Mask discomfort
  - Mask leakage
  - Pressure intolerance
  - Skin Irritation
  - Nasal congestion
  - Nasal drying
  - Nosebleeds
  - Claustrophobia
  - Bed partner disruption
  - Challenge to intimacy
- 25-50% of patients refuse or are unable to tolerate these therapies[3,4]
- 40-60% are non-compliant to even a minimal bar of 4 hours/night, 5 nights/week.[3,4]
- Randomized clinical trials have also revealed safety concerns for PAP therapies in patients with reduced left ventricular ejection fraction (LVEF) [5]

1. Bradley TD, et al. N Engl J Med 2005;353:2025-33
2. https://www.mayoclinic.org/diseases-conditions/sleep-apnea/in-depth/cpap/art-20044164
3. Takama N, Kurabayashi M, Circulation Journal 2012;76:661-7
4. Arzt M, et al., Circulation 2007; 115:3713-80
5. Cowie MR et al. New Engl J Med 2015; 373:1095-1105

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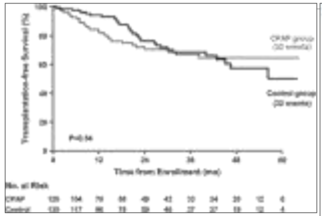
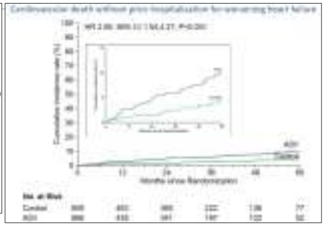
Positive airway pressure therapies have failed to meet their clinical endpoints

CANPAP[1]



CPAP study stopped early due to increased mortality in the treatment group and slow enrollment

SERVE-HF[2]



Adaptive servo-ventilation increased cardiovascular mortality and has a black box warning in patients with LVEF < 45%

1. Bradley et al. N Engl J Med. 2005;353:2025
2. Cowie MR et al. N Engl J Med 2015; 373:1095-1105

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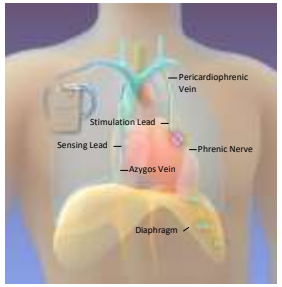
Transvenous phrenic nerve stimulation with the remedē® System



- **Fully implantable system** with an indication to treat moderate to severe central sleep apnea in adults; received U.S. FDA PMA approval October 2017
- **Stabilizes breathing** by activating the diaphragm to generate negative pressure in the chest (similar to natural breathing)
- **Turns on automatically at night,** ensuring nightly compliance and adherence over time
- Implanted by cardiac electrophysiologists (EPs)
  - **Pulse generator** implanted below clavicle
  - **Stimulation lead** placed either in left pericardiophrenic or right brachiocephalic vein
  - **Sensing lead** placed in the Azygos vein, helps optimize therapy (optional)

1. FDA-Approved Summary of Safety and Effectiveness Data (SSED) for the remedē® System and The remedē System Implant and Clinician Use Manual (P160039) Oct. 6, 2017.

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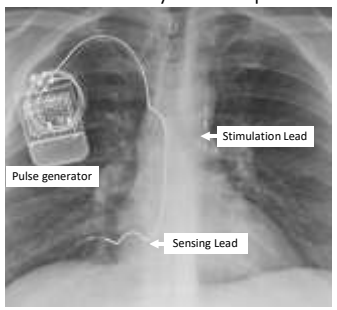
The remedē® System implanted



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Courtesy Respicardia, Inc

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remedē System therapy activates automatically each night

Therapy is delivered when…

It is within the pre-programmed sleeping hours…

Example

11:00 pm

…AND the patient is reclined past the programmed sleeping angle…

…AND the patient is not moving

Therapy is paused when…

The patient sits up…

…OR the patient moves

Therapy resumes a few minutes after the patient returns to a reclined position and is once again still

Courtesy Respicardia, Inc

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remedē® System therapy – recommended programming and follow-up

~1-month post-implant	1-3 months	Every 3-6 months
Therapy Initiation	**Acclimation / Therapy Titration**	**Long-Term Follow-Up**
Therapy is activated ~ 1 month post implant during a follow-up office visit	Patient acclimation period as therapy is customized to maximize efficacy while maintaining patient comfort	Programming checks every 3-6 months to optimize therapy. Physician may order a sleep study to help optimize.

Courtesy Respicardia, Inc

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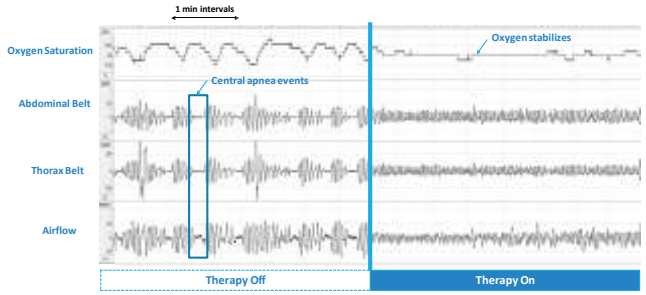
Breathing stabilizes and apnea events are significantly reduced when phrenic nerve simulation is being delivered[1]



1 Costanzo MR, et al., J Card Fail. 2015;21:892-902

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To demonstrate safety and efficacy and gain FDA approval, Respicardia has evaluated phrenic nerve stimulation for the treatment of CSA in 275+ patients across multiple trials

Safety Study	4 Subjects
Proof of Concept	10 Subjects
Lead and Algorithm Development	41 Subjects
Acute Feasibility *(Control Night vs Therapy Night)*	16 Subjects
Chronic Safety Study	8 Implanted Subjects
Pilot Study - Chronic Feasibility	49 Implanted Subjects
Pivotal Trial – IDE Study	147 Implanted Subjects

- **The pivotal trial is the largest randomized trial thus far in CSA patients to meet its endpoints and show benefit**
- **All chronic studies have shown consistent improvements in sleep metrics and quality of life**

Abraham et al. JCAF 2015;5:360-369.
Costanzo et al. J Card Fail 2015;21:892-902.
Costanzo et al. The Lancet 2016;388:974-82.
Costanzo et al. Am J Cardiol 2018;121:1400-1408.
Jagielski et al., Eur J Heart Fail 2014;DOI: 10.1002/ejhf.593.
Ponikowski et al. Eur Heart J 2017;27:391-474.
Zhang et al. Clin Respir J 2015;DOI:10.1111/crj.12320.
Zhang et al. Chest 2012; 142:927-934.
PMA FDA Summary of Safety and Effectiveness Data, PMA P160039

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Transvenous neurostimulation for central sleep apnoea: a randomised controlled trial

Summary

Background Central sleep apnoea is a serious breathing disorder associated with poor outcomes. The remedē system (Respicardia Inc, Minnetonka, MN, USA) is an implantable device which transvenously stimulates a nerve causing diaphragmatic contraction similar to normal breathing. We evaluated the safety and effectiveness of unilateral neurostimulation in patients with central sleep apnoea.

Interpretation Transvenous neurostimulation significantly reduced the severity of central sleep apnoea, including improvements in sleep metrics, and was well tolerated. The clinically meaningful effects of the therapy are supported by the concordant improvements in oxygenation and quality of life, making transvenous neurostimulation a promising therapeutic approach for central sleep apnoea.

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The remedē® System Pivotal Trial

Study design

- **Prospective, multi-center, randomized** controlled trial
- **Baseline criteria for moderate to severe CSA** was based on PSGs **scored by a blinded core laboratory**
  - AHI ≥ 20
  - CAI at least 50% of all apneas with at least 30 central apnea events
  - Obstructive Apnea Index ≤ 20% of the total AHI

ENDPOINT	DESCRIPTION	POPULATION
Primary Effectiveness (6 months)	Comparison of the proportion of subjects with ≥50% reduction in AHI between treatment and control	Intention to Treat (ITT)
Primary Safety (12 months)	Freedom from serious adverse events associated with implant, the remedē system, or delivered therapy	Intention to Treat
Secondary Hierarchical (6 months)	1. Central Apnea Index (CAI) 2. Apnea Hypopnea Index (AHI) 3. Arousal Index (ArI) 4. Rapid Eye Movement (REM) 5. Patient Global Assessment (PGA) 6. Oxygen Desaturation Index 4% (ODI4) 7. Epworth Sleepiness Scale (ESS)	Per-protocol

Costanzo MR, et al., J Card Fail. 2015;21:892-902.

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In the pivotal RCT, the remedē System demonstrated clinically meaningful improvements in sleep, sleep apnea and quality of life

		Change from baseline		Between group difference		
	Endpoint	Treatment	Control	Difference	p-value	Endpoint Met?
Primary endpoint (n= 141[4])	>50% reduction in AHI[1]	51%	11%	41%	<.0001[Δ]	Yes
Secondary endpoint (n= 131[4])	CAI (events/hr) Central Apnea Index	-25.7 ± 18.0	-2.9 ± 17.7	-22.8 ± 17.8	<.0001[†]	Yes
	AHI (events/hr) Apnea Hypopnea Index	-23.9 ± 18.6	1.1 ± 17.6	-25.0 ± 18.1	<.0001[‡]	Yes
	ArI (events/hr) Arousals	-20.2 ± 18.9	-5.0 ± 18.1	-15.2 ± 18.5	<.0001[‡]	Yes
	% of sleep in REM	1.8 ± 8.2	-0.6 ± 7.8	2.4 ± 7.9	.0244[†]	Yes
	QOL – PGA[2] % patients w/ marked or moderate improvement	60%	6%	55%	<.0001[Δ]	Yes
	ODI4 (events/hour) O2 Desaturation 4% below baseline	-19.1 ± 18.4	3.6 ± 17.3	-22.7 ± 17.8	<.0001[†]	Yes
	QOL – ESS[3] Epworth Sleepiness Score	-3.6 ± 5.6	+0.1± 4.5	-3.7 ± 5.0	<.0001[†]	Yes
Safety	91% (CI: 86%,95%) freedom from serious adverse events associated with the implant procedure, TPNS, or the delivered therapy at 12 months					

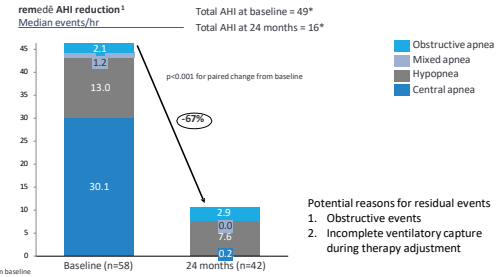
1. Primary endpoint is the proportion of subjects achieving ≥50% reduction in AHI
2. PGA = Patient global assessment
3. ESS = Epworth Sleepiness Scale, an 8-question assessment used to assess sleepiness
4. For primary endpoint, n=68 for treatment and n=73 for control; for secondary endpoints, n=58 for treatment and n=73 for control

Costanzo et al. Lancet 2016;388:974-82; Goldberg L et al. J Cardiac Fail 2017;23:515.

Δ Fisher's Exact Test.
† Mann-Whitney test for difference in change from baseline between groups.
‡ t-test for difference in change from baseline between groups.

45

After 24 months of therapy, an in-lab sleep study showed effective and durable results, including sustained apnea-hypopnea index (AHI) improvement and almost no central apneas



Potential reasons for residual events
1. Obstructive events
2. Incomplete ventilatory capture during therapy adjustment

1 Fox H, et al, *SLEEP*, zsz158, https://doi.org/10.1093/sleep/zsz158

* Total median AHI does not sum from component medians

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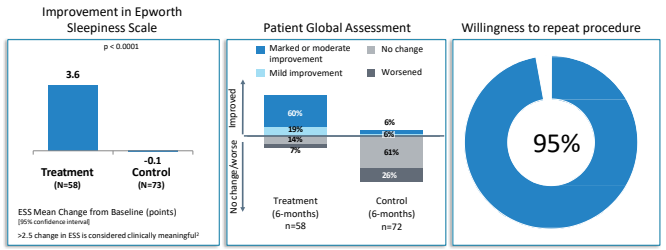
remedē System treatment also resulted in significant improvements in symptoms and quality of life after 6 months of treatment[1]



Demonstrated clinically significant improvement in daytime sleepiness

79% of patients had an improvement in quality of life with the remedē System

95% of patients reported they would "elect to have the medical procedure again"

1. Costanzo et al. Lancet 2016;388:974-82.
2. Patel S, Kon SSC, Nolan CM, et al. Am J Respir Crit Care Med. 2018;197(7):961-963

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The remedē System pivotal trial demonstrated a strong safety profile

- **91%** (CI: 86%,95%) **freedom from serious adverse events** associated with the implant procedure, the **rem**edē® System, or the delivered therapy at 12 months
- All related serious adverse events resolved **without any long term sequelae**
- **No deaths** related to the procedure, system or therapy
- **97% implant success** rate, including the 42% of subjects that already had a concomitant cardiac device

Costanzo MR, et al., The Lancet 2016;388:974–82.

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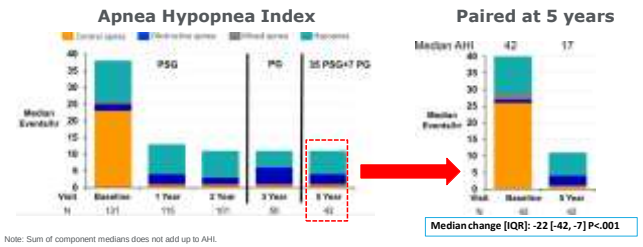
Sustained Improvement in Sleep Disordered Breathing

Late Breaking Clinical Trial Presentation



Note: Sum of component medians does not add up to AHI.

Javaheri, S. CHEST 2020 Late Breaking Abstracts DOI: https://doi.org/10.1016/j.chest.2020.09.011

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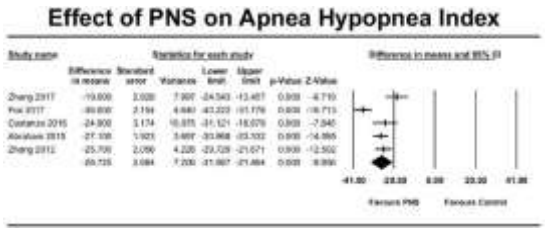
Consistent AHI reduction with phrenic nerve stimulation across multiple studies



Lumi FK, et al. The American Journal of Cardiology. 2020 Jun;125(11):1738-1744. DOI: 10.1016/j.amjcard.2020.02.012.

50

In heart failure, CSA can accelerate cardiac disease progression

Adapted from Bekfani and Abraham, European 2016; 18:1123-24

51

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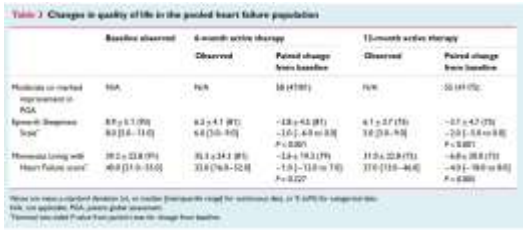

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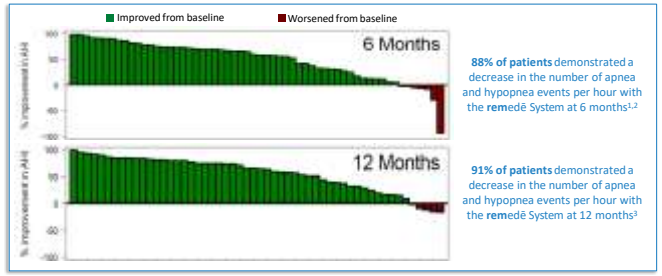
The majority of treated patients demonstrated a decrease in AHI at 6 months and again at 12 months



88% of patients demonstrated a decrease in the number of apnea and hypopnea events per hour with the **rem**edē System at 6 months[1,2]

91% of patients demonstrated a decrease in the number of apnea and hypopnea events per hour with the **rem**edē System at 12 months[3]

1. Costanzo MR, et al. Lancet. 2016; 388: 974–82.
2. 48% of the control group had a decrease in AHI.
3. Costanzo M, et al. Am J Cardiol. 2018;121:1600-1608

55

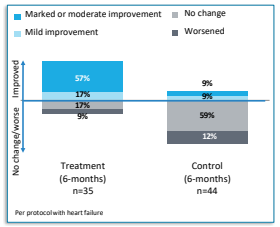
Post hoc analysis of the heart failure cohort demonstrated similar benefit in sleep and quality of life

Post-hoc analysis showed improvements from baseline at 12 months[1]

- **Sleep metrics** (All p= or < 0.001)
  - Apnea Hypopnea Index (AHI)
  - Central Apnea Index (CAI)
  - Oxygen Desaturation Index (ODI)
  - Arousal Index
  - % of sleep in REM
  - ODI4 (events/hour)
  - % of sleep with O2 saturation < 90%
- **Epworth Sleepiness Scale**
  - 3.1 ± 4.7 point improvement from baseline *(p<0.001)*
- **Minnesota Living with Heart Failure**
  - 6.8 ± 20.0 point improvement from baseline *(p=0.005)*

Similar results in quality of life improvements in heart failure cohort as broader patient population[2]

Patient Global Assessment



1 Costanzo et al., Eur J Heart Fail 2018; 1746-1756.
2 Goldberg et al., J Cardiac Fail 2017;23:S16

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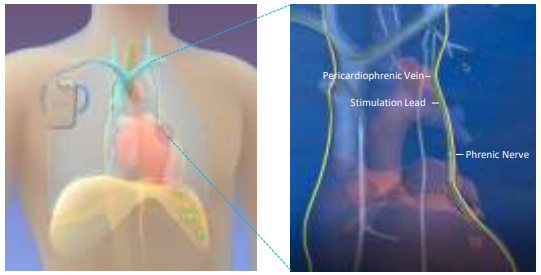
The remedē System – left stimulation lead placement



Courtesy Respicardia, Inc

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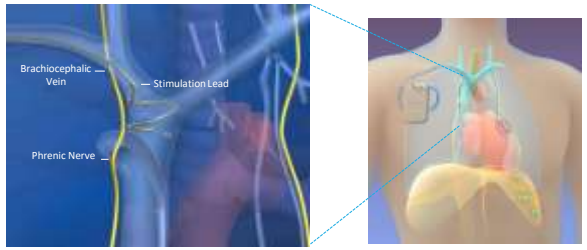
The remedē System – right stimulation lead placement



Courtesy Respicardia, Inc

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Combined Central and Obstructive Sleep Apnea

- The Remede and Inspire system can work together
- The remede initiates diaphragmatic breathing
- The Inspire senses the diaphragm then opens the airway.
- About 15 combined implant in USA

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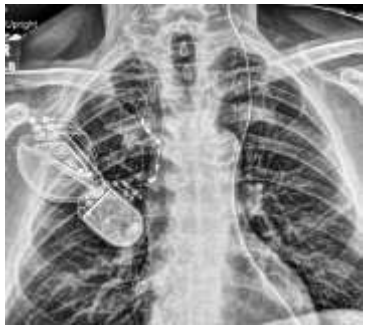
Respicardia and Inspire Device working together



60

VCU remede phrenic nerve stimulator cases:

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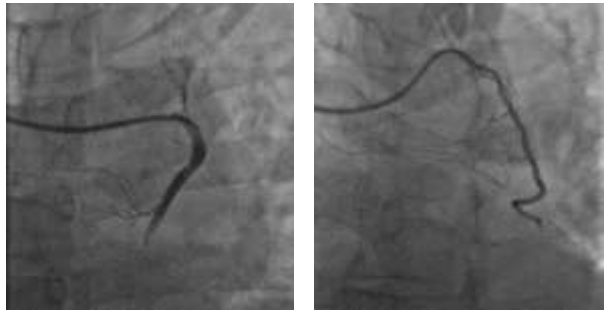
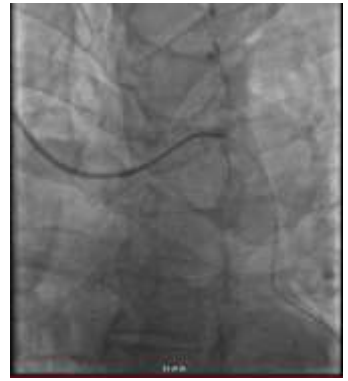
Internal Thoracic Vein

Pericardiophrenic Vein



62

Wire down pericardiophrenic vein



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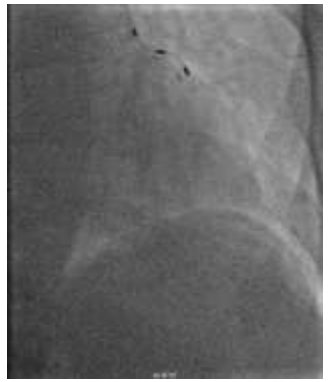
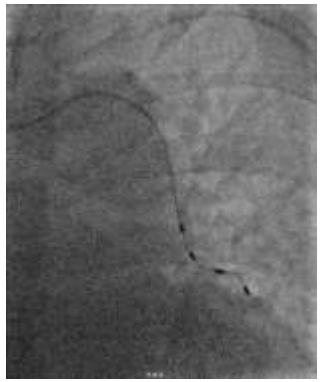
Phrenic Nerve Stimulation test
With strong response.



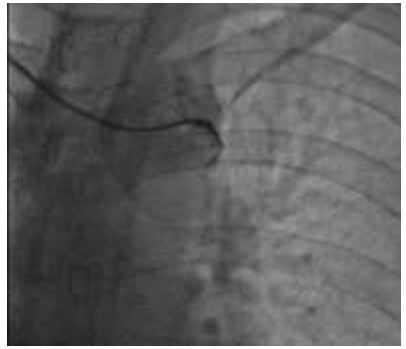
64

Final site of Repicardia lead in pericardiophrenic vein



65

Atretic pericardiophrenic vein



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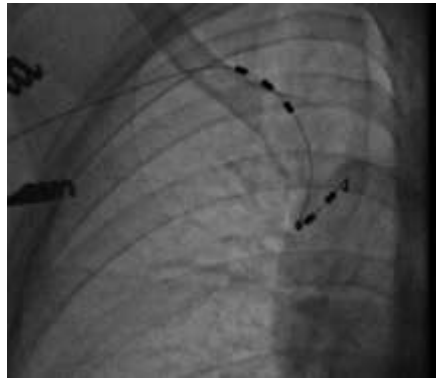

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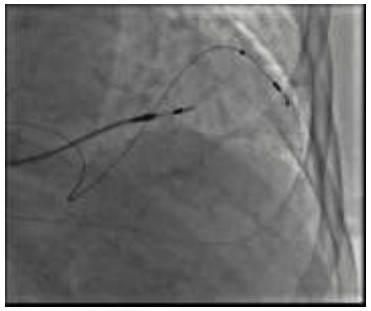
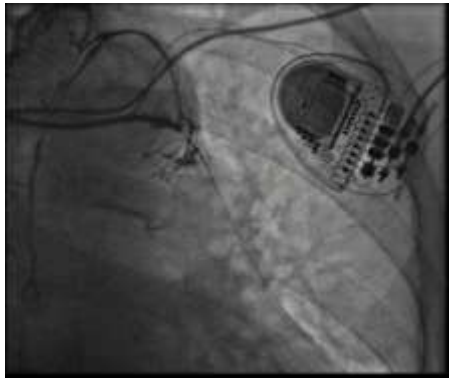


BiV pacing lead near pericardiophrenic vein

Wire down pericardiophrenic vein

68

Pericardiophrenic vein too small for lead, so had to use SVC site.



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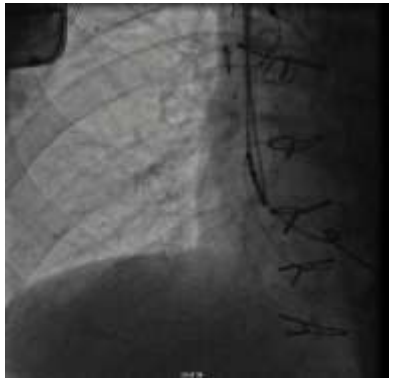
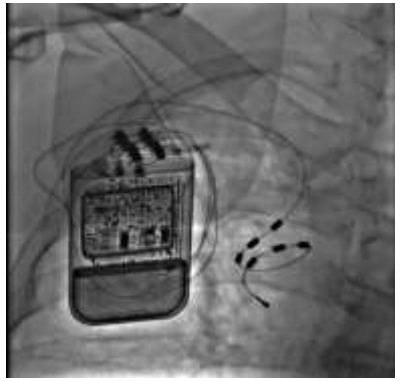
Phrenic Stimulation test



70

Pacing lead in Brachiocephalic/SVC



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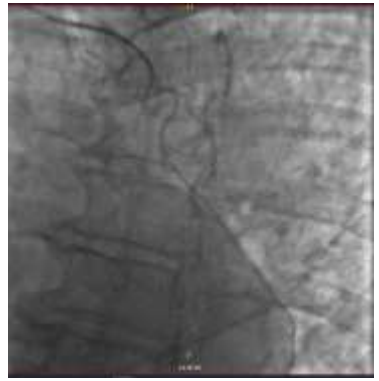

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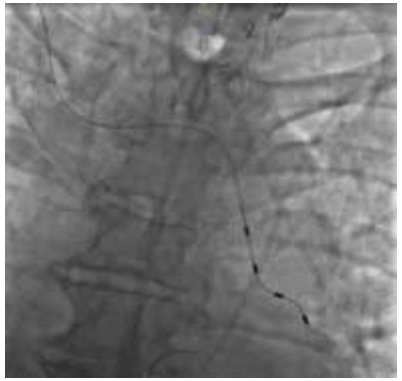

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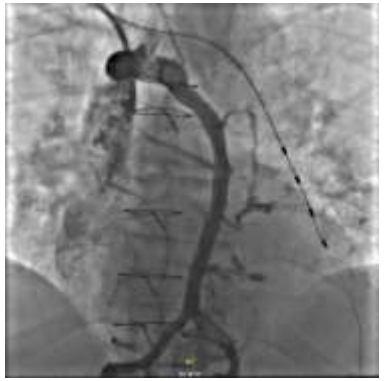
Lead in Pericardiophrenic vein

Venogram of Azygous vein for sensing lead



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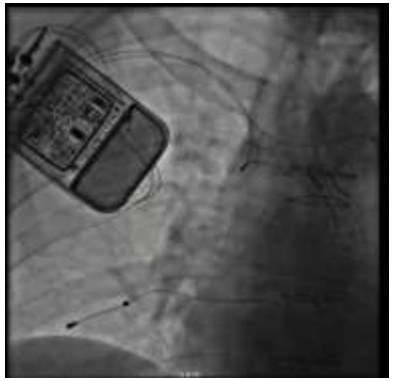
Pacing lead in pericardiophrenic and sensing lead in azygous vein



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Conclusions

Central Sleep Apnea contributes to a harmful progressive cycle of hypoxia, arousal and sympathetic activation

There have been few treatments for central sleep apnea and little randomized data demonstrating efficacy

Phrenic nerve stimulation offers a safe and effective therapeutic option for the treatment of CSA with improvements in both sleep and quality of life

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Questions?

VCU Health
Pauley Heart Center

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Epworth Sleepiness Scale

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STOP-BANG Sleep Apnea Questionnaire

STOP		
Do you SNORE loudly (louder than talking or loud enough to be heard through closed doors)?	Yes	No
Do you often feel TIRED, fatigued, or sleepy during daytime?	Yes	No
Has anyone OBSERVED you stop breathing during your sleep?	Yes	No
Do you have or are you being treated for high blood PRESSURE?	Yes	No
BANG		
BMI more than 35kg/m²?	Yes	No
AGE over 50 years old?	Yes	No
NECK circumference > 16 inches (40cm)?	Yes	No
GENDER: Male?	Yes	No
TOTAL SCORE		

VCU Health

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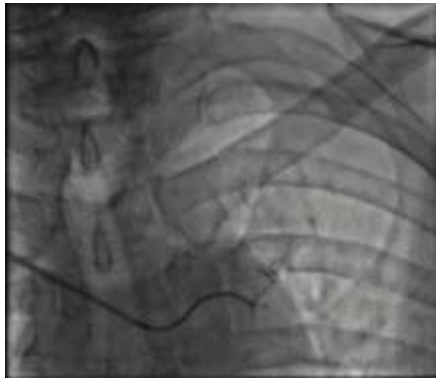

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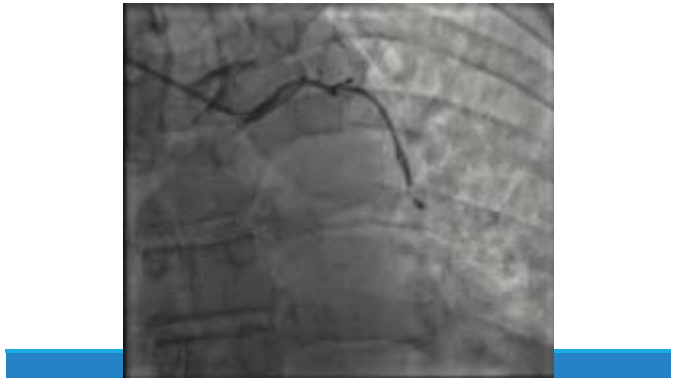

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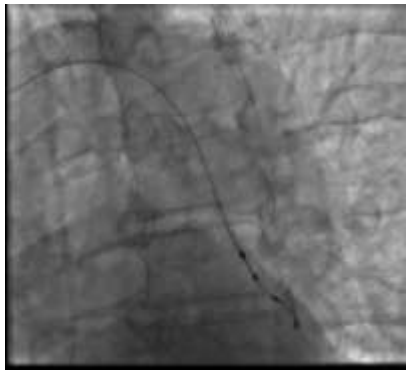

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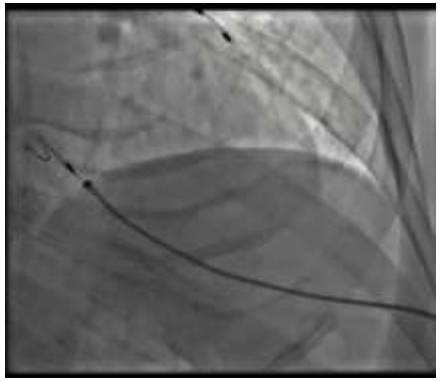

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remedē System Pivotal Trial Safety Events

Primary Safety Endpoint: Serious Adverse Events Related to Implant, Procedure, remedē System, and/or Delivered Therapy through 12 Months	Intention to Treat (N=151)	
	n (Events)	% (Patients)
Any serious related AE	**13**	**9%**
Lead Dislodgment[1]	2	1%
Impending Pocket Erosion	2	1%
Implant Site Infection	2	1%
Concomitant Device Interaction	1	1%
Extra Respiratory Stimulation[2]	1	1%
Lead Component Failure	1	1%
Lead Displacement[3]	1	1%
Implant Site Hematoma	1	1%
Non-Cardiac Chest Pain	1	1%
Elevated Transaminase	1	1%

Costanzo MR, et al. The Lancet 2016;388:974-82

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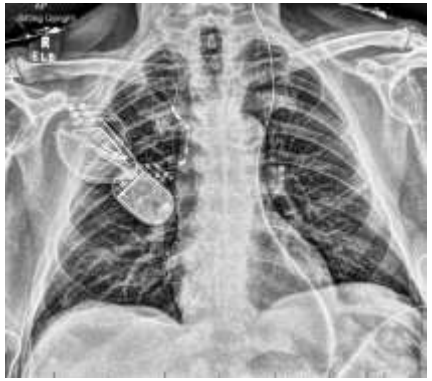

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Implanter and Sleep doctor team

Sleep Doctor makes initial diagnosis and referral for device

Electrophysiologist is primary implanter and manages any device issues or complications.

Sleep Doctor is primary programmer with Respicardia representative with follow up sleep studies

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