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Portable Sleep Testing in Hospitalized Patients

Rami Khayat, MD

Heart Failure AND Public Health

- ≈ 6 million Americans with heart failure (>2% population
- 20 million people with asymptomatic cardiac impairment
- 400,000 - 700,000 new cases diagnosed each year
- Most frequent cause of hospitalization in patients older than 65 years
- > 1.1 million heart failure hospitalizations annually

Redfield et al circulation 1998 And AHA Fact book

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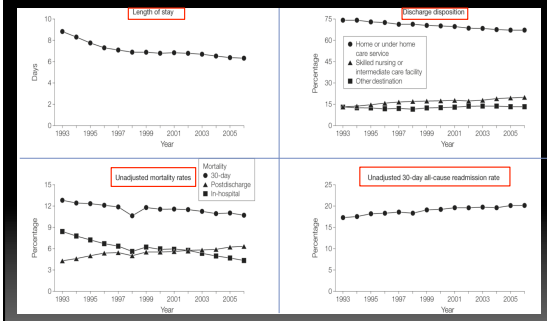
Trends in Length of Stay and Short-term Outcomes Among Medicare Patients Hospitalized for Heart Failure, 1993-2006

JAMA. 2010;303(21):2141-2147. doi:10.1001/jama.2010.748



Impact of Heart Failure on Public Health

- Heart failure causes or contributes to 250,000 deaths/ year
- 1-Year mortality rate is about 10-15%
- 5-Year mortality rate approaches 50%
- 25% readmission rate at 1 month; 50% at 6 months
- > $18 billion in annual direct costs
- Despite current therapies and disease management approaches, the rate of heart failure hospitalization and mortality remains unacceptably high

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Impact of Heart Failure on Public Health

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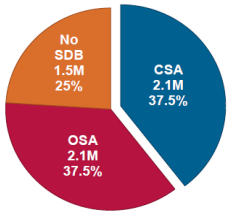
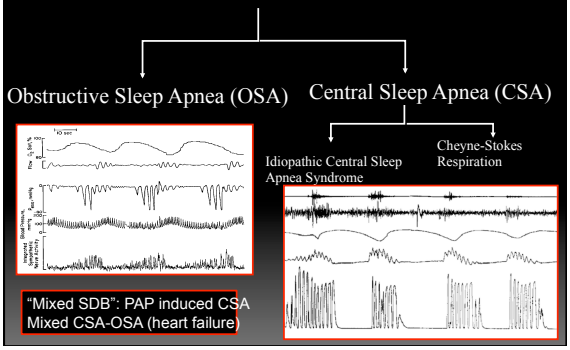
US Heart Failure Population
5.7 Million

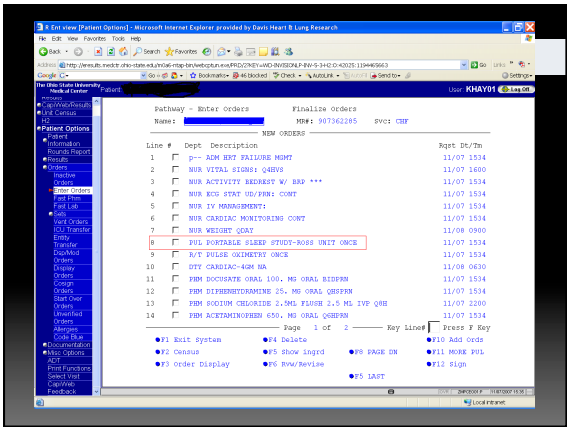


- 83% of all heart failure patients will be hospitalized once and 43% at least 4 times.
- In 2010, there were 1.023 million admissions with HF in the US, essentially unchanged from 2001.
- By 2030, the total cost of HF will increase by 120% to $ 70 billion from 2013 estimated cost of $32 billion.
- AHA Heart Disease and Stroke Statistics 2013

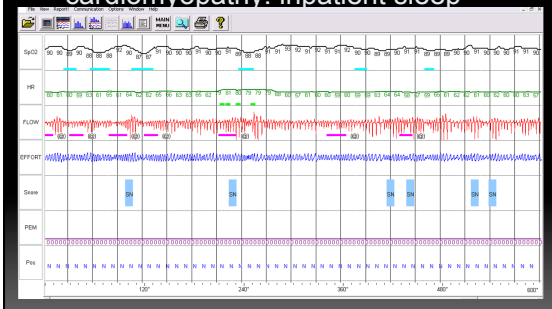
Roger et al Circulation 2011
Oldenburg et al Eur J Heart Fail 2007

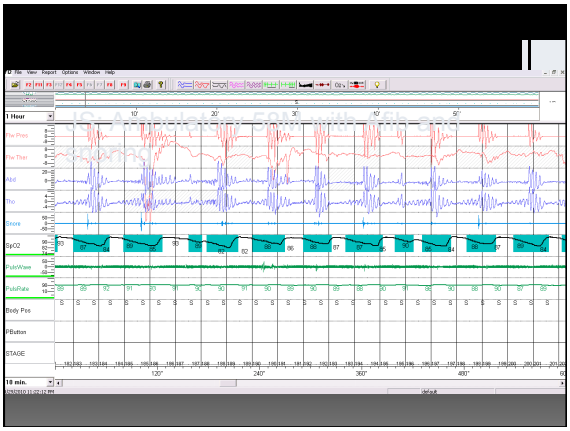
Sleep Disordered Breathing (SDB)



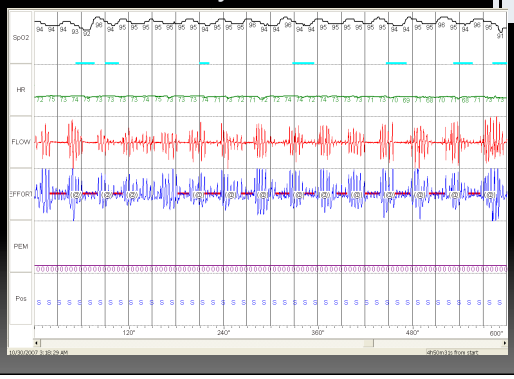


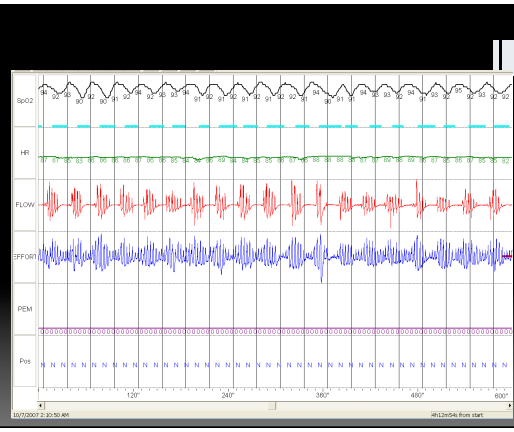
PR 56 y/o with dilated cardiomyopathy: inpatient sleep



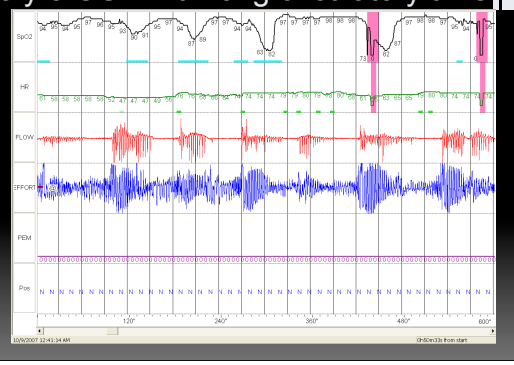


Patient AH, 79 y/f studied on O2

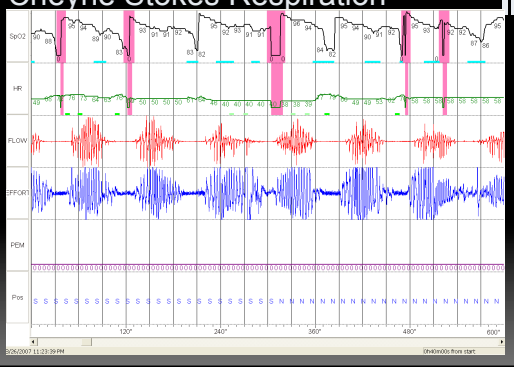


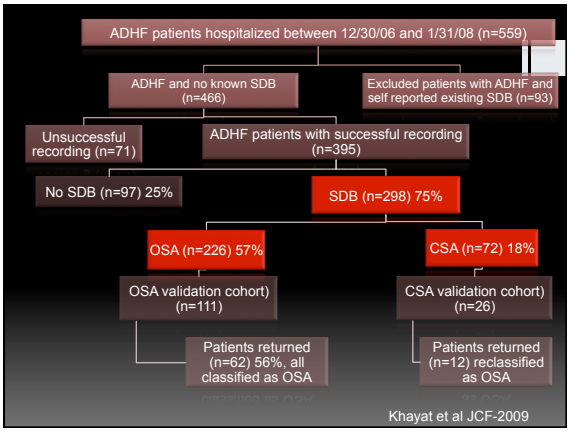


63 y/o OSA with long circulatory time



Cheyne Stokes Respiration





Characteristics of ADHF Patients by SDB Status

	OSA Mean (SE)	CSA Mean (SE)	Negative Mean (SE)	Negatives vs. OSA P value	Negative vs. CSA P value	CSA vs. OSA P value
Age	60 (0.9)	58 (1.8)	56 (1.6)	0.03	0.37	0.40
Male	69% (3%)	75% (5%)	38% (5%)	0.0001	0.0001	0.30
Ischemic	62% (3%)	64% (6%)	44% (5%)	0.003	0.01	0.82
Dilated	23% (3%)	14% (4%)	35% (5%)	0.02	0.001	0.11
Others	15% (2%)	22% (5%)	21% (4%)	0.22	0.80	0.16
LVEF	34 (1.2)	27 (1.7)	38 (1.8)	0.06	0.0001	0.0008
BMI	33 (0.6)	29 (0.9)	31 (0.8)	0.03	0.12	0.0001
LVEDD	57 (1.1)	63 (1.6)	54 (1.2)	0.14	0.0001	0.0037
BNP	746 (66)	1341 (161)	873 (130)	0.35	0.02	0.001
A-fib	39% (3%)	32% (6%)	28% (5%)	0.06	0.57	0.31

Khayat et al JCF-2009

Predictors of SDB in all patients with ADHF

Variable Names	Pearson Correlation Coefficients	Number of Patients	95% Confidence Limits
AHI with EF	-0.10	370	(-0.20, 0.00)
AHI with LVEDD	0.19	281	(0.07, 0.30)
AHI with BMI	0.17	393	(0.07, 0.26)
AHI with A-Fib	-0.02	394	(-0.12, 0.08)
AHI with Age	0.02	395	(-0.08, 0.12)
AHI with BNP	0.004	294	(-0.11, 0.12)

Predictors of AHI in all patients with ADHF and SDB

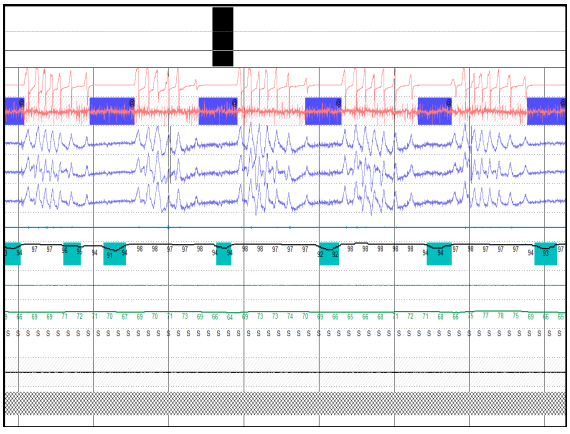
Variable Names	Pearson Correlation Coefficients	Number of Patients	95% Confidence Limits
AHI with EF	-0.01	279	(-0.13, 0.11)
AHI with LVEDD	0.15	212	(0.01, 0.28)
AHI with BMI	0.18	298	(0.07, 0.29)
AHI with Age	-0.06	298	(-0.17, 0.05)
AHI with BNP	-0.006	231	(-0.13, 0.12)

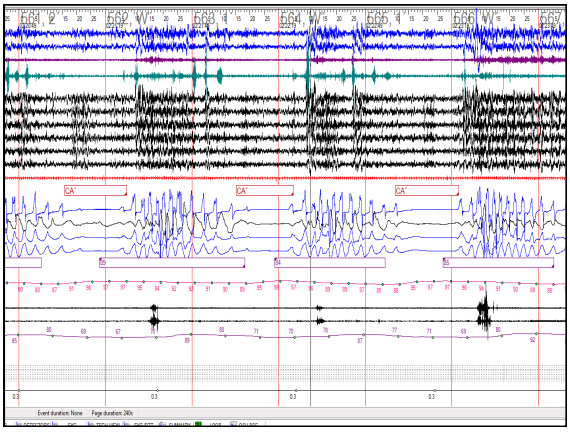
Predictors of severity of OSA

Variable Names	Pearson Correlation Coefficients	Number of Patients	95% Confidence Limits
AHI with EF	0.07	212	(-0.07, 0.20)
AHI with LVEDD	0.11	161	(-0.05, 0.26)
AHI with BMI	0.30	226	(0.17, 0.41)
AHI with A-Fib	-0.09	225	(-0.22, 0.04)
AHI with Age	-0.01	226	(-0.14, 0.12)
AHI with BNP	-0.07	174	(-0.22, 0.08)

Predictors of severity of CSA

Variable Names	Pearson Correlation Coefficients	Number of Patients	95% Confidence Limits
AHI with EF	-0.08	67	(-0.32, 0.16)
AHI with LVEDD	0.09	51	(-0.19, 0.36)
AHI with BMI	0.39	72	(-0.19, 0.27)
AHI with A-Fib	-0.05	72	(-0.28, 0.19)
AHI with Age	-0.16	72	(-0.38, 0.07)
AHI with BNP	-0.05	57	(-0.31, 0.21)





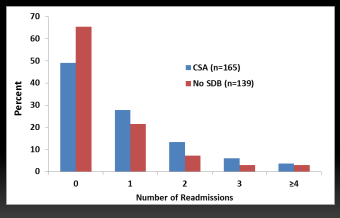
Persistence of SDB and validation of the Inpatient Testing [20]

Comparison of AHI between the in-hospital study and the polysomnography in the validated OSA and CSA patients

	PSG AHI	Inpatient AHI	Difference between PSG AHI and Inpatient AHI	95% CI for the Difference
	Mean (SE) (N)	Mean (SE) (N)		
OSA	41.7 (3.9) (62)	37.4 (2.5) (62)	4.3	-1.1, 9.6
CSA	36.4 (7.2) (12)	49.1(5.9) (12)	-12.7	-29.9, 4.5

Khayat et al JCF-2009

Comparison of Distribution of Cardiac readmissions in 6 months between CSA and no SDB Patients

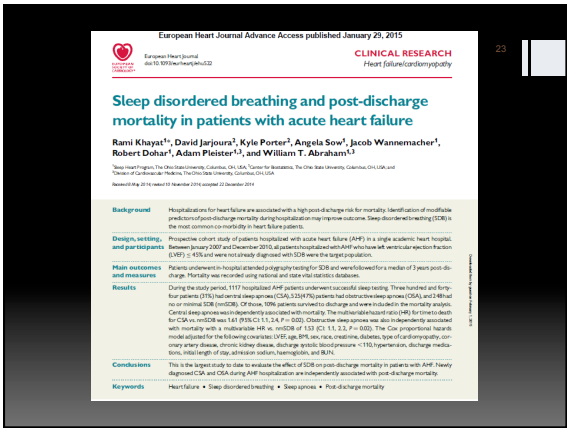


Note the higher percent of patients readmitted for each count in the CSA

Khayat et al JCF 2012

Negative binomial models for count of readmissions within 6 months- ADHF patients with HFrEF

Model	Rate Ratio (95% Confidence Interval) p-value		
	CSA vs Negative	CSA vs OSA	OSA vs Negative
Univariate	2.0 (1.6, 2.5) p < 0.0001	1.3 (1.0, 1.5) p = 0.02	1.6 (1.3, 2.0) p < 0.0001
Adjusted	2.0 (1.5, 2.6) p < 0.0001	1.2 (1.0, 1.5) p = 0.05	1.6 (1.3, 2.1) p < 0.0001



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CLINICAL RESEARCH
Heart failure/cardiomyopathy

Sleep disordered breathing and post-discharge mortality in patients with acute heart failure

Rami Khayat[1*], David Jarjoura[2], Kyle Porter[2], Angela Sow[2], Jacob Wannemacher[1], Robert Dohar[1], Adam Pleister[1,3], and William T. Abraham[1,3]

[1]Sleep Heart Program, The Ohio State University, Columbus, OH, USA; [2]Center for Biostatistics, The Ohio State University, Columbus, OH, USA; and [3]Division of Cardiovascular Medicine, The Ohio State University, Columbus, OH, USA

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Background Hospitalizations for heart failure are associated with a high post-discharge risk for mortality. Identification of modifiable predictors of post-discharge mortality during hospitalization may improve outcome. Sleep disordered breathing (SDB) is the most common co-morbidity in heart failure patients.

Design, setting, and participants Prospective cohort study of patients hospitalized with acute heart failure (AHF) in a single academic heart hospital. Between January 2007 and December 2010, all patients hospitalized with AHF who have left ventricular ejection fraction (LVEF) ≤ 45% and were not already diagnosed with SDB were the target population.

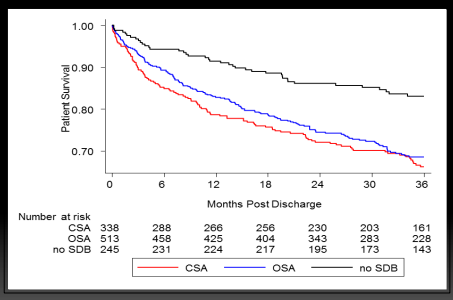
Main outcomes and measures Patients underwent in-hospital attended polygraphy testing for SDB and were followed for a median of 3 years post-discharge. Mortality was recorded using national and state vital statistics databases.

Results During the study period, 1117 hospitalized AHF patients underwent successful sleep testing. Three hundred and forty-four patients (31%) had central sleep apnoea (CSA), 525 (47%) patients had obstructive sleep apnoea (OSA), and 248 had no or minimal SDB (nnSDB). Of those, 10% patients survived to discharge and were included in the mortality analysis. Central sleep apnoea was independently associated with mortality. The multivariable hazard ratio (HR) for time to death for CSA vs. nnSDB was 1.41 (95% CI: 1.1, 2.4, $P = 0.02$). Obstructive sleep apnoea was also independently associated with mortality with a multivariable HR vs. nnSDB of 1.53 (CI: 1.1, 2.2, $P = 0.01$). The Cox proportional hazards model adjusted for the following covariates: LVEF, age, BMI, sex, race, creatinine, diabetes, type of cardiomyopathy, coronary artery disease, chronic kidney disease, discharge systolic blood pressure <110, hypertension, discharge medications, initial length of stay, admission sodium, haemoglobin, and BUN.

Conclusions This is the largest study to date to evaluate the effect of SDB on post-discharge mortality in patients with AHF. Newly diagnosed CSA and OSA during AHF hospitalization are independently associated with post-discharge mortality

Keywords Heart failure • Sleep disordered breathing • Sleep apnoea • Post-discharge mortality

SDB is Independently Associated with Post-discharge Mortality



Khayat et al EHJ 2015

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Treatment of SDB during ADHF and in the Post-Discharge Period

Pilot RCT Evaluating Treatment of OSA during ADHF; Khayat et al Chest 2009

Baseline Characteristics	Control group (n=23) Mean (SE)	Intervention group (n=23) Mean (SE)	95% CI for the difference
LVEF (%)	25.4 (1.8)	26.3 (1.8)	(-6.1, 4.3)
AHI (events per hour)	33 (3.0)	36 (2.0)	(-11, 5)
BNP	1154 (261)	1117 (259)	(-708, 780)
SBP (mmHg)	110 (4.0)	107 (4.0)	(-8, 14)
DBP (mmHg)	67 (2.0)	66 (2.0)	(-5, 8)
Heart Rate	88 (4.0)	81 (3.0)	(-3, 17)
Creatinine	1.3 (0.08)	1.4 (0.13)	(-0.4, 0.2)
LVEDD	62 (2.0)	64 (2.0)	(-8, 2)
LVEDV	227(18)	235 (20)	(-63, 47)
LVESV	169 (15)	171 (17)	(-48, 44)
Age	58 (3.0)	55 (3.0)	(-5, 11)
BMI (Kg/m^2)	32 (2.0)	35 (3.0)	(-10, 3)
% Male	83 (8.0)	65 (10)	(-9, 44)
% Ischemic cardiomyopathy	78 (9.0)	87 (7.0)	(-32, 14)
% of b-blokers	83 (8.0)	74 (9.0)	(-16, 34)
% of Number ACEI or AII-I	65 (10)	48(11)	(-12, 47)
% Diabetes	54 (11)	61 (10)	(-41, 20)

Effect of In Hospital APAP on Cardiac Function three days post-randomization

	Control	Treatment	Difference (APAP Effects) (p-value)
LVEF			
three days post randomization	25.8	30.4	4.6 (0.031)
change from base line (Final – Baseline)	-0.2	4.4	
LVESV			
three days post randomization	169	144	-24.8 (0.0007)
change from base line (Final – Baseline)	3.2	-22.1	
LVEDV			
three days post randomization	228	204	-23.9 (0.03)
change from base line (Final – Baseline)	2.1	-22	

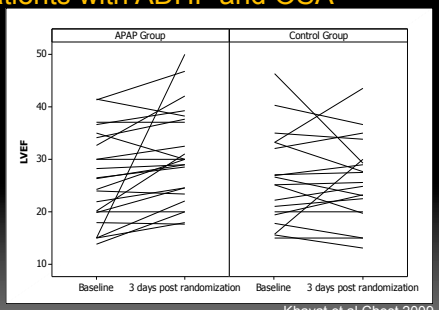
Khayat et al Chest 2009

Effect of PAP on hemodynamic and neurohumoral measures

Change from baseline	Control	Treatment	Difference (p-value)
Urinary Norepinephrine	-0.003	-0.011	-0.0008 (0.18)
BNP	17	-457	-474 (0.13)
BUN	-2.4	1.6	4.1 (0.18)
Creatinine	-0.03	0.21	-0.24 (0.19)
Systolic BP	-5.2	-6.5	-1.3 (0.78)
Diastolic BP	-1.2	-3	-1.9 (0.6)
Weight	-0.5	-2	-1.5 (0.048)

Khayat et al Chest 2009

Pilot RCT Evaluating the Effect of In-hospital PAP on Discharge LVEF in Patients with ADHF and OSA



Khayat et al Chest 2009