Snoring
and
Upper Airway Resistance

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Snoring

- Snoring is generated by the vibration of the nasopharynx during sleep
- Prevalence of habitual snoring is 24–50% in men and 14–30% in women
- Prevalence increases with:
  - age
  - obesity
  - alcohol ingestion
  - nasal obstruction
- Snoring results in social disability and relationship disharmony

Examination

Neck circumference
Waist circumference
(Hips)
BMI
Nasal obstruction
- DNS, polyps, rhinitis
Retrognathia
Throat - palate
- tonsils
- uvula
Sleep-Related Breathing Disorders
ICSD-3 Classification

1. Obstructive sleep apnoea (OSA) disorders
2. Central sleep apnoea (CSA) syndromes
3. Sleep-related hypoventilation disorders
4. Sleep-related hypoxaemia
5. Isolated symptoms and normal variants

Disorders may occur in combination, particularly OSA and CSA
Sleep-Related Breathing Disorders
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   - includes Upper Airway Resistance Syndrome
2. Central sleep apnoea (CSA) syndromes
3. Sleep-related hypoventilation disorders
4. Sleep-related hypoxaemia
5. Isolated symptoms and normal variants
   - Snoring
   - Catathrenia
Isolated snoring – ICSD-3  
(replaces simple/primary in ICSD-2)

• Audible noises are reported by an observer.

• The patient has no complaints of insomnia, excessive daytime sleepiness or sleep disruption attributable to snoring.

• PSG: Snoring noted without apnoeas, hypopnoeas or RERAs sufficient to diagnose OSA (RDI ≥ 15).

• Snoring is a cardinal symptom/sign of OSA.

• Not all snorers have OSA.
Isolated Snoring

- Cannot be diagnosed in individuals’ exhibiting symptoms, such as daytime sleepiness, fatigue or other similar symptoms or report of respiratory pauses, without objective measurement of breathing during sleep.

- In patients with comorbid cardio-vascular disease who are at increased risk for OSA, even in the absence of daytime complaints, PSG or OCST is required to effectively rule out OSA.
‘Habitual’ snoring

- Observation of ‘consistent’ snoring when asleep

- The subjective severity of snoring reported by the bed partner does not correspond with either objectively assessed snoring or the subjective assessment of the sleep technician monitoring the patient

Hoffstein V. Sleep 1996;19;3:789-710
Snoring Physiology

- High frequency opening and closing (fluttering) of upper airways under conditions of flow limitation.
- Involves tongue base, soft palate and mucosal secretions.
- Frequency up to 2000Hz (peak <500Hz).
- Increased total pulmonary resistance leads to increased respiratory effort.
- Loudest in SWS and softest in REM.
- Snoring is not part of AASM scoring criteria for respiratory events.

Perez-Padilla JR. Am Rev Resp Dis. 1993;147(3):635-44
Skatrud JB et al. J.Appl. Physiol 1985;59 (2) 328-335
Hoffstein V. 1996 1996;109;201-222

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Inspiratory flow limitation

Normal

Snoring

OSA

UARS

Pcrit < Pus

Pcrit < Pus

Pcrit > Pus

Pcrit > Pus

Pcrit < Pus

Pcrit < Pus

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Inspiratory flow limitation

Normal

Snoring

OSA

UARS

$P_{crit} < P_{us}$

$P_{crit} - 12$

$P_{crit} - 5$

0

$P_{crit} > P_{us}$

$P_{crit} + 5$

$P_{crit} - 10$

$P_{crit} - 9$

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Measurement of Snoring

- Sensors are microphones or PE transducers applied to neck near trachea or on face or chest (microphones).

- Snoring is not part of scoring criteria for respiratory events in AASM scoring manual.
Snoring has been implicated in the aetiology of:

- hypertension
- ischaemic heart disease
- cerebrovascular accidents

Snoring has been associated with:

- increased morbidity and mortality from road traffic and work-related accidents


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Association of habitual snoring with CVS disease

- PSG not performed in many studies.

- Heavy snoring (> 50% of night) associated with carotid atherosclerosis independent of other risk factors (nocturnal hypoxaemia or OSA severity).

- Correlation of time snoring and carotid stenosis in 110 overweight volunteers (27% smokers, 27% hypertensive, 69% hyperlipidaemia)
  
  Lee SA et al. Sleep 2008;31:1207:1213

- No correlation of time snoring with all cause CVS mortality in 17yr follow up of community n=380 normals

  Marshall NS et al. Sleep 2013;35 (9):1235-1240
Snoring
Indications for sleep studies

• Symptomatic
• Moderate or high likelihood of OSA
• Surgical intervention under consideration
• Prior to oral appliance therapy

OSA may change treatment approach – ie. PAP rather than surgery or OA for moderate or severe OSA

• After surgery or OA therapy

Kushida CA et al. Sleep 2005;28:499-521
Littner M. et al. Sleep 2001;24:603-619

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Snoring
Indications for sleep studies

- Polysomnography is indicated for **habitual** snorers with
- witnessed apnoeas
- hypersomnolence
- fatigue
- insomnia
- somatic syndromes (typically described among UARS patients)
- comorbidities including metabolic syndrome, cardiac dysrhythmia, or atrial fibrillation.

- Polysomnography may lead to treatment as OSA when the ICSD3 diagnostic criteria for OSA are met.
Healthy Habitual Snorers

• Monitor over time for signs and symptoms that would support obtaining a sleep study.

• Cost-benefit analysis:
  • Treatment not indicated, even if an individual fulfills ICSD3 criteria for OSA
    – Screened non-obese controls over 65yrs have mean RDI 22
    – 11% of healthy controls have RDI >15

Pavlova M et al. Sleep 2008;31 (2):241-248
Isolated Snoring Treatments

- Any treatment that will lower the pharyngeal Pcrit, reducing the occurrence of IFL, will also have a beneficial effect on audible snoring.

- A lifestyle modification such as weight reduction (by diet or bariatric surgery).

- Any effective treatment for OSA will be effective.

- Few asymptomatic snorers choose CPAP due to burden of use and maintenance.
Isolated Snoring
Treatments

As for mild OSA:

- Weight loss
- Side sleeping position
- Treatment of nasal congestion
- Avoidance of alcohol and sedatives
- Avoidance of sleep deprivation
- Oral appliance therapy
- Upper airway surgery
  - failed medical treatment
  - variable response


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Over the Counter Treatments (OTC) (AASM 2003)

- Limited or absent benefits of products such as nasal dilators, lubricants, oral dietary supplements, magnetic pillows and mattresses.

- Studies limited by:
  - small numbers of participants
  - inadequate design
  - lack of statistical analysis, and
  - sparse use of objective measurements
  - Lack of evaluation of product safety

Meoli AL e tal. Sleep 2003; 26 (5):619-624
Nasal Decongestants

• Avoid short acting decongestants
  - Rhinitis medicamentosa

• No benefit in snoring noise in non-apnoeic snorers (although AHI improved in apnoeic snorers, correlating with reduced nasal resistance)

Oral Appliance Treatment

- Device inserted into the mouth for treatment of snoring or OSA
  - Tongue retaining (stabilizing) device (TRD/TSD)
  - Mandibular repositioning appliance (MRA)

- OAs are appropriate for use in patients with primary snoring who do not respond to, or are not appropriate candidates for, treatment with behavioural measures such as weight loss or sleep position change.

- On average, snoring is halved in frequency and loudness.

Oral Appliance Treatment

- Snoring and mild-moderate OSA
- Patient preference
- Failed CPAP
- Thinner
- Positional
  - supine
Mandibular Repositioning Appliance Assessment

Requirements:
• 6-10 teeth in each arch (or implants)
• Able to open jaw and protrude mandible

Contra-indications:
• Moderate or severe TMJ disease
• ? Bruxism
Isolated Snoring

Surgery for nasal obstruction

• Improvement in nasal resistance

• No improvement in:
  – objectively assessed snoring intensity
  – snoring time
  – AHI

Isolated Snoring

Upper airway surgery

Indicated for failed medical treatment, but variable response

- UPPP - pain, nasal reflux, bleeding, voice change, globus

- LAUP - not recommended for OSA

- Radiofrequency palatoplasty - less painful

- Palatal Implants (Pillar) – improved snoring but not AHI

(Bariatric surgery)

(Bariatric surgery improves snoring due to $\downarrow$ Pcrit)

Caples SM et al. Sleep 2010;33:1396-1407
Aurora RN et al. Sleep 2010;33:1408-1413

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Isolated Snoring
Upper airway surgery

- Short-lived subjective and objective improvement
- Objective improvement correlated poorly with individual patient subjective assessment

6 year UPPP follow up study:
- Rebound snoring in absence of weight gain
- Patient dissatisfaction with ongoing side effects in 38% (swallowing dysfunction, voice change, pain)

Jones TM et al. ERJ 2005;25 (6) 1044-1049
Isolated Snoring
Summary

• Isolated snoring is a diagnosis of exclusion reserved for habitual snorers who are otherwise asymptomatic without metabolic syndrome and cardiovascular disease and who do not meet polysomnographic or OCST criteria for OSA.

• Potential for adverse cardiovascular outcomes remains uncertain.

• Treatment is currently limited to improving sleep quality of the bed partner.

• Treatments include lifestyle modifications, oral appliances, and surgery.

• Most treatment options lead to short-term success but fail in the long-term

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Upper Airway Resistance Syndrome (UARS)

- Subjective and objective daytime sleepiness (MSLT)
- Snoring in 67% (71% of men and 11% of women)
- AHI < 5 (nasal thermistors)
- RERA >10 (oesophageal pressure monitor)
- RERA not associated with desaturation or change in thermistor airflow
- Mean arousal index 33/hr (16-52)
- Mean max. negative oesophageal pressure -37cmH$_2$O
- Sleepiness improved on CPAP

RERAs
AASM 2012 definition

• A sequence of breaths lasting at least 10 seconds characterized by:
  • increasing respiratory effort or
  • flattening of the inspiratory portion of the nasal pressure (diagnostic study) or PAP flow waveform

- which leads to an arousal from sleep and does not meet the criteria for an apnoea or a hypopnoea.

• Arousals coincide with autonomic, parasympathetic and cardiovascular activations during the night.\textsuperscript{125}

• 20% decrease in insulin sensitivity and significant reduction in glucose effectiveness in healthy volunteers.\textsuperscript{3}

3. Stamatikis, 201
5. Morgan, 1998
Arousals during Sleep

– General tiredness, fatigue and daytime sleepiness¹
– Significant daytime impairment, daily functioning, difficulty concentrating and completing tasks. Impaired memory consolidation²,⁵
– Depressed mood, poor sleep quality and insomnia²,³
– Poor psychomotor performance, reaction time, vigilance and attention⁴

1. Guilleminault, 2001
2. Stooohs, 2008
3. So, 2015
4. Stooohs, 2009
5. Malhotra 2015
Nasal cannula signal shows two flow limitation events with < 50% reduction in amplitude and flattening of the inspiratory flow contour. Oesophageal pressure signal shows RERAs with a crescendo increase in pressure swings terminated by an abrupt decrease in pressure swings simultaneous with arousal.
ICSD-3 has included RERA in alternative definition of hypopnoea:

- Recommended: 30% reduction in airflow with 3% desaturation and/or arousal (RERA)
- Acceptable: 30% reduction in airflow with 4% desaturation

Using recommended hypopnoea definition classifies more previous UARS as OSA by including RERAs

UARS
Definition of hypopnoea

• Patient with 30% reduction for 15 seconds with 2% desaturation and arousal.

  – ICSD-2: RERA not Hypopnoea = UARS
  – ICSD-3: Hypopnoea (recommended criteria) = OSA
Measurement of apnoeas and inspiratory flow limitation

- Apnoea = 10 second cessation of breathing

- Hypopnoea = 10 second reduction in breathing amplitude by 30% with 3% desaturation and/or RERA (or 4% desaturation).

- Inspiratory Flow Limitation
  - Audible: snoring
  - Silent: Isolated Snoring or Habitual Snoring

- RERA – Arousal following 10 seconds IFL

Measurement of apnoeas and inspiratory flow limitation

Naso-oral thermistor detects absence of airflow but the signal does not vary proportionately to airflow and overestimates flow as airflow decreases.

Nasal pressure is more accurate for flow but, in mouth breathers, may show absence of airflow, while the nasal-oral thermistor shows continued flow.

Oesophageal manometry might show change without nasal pressure thermistor change.

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Diagnostic criteria of UARS
AASM (2005)

Major criteria
• Excessive daytime sleepiness
• AHI < 5
• RERA > 20

Minor criteria
• Snoring
• Increase in the intensity of snoring before EEG arousal
• Clinical response to CPAP therapy

Prevalence

• The exact prevalence of UARS is not known.

• Prevalence has been reported as 6-32% of patients with suspected OSA.

• Female patients represent close to 50% of patients.

UARS versus OSA

• Younger
• Leaner
• More often female (50%)
• Mean age 40 years
• Normal or overweight; less often obese
  (average BMI 23-30 kg/m²)

Stoohs RA et al. Sleep Med 2008:9 (2) 121-128
UARS Presentation

• Non-restorative sleep
• Fatigue
• Insomnia (1/3 Sleep Initiation; 2/3 Sleep Maintenance)
• Sleepiness
• Snoring may or may not occur
  – Inaudible IFL in 10%
• Witnessed apnoeas may or may not occur
  – 1/3 have apnoeas but AHI <5

Stoohs RA et al. Sleep Med 2008:9 (2) 121-128
Gold AR et al. Chest 2003; 123 (1) 87-95

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UARS Presentation

- Bruxism
- Sleep-walking
- Catathrenia
- Hypertension
- Hypotension (20%)
- Anxiety and Depression

So SJ. et al. Psychiatric Investig. 2015; 12(2) 183-189
Guilleminault C et al. Pediatrics 2003; 11 (1) e17-25
Guilleminault C et al. Sleep 2008; 31: 132-139
Guilleminault C et al. Chest 1996:109 (4);901-908
Guilleminault C et al. Am J Crit Care Med 2001;164 (7) 1242-1247
UARS Presentation

• Functional Somatic Symptoms
  – Sleep Initiation Insomnia
  – Headaches
  – IBS
  – Alpha-delta sleep

• Nasal CPAP improves symptoms by relieving IFL

Gold AR et al. Chest 2003; 123 (1); 87-95
Gold AR et al. Sleep 2004; 27 (3); 459-456
Amim MM et al. Sleep Breath 2001; 15 (3); 579-587
RERA and Hypertension

Pepin JL et al. Respiration 2012;83:559-66.
Parasympathetic activation

- Patients with UARS have much higher parasympathetic activation during sleep than OSA patients.

- This enables them to arouse quickly in response to small increases in respiratory effort.

- UARS patients have an intact local neurological system which responds efficiently to upper airway changes, while OSA patients have neurological impairment which permits apneas to occur.

UARS
PSG findings

• AHI < 5 (consistently 2/hr)
• IFL in sleep with flows > 50% of wake levels
  - terminated by RERA or change in EEG with return to non-flow limited state.
• RERA 5-20/hr
• Alpha-delta sleep
• Sleep state instability
• CAP associated with IFL

Stoohs RA et al. Sleep Med 2008:9 (2) 121-128
Development of OSA

• 30 UARS patients were followed over an average of 6.6 years.

• During this time 9 (30%) developed OSAS, 19 still had UARS and 2 had normalized breathing.

• The progression from UARS to OSA was primarily associated with increases in BMI.

• A similar follow up of a group of 94 patients after an average of 4.5 years found that only 5 (5%) had developed OSA during this time.

UARS Treatment

- As for snoring and mild OSA
  - Weight loss
  - Side sleeping position
  - Treatment of nasal congestion
  - Avoidance of alcohol and sedatives

- CPAP titrated to relieve IFL

- Oral Appliance Therapy

Stoohs RA et al. Sleep Med 2008:9 (2) 121-128

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UARS
Treatment outcomes

CPAP:
• Normalizes breathing
• significantly reduces nocturnal arousals
• eliminates daytime sleepiness in UARS
• Controls BP
• Average CPAP pressure needed to overcome flow limitation and eliminate RERAs was 7.1 ± 1cm H$_2$O

Oral Appliance Treatment:
• significantly reduce daytime sleepiness, arousal index and minimum oxygen saturation