From Dusk till Dawn
Sleepless in Scotland

Image 1: https://www.beckerentandallergy.com; Image 2: Photograph: Channel 5

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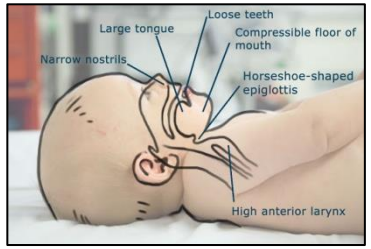
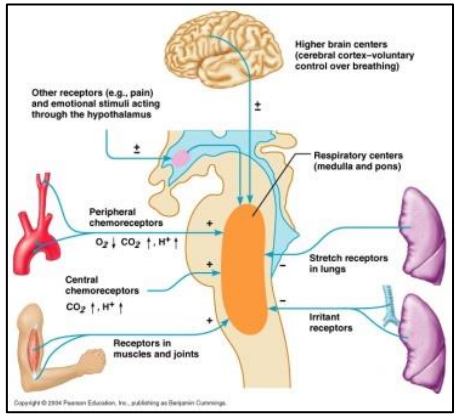
Normal sleep breathing

- Normal sleep breathing in children depends on a number of factors
  - Age of the child

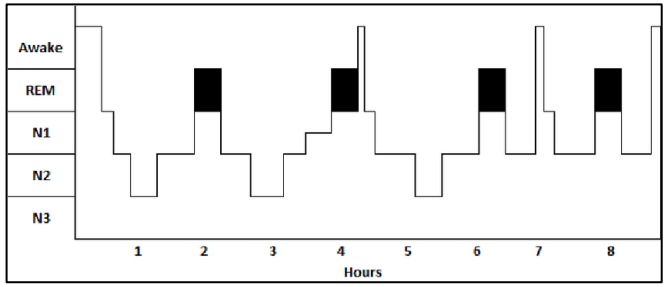
  - Integrity of the upper airway

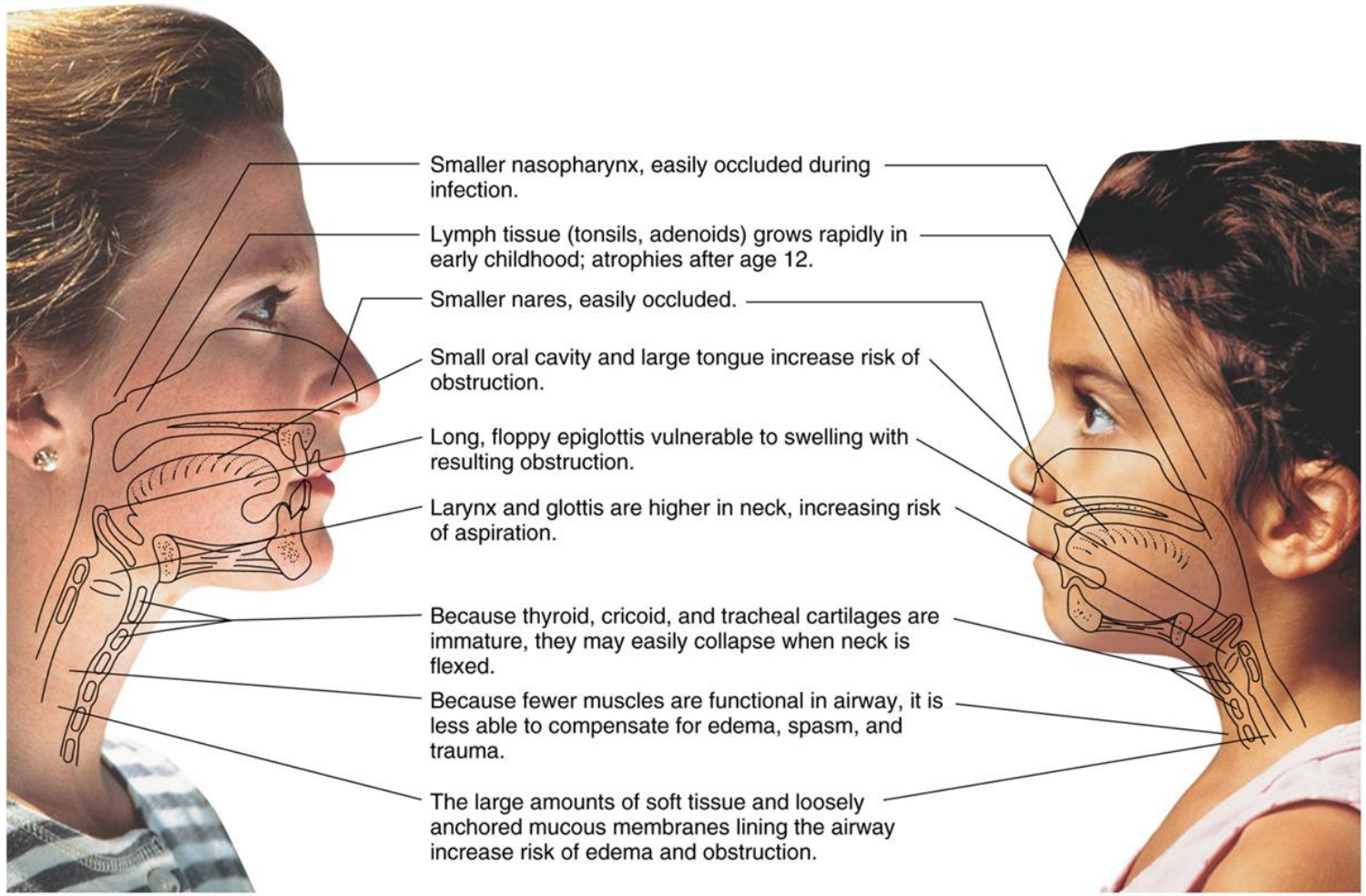


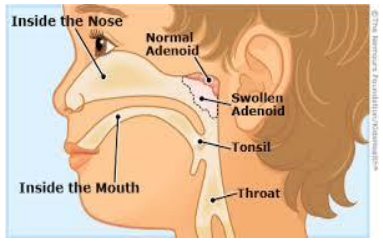
  - Factors influencing respiratory control

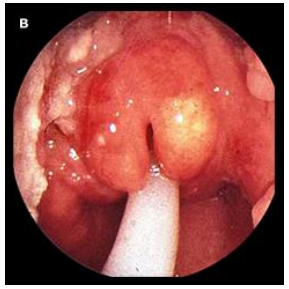


  - Sleep stage




Smaller nasopharynx, easily occluded during infection.
Lymph tissue (tonsils, adenoids) grows rapidly in early childhood; atrophies after age 12.
Smaller nares, easily occluded.
Small oral cavity and large tongue increase risk of obstruction.
Long, floppy epiglottis vulnerable to swelling with resulting obstruction.
Larynx and glottis are higher in neck, increasing risk of aspiration.
Because thyroid, cricoid, and tracheal cartilages are immature, they may easily collapse when neck is flexed.
Because fewer muscles are functional in airway, it is less able to compensate for edema, spasm, and trauma.
The large amounts of soft tissue and loosely anchored mucous membranes lining the airway increase risk of edema and obstruction.


Inside the Nose
Normal Adenoid
Swollen Adenoid
Tonsil
Inside the Mouth
Throat


B

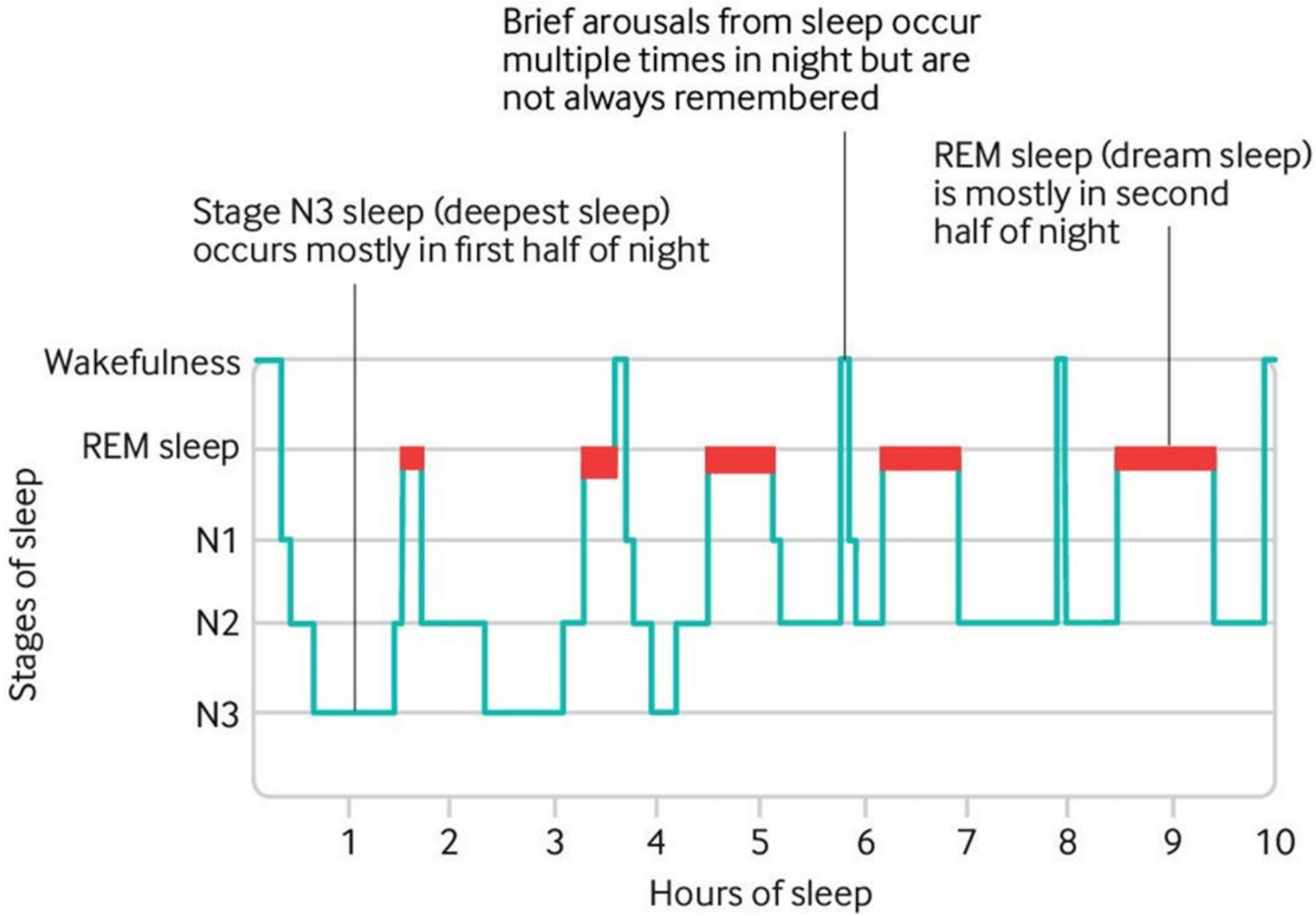
Why is breathing vulnerable during sleep?

REM sleep

Decreased drive to breathe

Tone decreases significantly and upper airways resistance doubles

variable tidal volumes and respiratory rate



REM sleep: rapid eye movement sleep

Childhood sleep-disordered breathing

- Obstructive sleep apnoea syndrome

- *Central sleep disordered breathing (Central apnoea)*

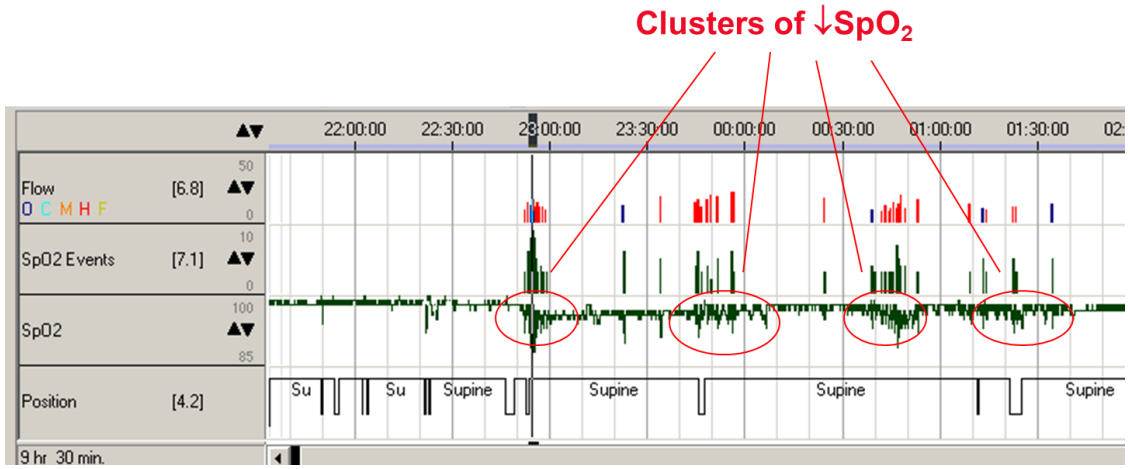
- *Disorders of breathing control*

Obstructive Sleep Apnoea in Children

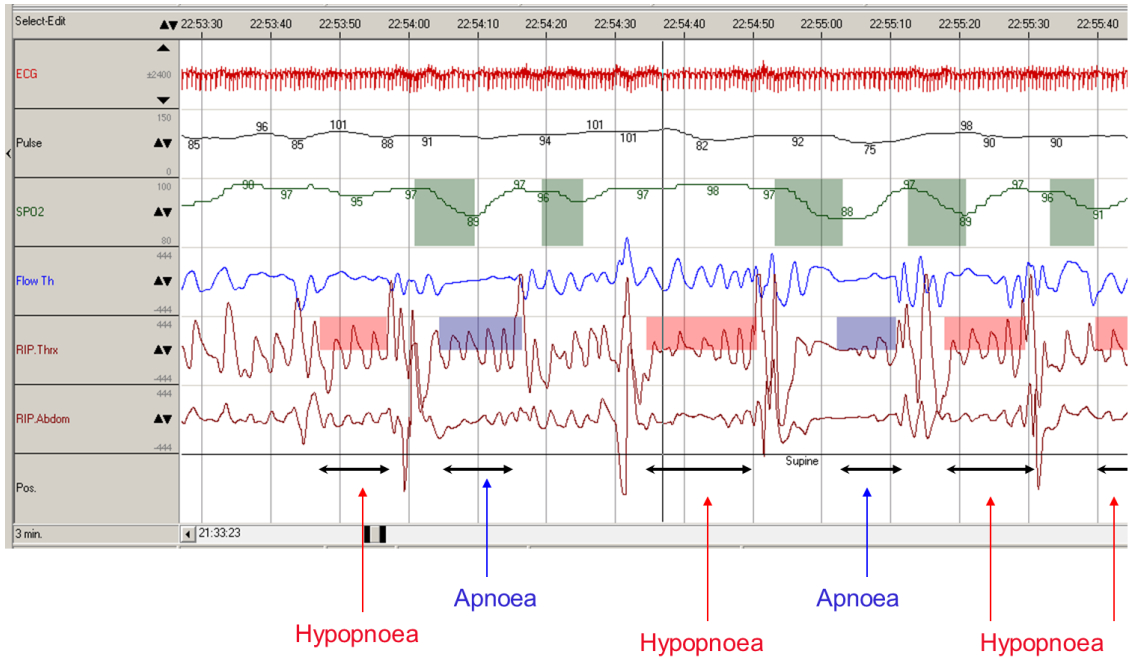
"The stupid-lazy child who frequently suffers from headaches at school, breathes through his mouth instead of his nose, snores and is restless at night, and wakes up with a dry mouth in the morning, is well worthy of the solicitous attention of the school medical officer." – W.Hill, 1889

Case 1 – 4 year old Adam

- Snoring
- Restless sleep
- Witnessed pauses overcome by "gasps"
- Referred by local ENT team

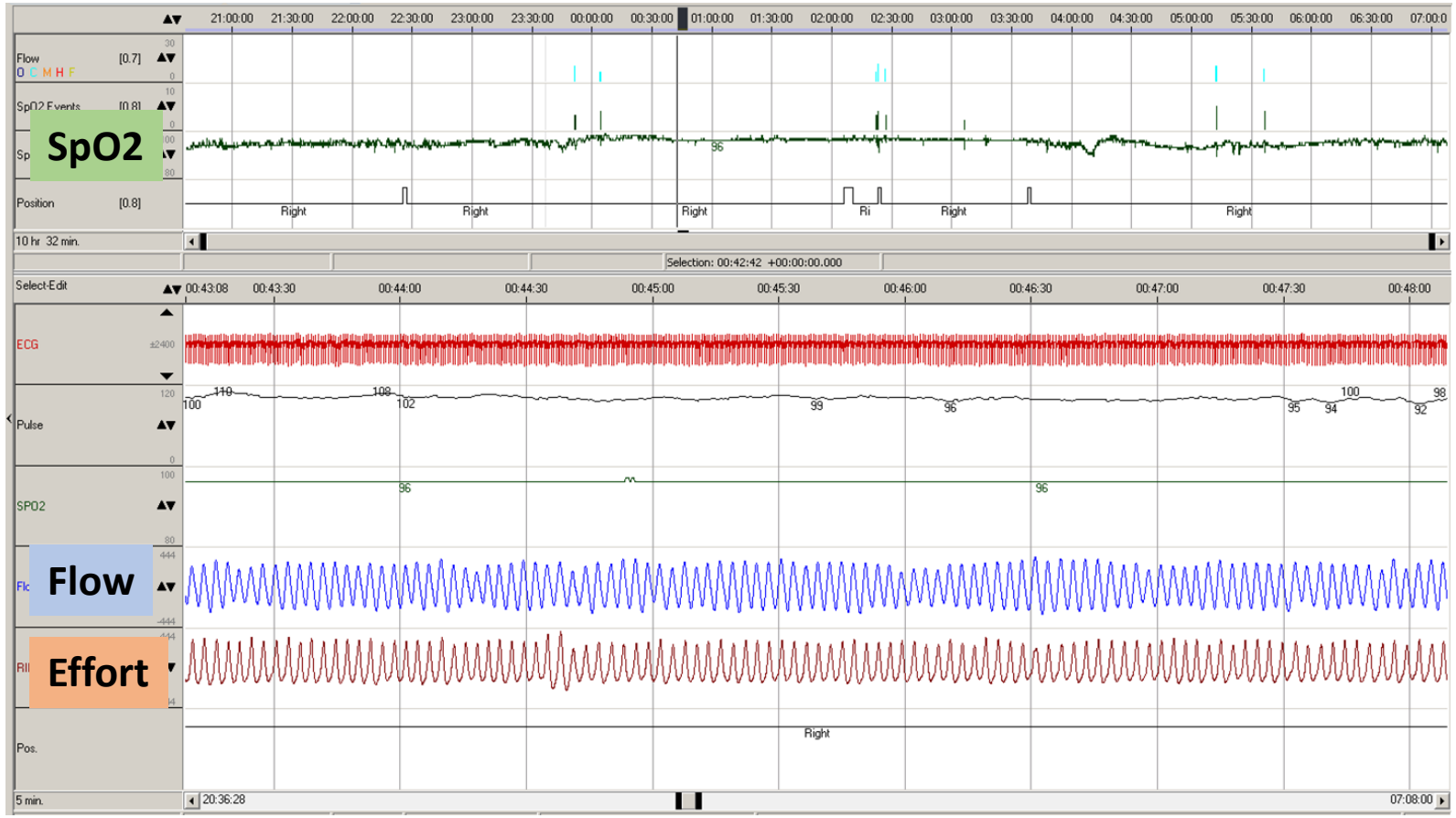


- Cardiorespiratory Polygraphy:
  - Sleep stage related desaturations
  - AHI (apnoea/hypopnea index) – 7/hr
  - Nadir of SpO2 = 87%



Case 1 – 4 year old Adam

Post Adenotonsillectomy



Stable gas exchange (oxygenation)

Better sleep and improved daytime behaviour & functioning

Overview

- Pathophysiology
- Definition of Obstructive Sleep Apnoea (OSA)
- Why Children are at risk
- Epidemiology
- Causes / Predisposing Factors
- Presenting symptoms
- Consequences of OSA in children
- Investigations
- Management

Pathophysiology

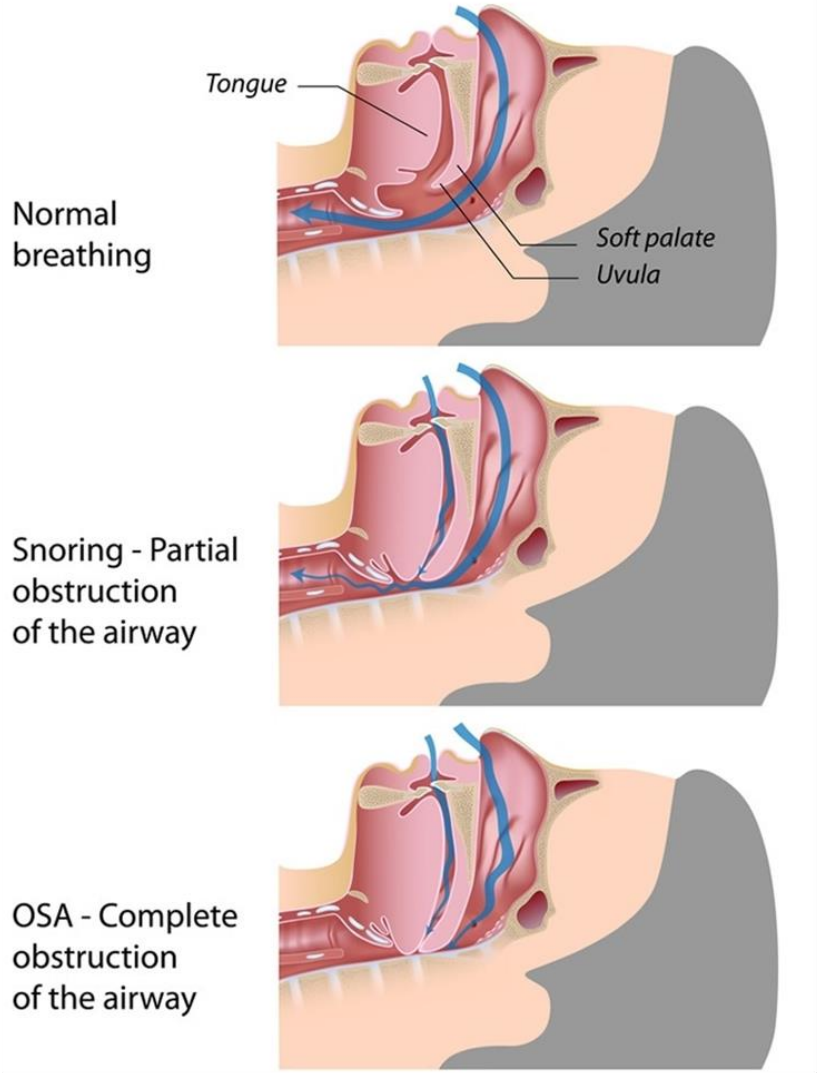
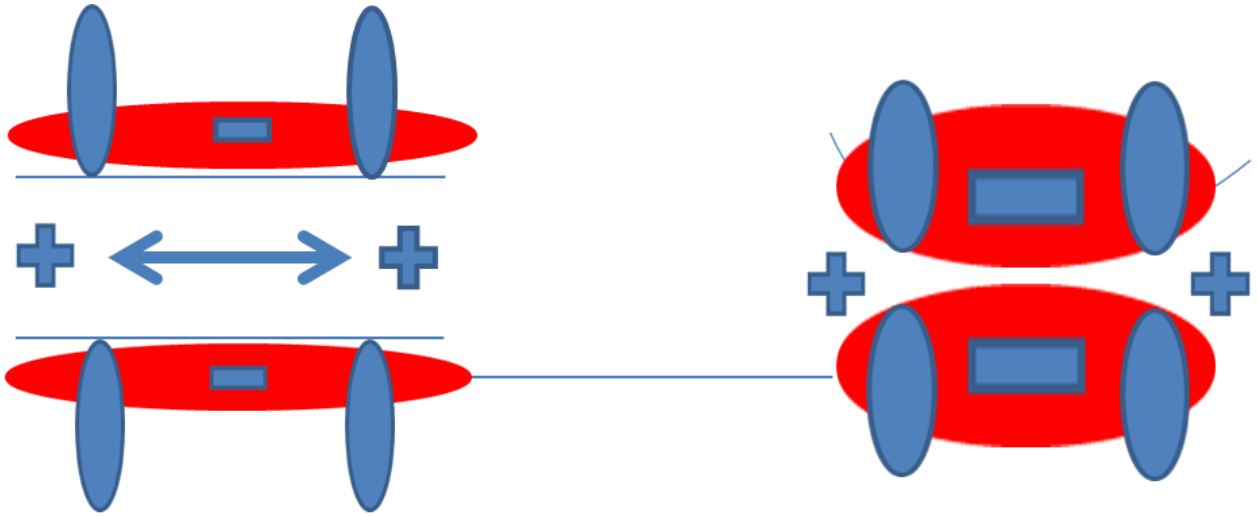


Image Credit: Alila Medical Media / Shutterstock

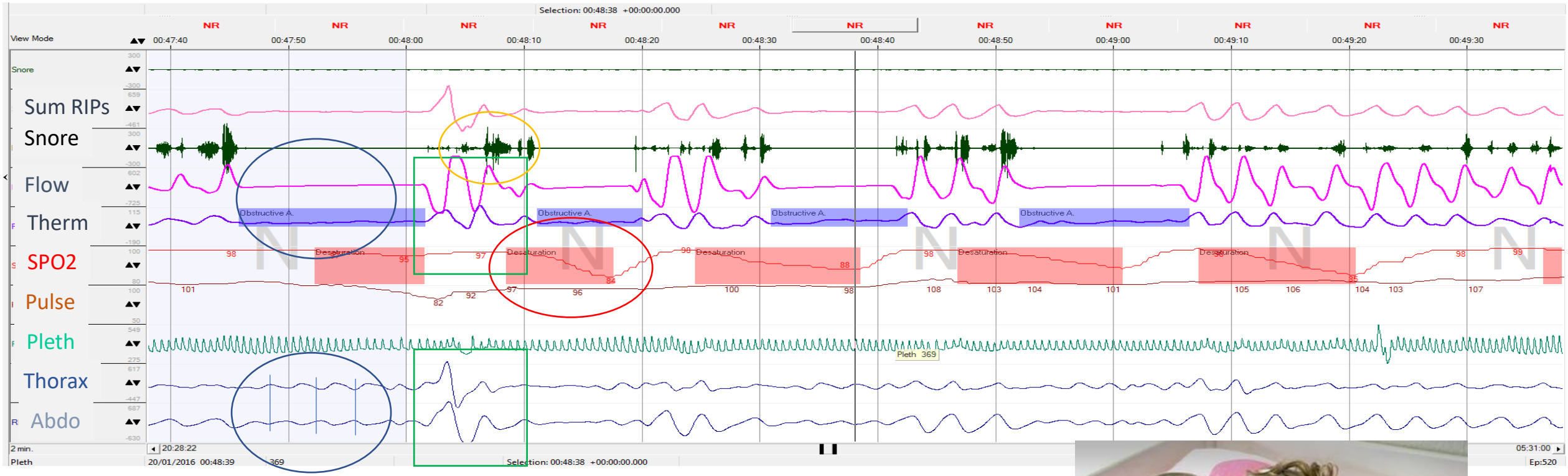


- Balance between the obstructive pressure of the soft tissue against the dilating intraluminal pressure of the upper airways = critical closing pressure

Definition

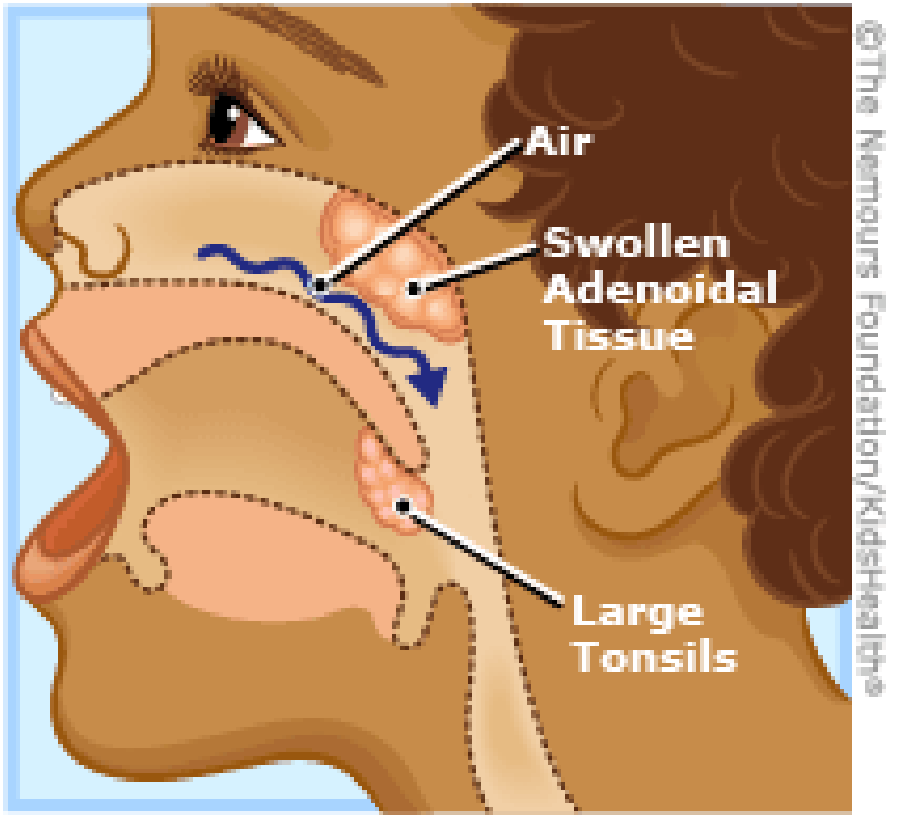
- **Obstructive sleep apnea** (OSA) is characterized by episodes of complete collapse of the airway (and absent airflow; **apnoea**) or partial collapse (and markedly reduced airflow; **hypopnoea**) with an associated **decrease in oxygen saturation** or **arousal** from sleep.
- This disturbance results in fragmented, nonrestorative sleep

Obstructive sleep apnoea syndrome



Absent airflow with ongoing or increased effort

Why are children in particular at risk?



Common Causes of Sleep Apnea
Large tonsils and adenoids make airflow more difficult.

Epidemiology

- A spectrum ranging from **primary snoring** to **obstructive sleep apnoea (OSA)**

- **Habitual snoring** – 1 in 5-10 children, **OSA** – 1 in 20 children

- **2 Peaks**:
  - Pre-school: max ratio of adenoids and tonsils to airway

  - In adolescence: often associated with obesity

Obesity

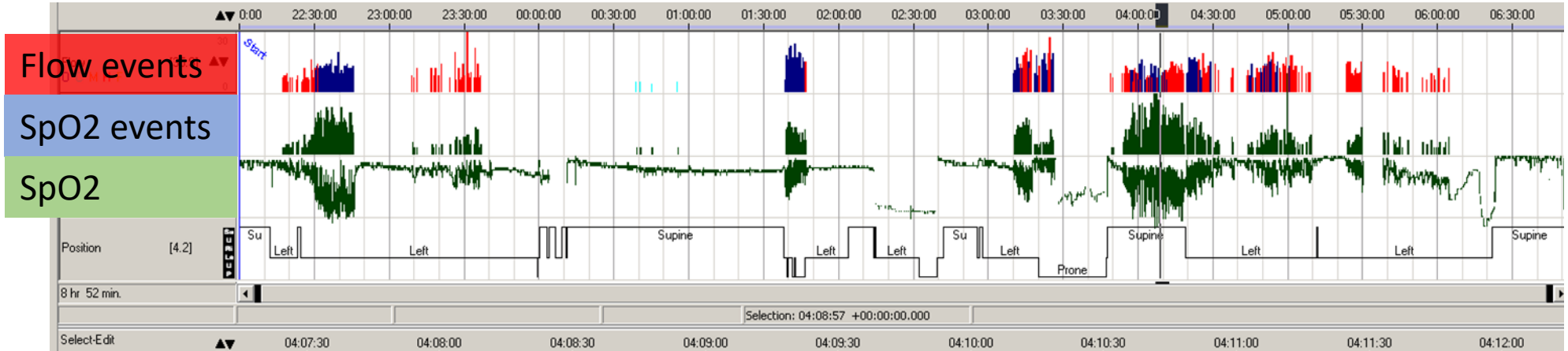
- Childhood obesity tripled since early 1980's
- 16% paediatric population
- Risk of OSA = 16-36%
- Extrinsic pressure on airway causing increased tendency to close airway
- 75% residual OSA post Adenotonsillectomy

Predisposing Conditions

- Syndromes associated with **maxillary or mandibular hypoplasia**
  - Down Syndrome
  - Pierre Robin Sequence
- Conditions predisposing to **airway obstruction**
  - Beckwith Wiedeman syndrome
  - Airway secretions in Cerebral Palsy

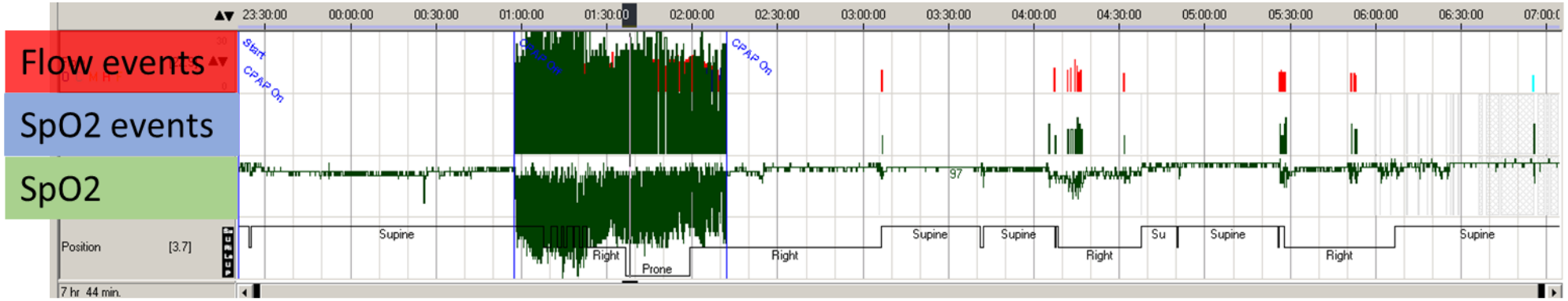
Case 2 – 12 year old Anna

- Weight 148kg (>23 stones)
- Snores at night
- ECG normal
- No evidence of hypertension or glycaemic dysregulation
- Referred from another centre for:
  - **Sleep study – multiple desaturations related to obstruction, Nadir 61%**



Case 2 – 12 year old Anna

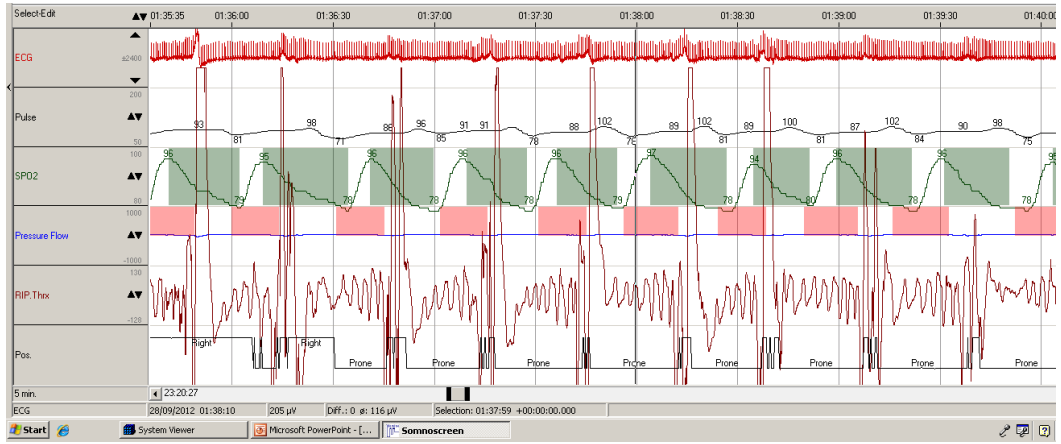
- Treatment: Secondary Prevention – prevention of OSA effects and complications
- Adenotonsillectomy versus CPAP



CPAP

Room Air

CPAP



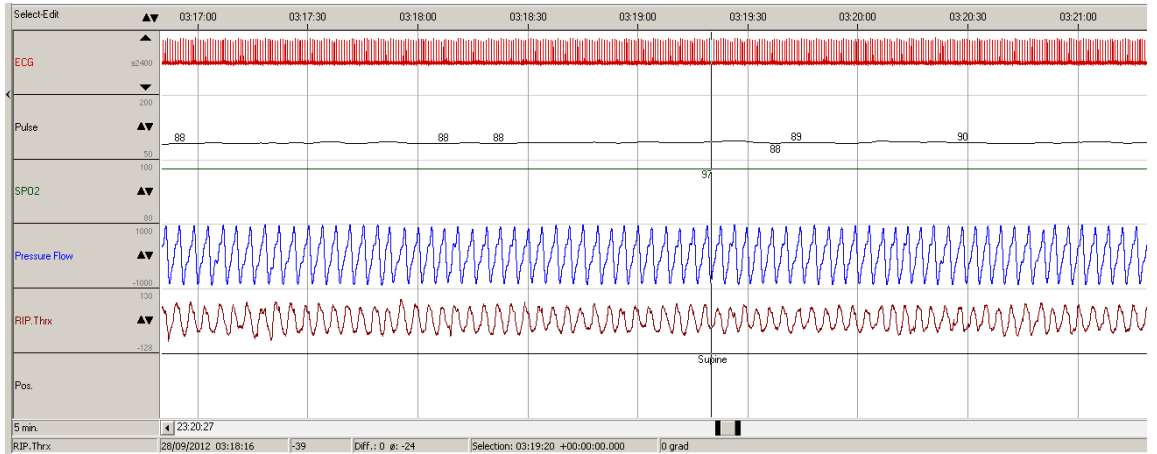
Off CPAP

- Obstructive events
- Desaturations

VERSUS

On CPAP

- Stable respiration



Presenting Symptoms / History

Table. Symptoms of sleep dis

Infants (3-12 months)	Toddlers (1-3 yr)
Snoring	Snoring
Witnessed apnoeas	Witnessed apnoeas
Frequent arousals	Frequent arousals
Mouth breathing/dry mouth	Mouth breathing/dry mouth
Nocturnal sweating	Nocturnal sweating
Failure to thrive	Failure to thrive
Nasal congestion	Nasal congestion
Hyper extended neck	Hyper extended neck
Recurrent otitis media/Upper	Recurrent otitis media/Upper
Respiratory Infection (URI)	Respiratory Infection (URI)
Noisy breathing	Noisy breathing
Confusional arousal	Confusional arousal
Sleepwalking	Sleepwalking
Daytime sleepiness/ persistent naps	Daytime sleepiness
Restless sleep	Restless sleep
Enuresis	Enuresis
Hyperactivity, inattention	Hyperactivity, inattention

'Does your child breathe through their mouth?'

'Is your child thirsty in the mornings?'

'Does your child's breathing go quiet and then he/she gasps?'

('Does your child stop breathing?' is a poor discriminator of OSA as respiratory effort is preserved during an apnoea.)

Other clinical assessment

Physical examination

- Dysmorphic features
- Disorders affecting muscle tone
- Chest wall deformity
- ENT examination
- Weight centile / BMI

Past medical history

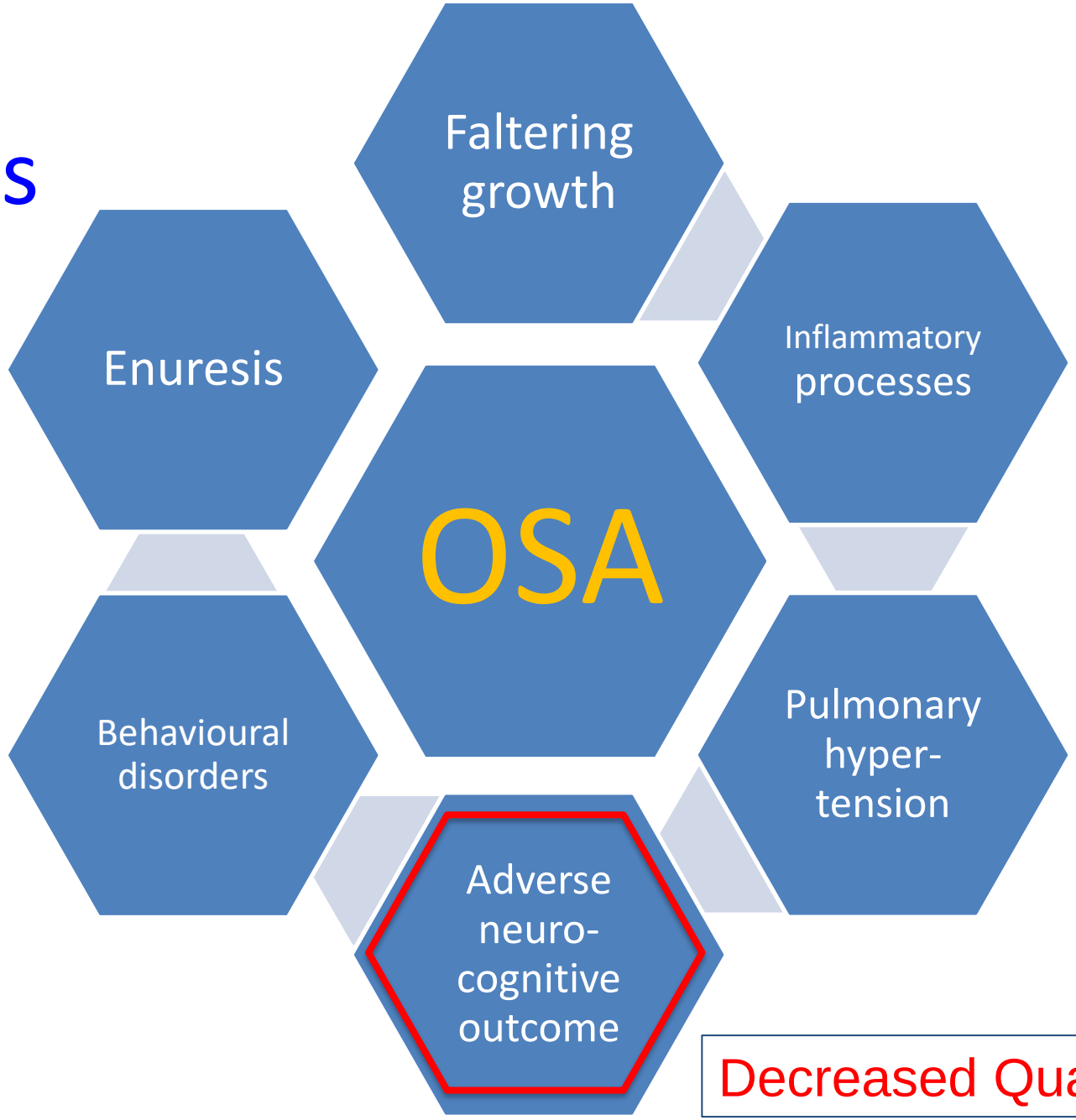
- History of prematurity

Family history

- Parental history of OSAS or adenotonsillectomy in childhood
- sibling history of OSAS or adenotonsillar hypertrophy

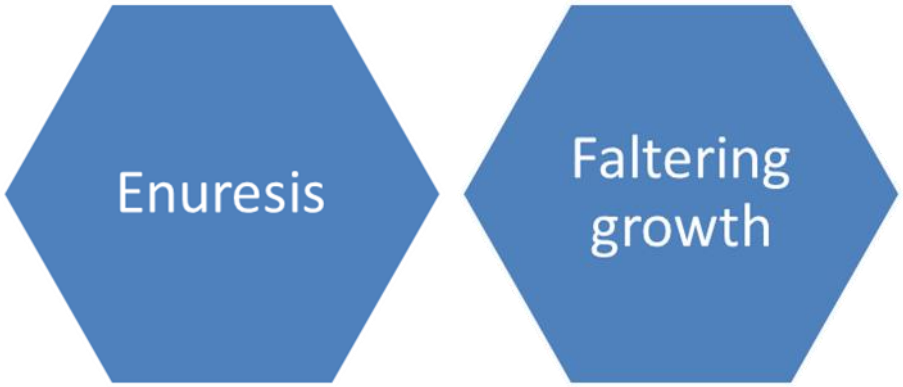
(Why) Does it matter or Should we worry?

Secondary Effects



Decreased Quality of Life

Secondary Effects of OSA



- Enuresis
  - Three class IV studies support an association between frequency of nocturnal enuresis and SDB severity

    Alexopoulos *et al.* Pediatr Res 2014

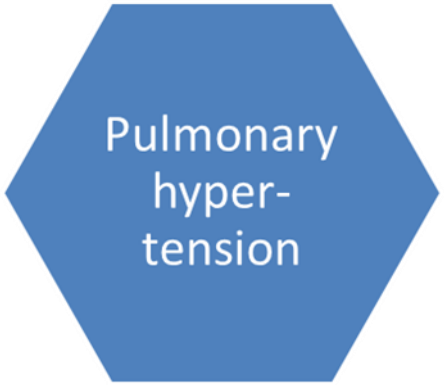
    Barone *et al*. Pediatrics 2009

    Brooks LJ, **Topol** HI. J Pediatr 2003
  - Resolution or decreased frequency of enuresis after treatment of SDB is indicative of an aetiological relationship between the two conditions

    Jeyakumar *et al*. Laryngoscope 2012
- Growth Failure
  - In six out of 20 studies included in a systematic review and meta-analysis, growth failure was reported in a proportion of participants with SDB
  - After adenotonsillectomy, a significant increase in weight and height z-scores was noted

    Bonuck *et al*. Arch Dis Child 2009

Secondary Effects of OSA



- Pulmonary hypertension
  - Children with severe OSAS are at risk of pulmonary hypertension and cor pulmonale especially in the presence of complex disorders
    - Syndromic craniosynostosis — **Amonoo-Kuofi** *et al*. J Craniofac Surg 2009; **Spier** *et al*. Chest 1986
    - Duchenne muscular dystrophy — **Melacini** *et al.* Neuromuscul Disord 1996
    - Achondroplasia — **Afsharpaiman** et al. Sleep Breath 2011; **Ednick** *et al*. J Pediatr 2009; **Sisk** *et al*. Otolaryngol Head Neck Surg 1999
    - Down syndrome — **Lefaivre** *et al*. Plast Reconstr Surg; **Jacobs** *et al*. Arch Otolaryngol Head Neck Surg 1996
    - Mucopolysaccharidosis — **John** et al. Am J Med Genet A 2011

Secondary Effects of OSA

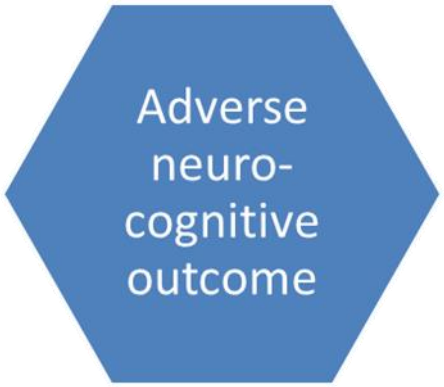
- Behavioural disorders
  - Children with SDB have increased frequency of behavioural disorders (conduct problems, emotional lability, anxiety and depressive symptoms)

    Kaditis *et al.* Eur Respir J 2016
  - Results of the TuCASA study reveal a significant association of SDB with behavioural problems (aggression, lower social competency, poorer communication and/or diminished adaptive skills) (class I)

    Perfect *et al.* Sleep 2013
  - A review article has summarised evidence on cognitive and behavioural deficits in children with primary snoring

    Biggs *et al.* Sleep Med Rev 2014
  - The **Paediatric Sleep Questionnaire** is a useful tool for the prediction of obstructive AHI >5 episodes·h−1, OSAS-related neurobehavioural morbidity and its improvement after adenotonsillectomy

Secondary Effects of OSA



- Adverse neurocognitive outcome
  - OSAS is associated with cognitive impairment

    Friedman *et al.* Sleep 2003
    O'Brien *et al.* Pediatrics 2004
    Suratt *et al.* Pediatrics 2007
  - Cognitive deficit may be as much as 10 IQ points even in mild disease

    Kohler *et al.* PLOS 2009
  - 1,010 children aged 5-8 years prospectively studied with PSG and neurocognitive tests.
    - Dose dependent effects of OSA in pre-pubertal children on neurocognitive function; apnoea/hypopnoea indices (AHI) > 5/hr had worst performance
    - Conclusion: SDB could adversely impact on children's capacity to attain academic and adaptive goals

    Hunter *et al.* Am J Respir Crit Care Med 2016

Secondary Effects of OSA

- Decreased quality of life
  - In a meta-analysis of 10 studies, children with OSAS had poorer scores in the Child Health Questionnaire than healthy children and similar scores to those of patients with juvenile rheumatoid arthritis

    Baldassari et al. Otolaryngol Head Neck Surg 2008

  - Starting early in life, children with OSAS have increased utilisation of healthcare services, mostly related to respiratory morbidity and thus increased societal costs

    Tarasiuk et al. Am J Respir Crit Care Med 2007

  - Both generic and disease-specific health-related quality of life measures improve after adenotonsillectomy

    Garetz et al. Pediatrics 2015

Chat Study

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

A Randomized Trial of Adenotonsillectomy for Childhood Sleep Apnea

Normalization of polysomnographic findings was observed in a larger proportion of children in the early-Adenotonsillectomy group than in the watchful-waiting group (79% vs. 46%)

- 464 children, 5 to 9 years of age
- mild-moderate OSA
- Adenotonsillectomy (AT) or 'watchful waiting'
- Reassessment after 7 months

- AT group showed improvement in:
  - Behaviour, quality of life, respiratory events on sleep study
- No difference between AT and watchful waiting regarding:
  - Attention or executive functioning (Primary Outcome)

POSTA Study

The Pre-School OSA Tonsillectomy Adenoidectomy Study

Cognitive parameters in children with mild obstructive sleep disordered breathing

Chawla et al. 2021

- Preschoolers
- 52 mild to moderate OSA / 39 PS
- No significant differences in neurocognitive or behavioural parameters

Despite having identical symptoms, children with PS on PSG are often treated conservatively, while children with OSA on PSG are considered for adenotonsillectomy. Symptoms and behavioural disturbances should be considered in addition to OAHI when determining the need for treatment

Diagnosis

- Paediatric Sleep Questionnaires
- Video evidence
- Oximetry studies (+/- transcutaneous CO2)
- Cardiorespiratory Polygraphy (CRP)
- Full Polysomnography (PSG)

Questionnaires

British Thoracic Society Guideline for diagnosing and monitoring paediatric sleep-disordered breathing
Hazel J Evans et al. 2023

- Sleep questionnaires appear to have a **moderate sensitivity and low specificity** for diagnosing sleep disordered breathing in children
- The **Sleep-Related Breathing Disorder scale** of the Paediatric Sleep Questionnaire (SRBD-PSQ), with a cut-off of ≥0.33, or **Obstructive Sleep Apnoea-18 item questionnaire** (OSA-18), with a cut-off of ≥0.60, can be considered for diagnosing moderate-to-severe SDB in children of at least 2 years of age with no comorbidities

- *not enough evidence in **children under two years** of age*
- *not enough evidence in **children with comorbidities** is not supported at this time.*
- *Sleep questionnaires will not detect **mild SDB**.*

Franco, R.A., Jr., Rosenfeld, R.M. and Rao, M. (2000)
Chervin RD1, Hedger K, Dillon JE, Pituch KJ. (2000)

Overview of “sleep studies” – what do we measure?

Overview of “sleep studies” – what do we measure?

Oximetry	**Polygraphy**	**Polysomnography**
• Gas exchange – O2	• *Gas exchange – O2 (& CO2)* • Respiration – movements • Respiration – airflow • ECG • Snoring • Body position	• *Gas exchange – O2 & CO2* • Respiration – movements • Respiration – airflow • ECG • Snoring • Body position • EEG/EOG/EMG • Muscle activity • Oesophageal pressure catheter

Pulse oximetry in paediatric SDB

Advantages

- Simple; easy to perform
- Inexpensive
- Well accepted by parents

Disadvantages

- Low sensitivity
- Not useful in first (2) year(s) of life (central apnoeas)
- Cannot assess severity

Pulse oximetry

British Thoracic Society Guideline for diagnosing and monitoring paediatric sleep-disordered breathing
Hazel J Evans et al. 2023

Children <u>without comorbidities</u>

- For children with suspected SDB, pulse oximetry can be considered as a **first-line diagnostic test for SDB**. If a test result does not fit the clinical picture, a higher level of investigation, such as a CRSS, may be required

Children <u>with comorbidities</u>

- If a CRSS is not available, pulse oximetry can be considered as an initial diagnostic test for SDB in children with comorbid disorders, but if a test result is abnormal caution must be taken in interpreting the results as desaturations may have varying causes.

Cardiorespiratory Polygraphy

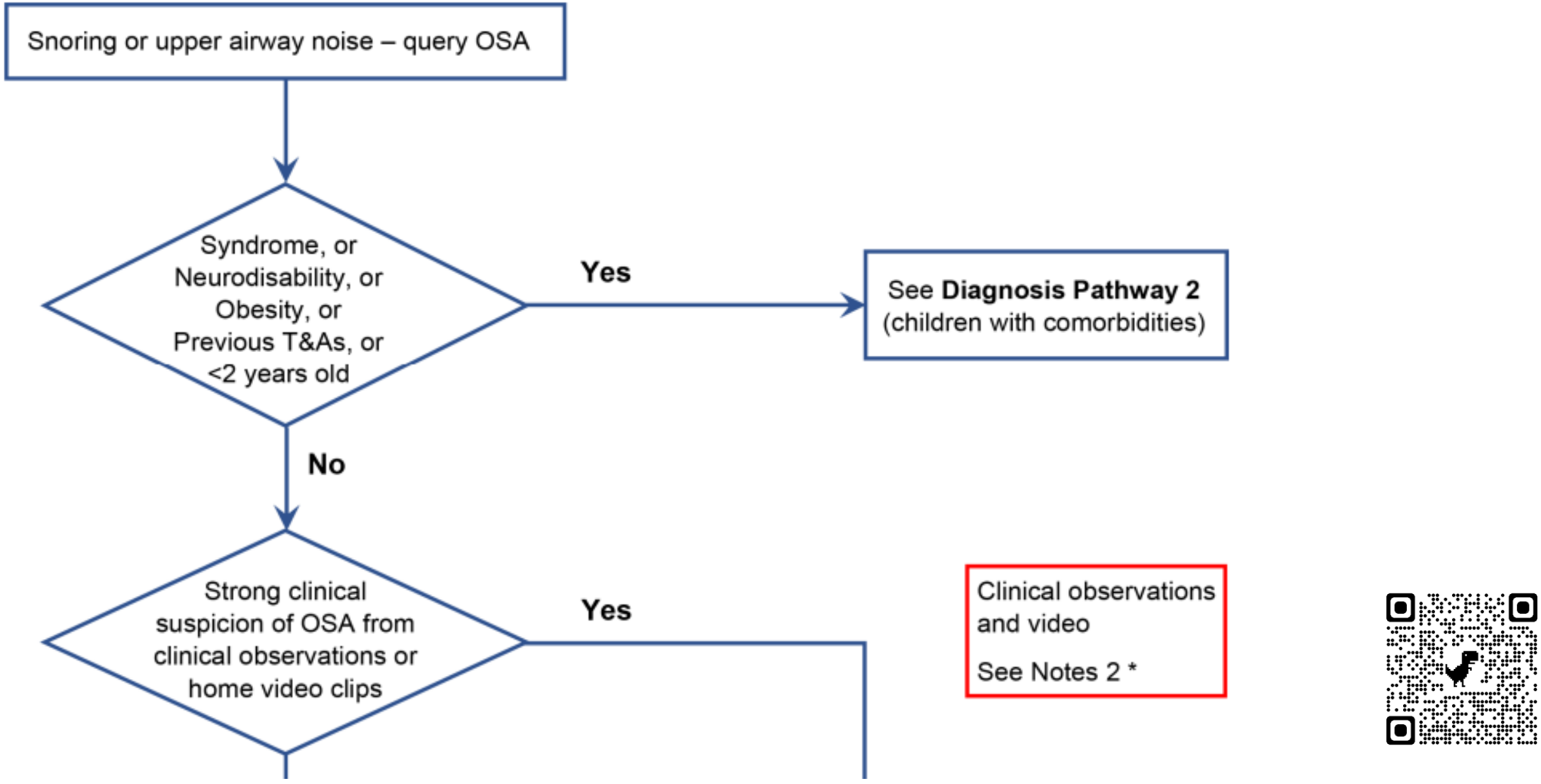
- Respiration – movements
- Respiration – airflow
- ECG
- *Gas exchange – O2 + CO2*
- Snoring
- Body position

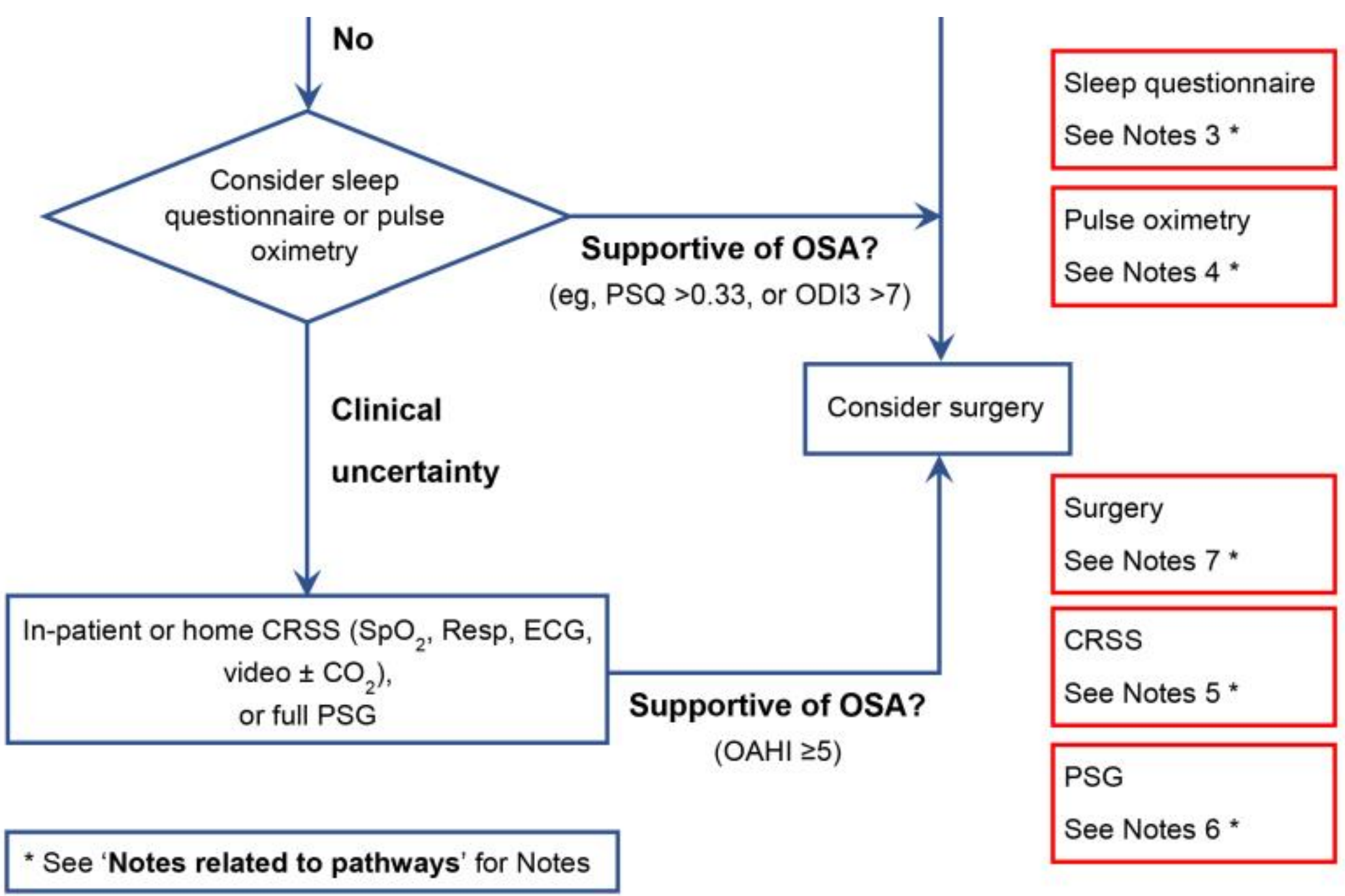
Cardiorespiratory Polygraphy

British Thoracic Society Guideline for diagnosing and monitoring paediatric sleep-disordered breathing
Hazel J Evans et al. 2023

- If pulse oximetry is normal, but there is suspicion of SDB, a CRSS may be useful to identify mild OSA.
- If pulse oximetry is abnormal, CRSS are more specific and can discriminate between central and obstructive events.
- Although CRSS can only be recommended as a diagnostic tool for SDB in children with neuromuscular disorders or Down Syndrome, CRSS can be considered as a first line diagnostic tool for **children with other comorbidities**.

Obstructive sleep apnoea pathway




No
Consider sleep questionnaire or pulse oximetry
Supportive of OSA?
(eg, PSQ >0.33, or ODI3 >7)
Clinical uncertainty
Consider surgery
Sleep questionnaire
See Notes 3 *
Pulse oximetry
See Notes 4 *
In-patient or home CRSS (SpO_2, Resp, ECG, video ± CO_2), or full PSG
Supportive of OSA?
(OAHI ≥5)
Surgery
See Notes 7 *
CRSS
See Notes 5 *
PSG
See Notes 6 *
* See '**Notes related to pathways**' for Notes

Management decisions

- OAHI > 5 – refer to ENT for consideration of AT
- OAHI 2-5
  - Review clinically
  - Decision to intervene based on
    - Comorbidities
    - Family concerns and effect on daily function

STEP 5: Indications for treatment of SDB:

5.1

a) AHI >5 episodes·h^{-1} irrespective of the presence of morbidity

b) Treatment may be beneficial if AHI 1–5 episodes·h^{-1} especially in the presence of: morbidity from the cardiovascular system (see 2.1); morbidity from the central nervous system (see 2.1); enuresis; somatic growth delay or growth failure; decreased quality of life; risk factors for SDB persistence (see 3)

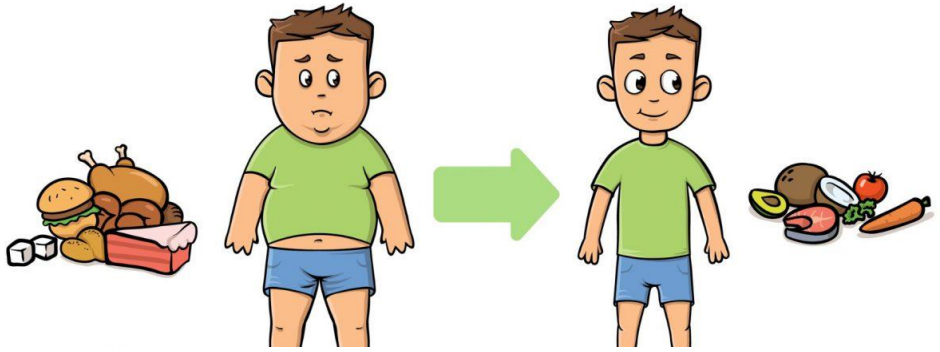
c) If at risk for SDB and PSG or polygraphy not available, treatment is considered when positive oximetry or SDB questionnaires (see 4.4) or morbidity present

5.2 Unclear whether should treat primary snoring (evaluation annually)

5.3 OSAS treatment is a priority in the presence of: major craniofacial abnormalities; neuromuscular disorders; achondroplasia; Chiari malformation; Down syndrome; mucopolysaccharidoses; Prader–Willi syndrome

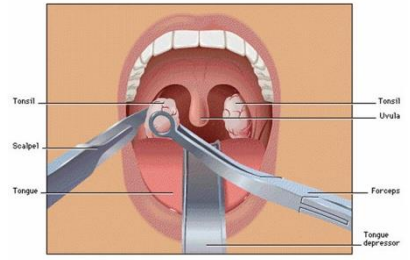
Kaditis *et al* 2016

Therapeutic Options



- Weight loss if child is overweight or obese
- Nasal corticosteroids and/or Montelukast orally
- Adenotonsillectomy
- CPAP

- Nasopharyngeal Airway
- Rapid maxillary expansion or orthodontic appliances
- Craniofacial surgery
- Tracheostomy



Any questions

Acknowledgements

Dr Don Urquhart – Cases