

**SLEEP-RELATED UPPER AIRWAY OBSTRUCTION IN DOWN'S
SYNDROME: DIAGNOSTIC APPROACHES AND TREATMENT**

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To give a clear picture of some of the issues in sleep-related upper airway obstruction (srUAO) and dealing with the upper airway in children with Down's syndrome (DS), I will talk initially about children without DS and the complex issues that are relevant to all children with srUAO.

I will start by running a video clip. Video is a very useful tool in investigating srUAO. Parents can be given recording equipment to use at home for one or more nights and it is then possible to see and hear the child breathing while asleep. This sort of recording poses a number of questions as to the significance of the noises you can hear. How do we assess them further? Do we need to do anything about it? I hope in this presentation to paint a picture to help put some of these issues in perspective. I will talk through the epidemiology – which is predominately based on questionnaire studies. These have inevitable problems and rely on clinical features to establish a diagnosis. However what we mean by diagnosis is questionable. We do use sleep studies but there are complex issues relating to these in children. Finally I will talk a little about treatment.

The spectrum of sleep disordered breathing (SDB)

SDB includes srUAO but covers a broader range of respiratory control disorders, because not all sleep-related breathing problems are simply related to the upper airway. There are complex relationships between the upper and lower airway and it is important to be aware that lower airway problems may also cause problems that are aggravated by sleep.

Snoring is the first stage. A good proportion of normal children snore and we have to question how important this is and what is the relationship to more extreme or severe degrees of srUAO.

Upper airway resistance/upper airway resistance syndrome

This term is used to describe children who snore and have other symptoms reflecting UAO and who, on a standard sleep study, may not demonstrate anything very dramatic in terms of hypoxaemic episodes or increased upper airway resistance. However if oesophageal manometers are inserted you can see very large negative swings suggesting large negative pleural pressures which are a reflection of the increased work of breathing. Opinion is divided as to whether this is an important condition to recognise and whether we should be using oesophageal monitors in these children.

Obstructive sleep apnoea is an alternative term for srUAO. I prefer not to use this because I don't think it is as accurate or clear a description.

It is important to recognise that the spectrum is not static – for instance children can move from normal to snorers – having some upper airway resistance syndrome as, for example, part of a respiratory infection – then moving out again into normal sleep breathing.

Presenting features

Snoring

Table 1 shows data from six population-based studies on healthy children without DS.¹⁻⁶ The prevalence of snoring ranges from 3% to 12% and interestingly the two UK studies show very close agreement – 12% of children in Ali's Oxfordshire study and 11% in Owen's Somerset study snore.^{3,6} These studies distinguished between the children who snore occasionally or just with colds, and regular, habitual snoring. The figures quoted are for habitual snorers – so snoring itself is actually common. Of these 6 studies, three have undertaken further assessment to look at or estimate the prevalence of srUAO. In the Oxfordshire study based on a questionnaire and video recordings it was estimated that 0.7% of their 4–5 year old children had srUAO. If

children who had had tonsilloadenoidectomy for upper airway problems were included the estimated prevalence goes up to 1.1% and if children who had reached a certain criteria of desaturation were included, then it would go up to 2%.³ These criteria were also met in the study by Gislassan et al. to show an incidence of 2.3%.⁴ The research by Owen et al. in Somerset showed a very high percent – 25% – if based just on desaturation criteria.⁶ This raises a question over the validity of the definition criteria used in that study for abnormal desaturation levels.

Is snoring important? It has been shown that snoring is related to daytime problems. In North America, from a very large population of children who attended paediatric offices, 71 children with behavioural, developmental or academic problems were compared with 355 control children (each child was matched to 5 controls). Snoring was found to be 2.3 times more common in the children with these sorts of daytime problems and difficulty breathing in sleep was 2.6 times more common.⁷ Ali³ and colleagues in the Oxfordshire study also looked at daytime problems in habitual snorers and compared them to non-snoring children and found that hyperactivity was 1.7 times more common in the snorers (hyperactivity was defined as a response of 'often' to the question: 'Do you consider your child hyperactive?'). Behavioural questionnaires were also administered and on the sub-scales for hyperactivity and inattention 5% of the control children were at a level defined as abnormal compared with 30% of the snorers. This study also looked at the longitudinal change which gives an indication of a 'dose response' relationship. These children were assessed after a further two years and they were categorised according to one of four groups (Table 2):

- They had never snored
- They had snored but had stopped two years later
- They hadn't snored but had started by the second assessment
- They had snored at both assessments.

It can be seen that snoring is certainly related to daytime behavioural problems. However, snoring is just one symptom to consider when diagnosing srUAO, others are described below.

Sleep disturbance

Another cardinal symptom of srUAO is sleep disturbance and, of course, sleep disturbance is also very common in childhood so it is important that the reasons are thought through and distinguished. There are a number of factors that could be influencing a child's sleep which need to be distinguished from UAO:

- Nocturnal cough
- Pruritus
- Polyuria
- Psychological
- Drugs
- Parasomnias

There is a relationship between children who snore and children who have atopy – asthma, rhinitis, etc. It is quite possible that children who have problems in the upper airway and episodic hypoxaemia may actually aggravate their lower airway disease because the lower airways may react if they are hypoxic. Similarly there may be lower airway problems that, because of the increased work of breathing, actually bring out an upper airway problem. Trying to distinguish what the sleep disturbance is due to and whether snoring and the upper airway is the only issue can sometimes be difficult.

Apart from breathing difficulties and snoring other distinguishing features of sleep-related breathing problems are:

- Mouth breathing (suggesting a regular nasal blockage) and halitosis
- Restless sleep
- Chronic rhinorrhea
- Subcostal and sternal recession
- Odd sleep positions – These are found in some children when they have srUAO. They will hang over the side of the bed so that their head is partially upside down to optimise their upper airway, presumably helping the tongue to fall away from the back of the throat. They may sleep upright or propped up against a wall with their head extended to try and optimise the upper air passage. These will only be

discovered if they are actively asked about or during further investigations such as video recording.

More extreme features are secondary cardiovascular effects:

- Pulmonary hypertension
- Heart failure

There are a number of these other features which are less strongly related:

- Swallowing difficulties
- Recurrent upper respiratory tract infections
- Nausea and vomiting
- Daytime sleepiness
- Persistent or secondary enuresis
- Nocturnal sweating
- Cyanosis
- Apnoea

The other important issue about srUAO is its insidious onset as the child may appear completely normal in a clinic setting. You have to rely on historical features.

Symptoms will have developed over a period of time, so parents may not be fully aware of what has happened to their child with time and growth, but they are aware that the snoring and restlessness has increased. A relationship between this and behavioural or academic issues that are relevant in the child's progress may not necessarily have been considered.

Physiological effects

- Hypoxaemia – This usually causes dips in oxygen saturation because of episodic or cycles of obstruction, rather than an overall drop in baseline oxygen saturation. Baseline lowering is also seen in children with Down's syndrome and again this may reflect lower airway problems or the inter-relationship of the two.
- Hypercapnia
- Sleep disruption
- Arousals from sleep.

Clinical effects

There are other significant clinical effects of srUAO and it can be hard in an individual child to characterise how much their symptoms of UAO relate to daytime problems. Studies of cohorts have actually identified that learning difficulties, behavioural disturbances and personality changes – children who are unusually aggressive or temperamental – can be related to srUAO as well. As mentioned previously, there are cardiovascular effects, poor growth and other effects of hypoxaemia on the lower airways possibly producing a rising airway resistance which may have been labelled as asthma.

Pathophysiology

This is not straightforward, there are complex issues that lead to the development of upper airway problems. There are anatomical factors such as changes in cranio-facial structure, obesity and lymphoid hyperplasia (particularly between 2 and 6 years), central effects such as abnormalities in pharyngeal tone, and there are undoubtedly also genetic factors. Sleep-related upper airway obstruction often does run within families.

There are a number of these factors that all conspire together to make the child with Down's syndrome much more likely to have srUAO as a clinical problem:

- Maxillary/mandibular hypoplasia
- Macroglossia
- Small upper airway

- Increased secretions
- Increased lower respiratory tract anomalies
- Obesity
- Hypotonia

The research in children on srUAO differs from much of the work in the adult field. Sleep-related UAO typically affects the child at the age when the lymphoid tissues are larger – the younger child, in adults it is the 30 to 60 year olds. Children with srUAO could be of any weight – they are not necessarily the Pickwickian types found in adult sleep medicine – they can have growth failure as well and be very underweight and failing to thrive. As already discussed there are the behavioural and developmental issues found in children, and the effects on daytime performance in particular seem more subtle compared with those in adults where overwhelming periods of daytime somnolence are very much part of obstructive sleep apnoea. Adults are affected more on the cardiac side, whereas in children it tends to be the respiratory side that seems to be a primary target.

Children with DS have differing pathophysiology to adults and children without DS (Table 3). Children compared with adults desaturate more for a number of reasons: they don't maintain lung volume as well, their airways close more regularly and they have less oxygen stores. In Down's syndrome this is exacerbated for reasons such as hypoplasia and abnormalities in alveolar structure. Children compared with adults with srUAO arouse less, and therefore preserve a better sleep architecture, which may explain why children can often carry on functioning relatively well during the day. Adults who have obstructive sleep apnoea seem to 'crash out' during the day and have more fragmentation with disruption of the sleep stages. Children are more likely to have partial obstructions that go on for long periods of time – perhaps through the whole of a period of REM or active sleep, whereas in adults there are often short epochs of complete obstruction of the upper airway. In children the problems are mainly in REM sleep although in DS there may be problems appearing through the whole of sleep and therefore children with DS have more disturbance of their sleep architecture.

A recent study by Levanon et al⁸ looked at sleep structure in children with DS and compared this with a control population - sleep efficiency (the length of time asleep as a proportion of the whole time spent in bed) was similar. Children with DS also had a similar distribution of sleep stages (stages 1, 2, 3, 4 of quiet sleep and REM sleep), but the children with DS did have an increase in sleep fragmentation:

- More shifts between sleep stages
- More arousals – movements and awakenings.

Interestingly, Levanon et al. found that of all the arousals during sleep, quite a small proportion were actually related to respiratory events. Although, this may in part relate to how the respiratory events were defined. It is also possible that there may be central nervous system differences in children with DS that also make them more prone to sleep disruption.

Investigations

The key investigation is the *sleep observation* or *sleep study*, but other investigations are also part of a work-up. *Fibreoptic endoscopy* is very useful in identifying the site of obstruction. This is best done under a light general anaesthetic to give a much better picture of the dynamics of the airway rather than under a deep anaesthetic with a rigid scope. There may be multiple sites or there may be one main site which when dealt with the obstruction is predominantly overcome. In DS often it is tongue-based obstruction, the back of the tongue where it approximates to the pharynx during sleep, that seems to be the biggest problem and the most difficult to treat. If there is noisy breathing include a *barium/cine swallow* looking for vascular ring or a large airway obstruction because sometimes it can be difficult to distinguish exactly where the noise is coming from – whether it is simply upper airway or whether there is a lower airway component as well. If there are problems in trying to work out the anatomy or why a child is resistant to initial attempts at treatment, then *MRI* or *CT imaging* can sometimes be useful at identifying problems that aren't always so easily worked out by an expert ENT surgeon at endoscopy. An *ECG* and *echo* are useful in a cardiac assessment to look at the effects of any sleep related breathing disorder and if a procedure is going to be undertaken or if there has been severe hypoxaemia a *haemoglobin count* is useful.

Sleep studies

There are different ways that sleep studies have been done – daytime naps have been used as a way of screening children with sleep-related problems and children have even been sedated with chloral to enforce a three hour afternoon sleep to look at the physiological parameters. However, there is evidence that this is not a useful way of assessing sleep – it is not a natural sleep and it is only a short sleep which doesn't take account of the problems that occur after several hours of sleep. The preference is for a full night-time study. Traditionally a full polysomnogram is used (looking at respiratory movements, airflow, ECG, EEG, EOG, EMG, oxygenation, CO₂, movement and a video recording). This has been handed down from adult medicine and there are questions as to which are the key measures that are relevant to the outcome in the child. A group at Stanford, California would include putting oesophageal manometers down these children to measure oesophageal pressure swings, but there is a view that this is too much in terms of invasive procedures in these children.

Sleep study measurements

In Britain sleep studies are well and truly fragmented as far as the paediatric service is concerned. They are very variable around the country and although improving, people are often measuring very different things and there is not a good consistency in the measurements that are undertaken. The simple straightforward measures which we have used for years are:

- Video tape – actually seeing what the child is doing is very useful and if they are exposed from neck to waist the recession and increased work of breathing can be seen on the video tape.
- Pulse oximetry
- Inspiratory resistance
- Carbon dioxide measurements

Less frequently used measures are:

- Hypopnoea – this refers not to stopping breathing, but to a reduction in breathing, usually considered as greater than a 50% reduction in amplitude of either airflow or the breathing movements.
- Paradoxical inward rib cage movement (PIRCM) – There was a paper earlier this year in *Archives of Disease in Childhood* on PIRCM⁹ which refers to the fact that when children breathe normally their abdomen goes out on inspiration and their chest wall rises as well, but if you have an obstructive upper airway what happens is that the abdomen goes out but the chest wall may cave inward. It is thought that this is quite a useful measure for looking at obstruction and requires only a band around the chest looking at respiratory movements. However, some of the recent work suggests that it is less straight forward than this. PIRCM is quite a commonly seen pattern in young infants and I think that in up to three or four year olds it is quite normal. It may be that this is a useful measurement in screening children older than 3–4 years of age and may be as good as putting an oesophageal manometer down to look at the increased work of breathing.
- Arousals from EEG – There's increasing work now in the adult field about what sort of criteria should be used for measuring arousal thresholds and the exact relationship between some of the daytime symptoms that adults have – this is even less well worked out in children.
- Oesophageal pressure measurements (see previously).

Home video-oximetry

This is a screening tool which we have used for many years and have found very helpful. A video camera and oximeter are set up in a child's home next to their bed, a low level light is available and preferably the child is exposed down to the waist. A number of things are reviewed from the tape:

- Falls in baseline oxygen saturation
- Chest wall recession
- Snoring
- Sleep position
- Nocturnal movement

Interestingly, when comparing the results with the history, the one night recording often didn't show what was being described to us in the clinic. We weren't seeing loud or prolonged snoring and a lot of restlessness. Generally, parents preferred this sort of monitoring because it was simple, easy to use and it was in the home – it didn't mean an admission to hospital. Whether this is useful in DS is unclear. There are so many complicating factors in DS because the sleep-related abnormalities are not just related to obstruction. My inclination for this group of children would be to move straight towards a proper sleep study in hospital. Thus providing more information at the first take.

Sleep study traces

The traces from the sleep studies show oxygen saturation, ECG, the pulse waveform from the pulse oximeter, breathing movements and end-tidal carbon dioxide (an additional way for assessing hypoventilation compared with transcutaneous carbon dioxide). It is important to have normative data when doing sleep studies. For measurement of baseline oxygen saturation, we concentrate on the regular breathing pattern which equates quite nicely with quiet sleep because it is a period of sleep when there's relatively little movement or disturbance so the signal pick up is at its best. It's also a state in the sleep when the oxygen saturation is probably higher than it is during REM sleep. Falls in saturation are normal in relation to pauses, particularly in infants, and it is important to have that normative data if assessments are being made on oxygen saturation and dips.

Another normal pattern is periodic breathing. This is particularly common in young infants, but interestingly the dips in oxygen saturation in the apnoeic pauses are very similar to the periodic dips you see in srUAO. In srUAO there are cyclical dips in oxygen saturation, but the breathing movements are continued. However, if the trace of the breathing movements is expanded respiratory waveform changes indicating increased upper airway resistance can be seen (respiratory inductance plethysmography).

Figure 1 is an expanded trace showing the dips in oxygen saturation with srUAO and interestingly as the obstruction increases the amplitude of the breath decreases. It

might be expected that to overcome an obstruction a child will make bigger movements, but this indicates the central mechanisms that are going on in this condition. There is a diminution of the respiratory amplitude until the shouldering on the inspiratory waveform occurs and the very small amplitude breaths are reflected in an absence of airflow, so these are complete obstructions. These are followed by a fall in saturation (slightly out of time sequence) and then there's an arousal and after a large breath the saturation rises again. This is the sort of typical cyclical pattern.

Even traces that are typical of an obstructive event must be treated with caution because the clinical situation must be considered. For example a trace may show a dramatic fall in oxygen saturation with continued respiratory movements and an absence of airflow, but if the child has an unobstructed tracheostomy then this isn't upper airway obstruction. This type of finding may be relevant to the mechanisms for hypoxaemic episodes, because a lot of hypoxaemic events are not just related to upper airway mechanics but also events in the lungs as well. It may be that there is small airway occlusion accompanying upper airway obstruction, and that this may also reflect episodic intrapulmonary shunting occurring.

We have not used EEG monitoring routinely in all sleep studies because we've not been undertaking detailed measurements of EEG arousal, but in some circumstances where there is an obstructive hypoxaemic episode, it's useful to have EEG to distinguish whether there is a fit occurring first.

A point to be aware of is that most clinical oximeters, and oximeters used in sleep studies, give a measurement averaged over several seconds. The one we use has beat to beat output so, for instance, in cases where the end-tidal CO₂ is high and oxygen saturation is low for prolonged periods, the true depth of oxygen dips in some of the troughs of the cycles shows up. With averaging, the trace would be smoothed out which could give a false appreciation of the adequacy of oxygenation.

Sleep-related UAO in DS

One study looked at a group of 53 children with Down's syndrome from California and found that 60% of them had srUAO.¹⁰ Interestingly, this was compared with an

estimate based on parental histories (39%). This and the data from the home video monitoring give an indication that relying on the historical features can mislead in both directions – either missing important problems or actually over-diagnosing. In this study Marcus and colleagues found 70% had an abnormality on a nap polysomnogram, but 100% on overnight polysomnogram, which is why they recommend an overnight study. The biggest abnormality found in this group of children with Down's syndrome was hypoventilation – 80% of them had elevated carbon dioxide levels. In a high proportion this will have been related to srUAO, but there are other issues why these children may hypoventilate from having undiagnosed lung parenchymal problems or lung airway problems through to having central hypoventilation from CNS problems.

We ourselves did a cohort study in the Oxfordshire area some years ago. We looked at 32 out of the 34 children with DS resident in the area who were up to 5 years of age. Results were analysed in a blinded fashion and compared with controls.¹¹ There was a questionnaire looking for six signs and symptoms, overnight tape recordings and an overall clinical assessment (Table 4). The questionnaire findings suggested that in a population group of children with DS a third would have at least three symptoms suggesting sleep-related problems. The most frequent problems were snoring and chest wall recession. The recordings showed that 41% of the children with DS had the pattern of an increased inspiratory resistance on the respiratory waveform compared to 3% of controls. Two-thirds of the children with DS had oxygen saturation levels below that of the lowest found in controls (excluding those known to have low saturations from a cardiac problem). This was probably not just because of srUAO, but also a combination of lung hypoplasia and small airways. Unsurprisingly they also had an increased number of dips in oxygen saturation during sleep – again these featured particularly during the non-regular breathing which is consistent with the known tendency for this to occur during active sleep.

On a period of reassessment looking at the children it was found over a period of time that 31% of these children had evidence of UAO and most of them had an adenoidectomy or tonsillo-adenoidectomy. There was only one who had spontaneous resolution which is a much more common phenomena in children without Down's

syndrome. One had had a serious event at home needing resuscitation before UAO was identified and dealt with. Interestingly there's an association with cardiac problems – one had cardiac surgery and the sleep-related upper airway problems improved after surgery. We postulated that if there was increased pulmonary blood flow to the lungs, the lungs were stiffer which increased the work of breathing, sucking in the upper airway and bringing out the upper airway problem. When the heart problem was dealt with there was not the increased work of breathing from the increased lung fluid and the upper airway problems improved. Similarly it is known that children with Down's syndrome have an accelerated pulmonary hypertension and an increased incidence of primary pulmonary hypertension. It is extremely important to assess them for sleep related problems because this may be a contributing factor in some of these cases.

Treatment options

Time is a very useful treatment. If it is uncertain as to whether a child should have some form of treatment waiting 3–6 months and re-assessing to see whether the problem has got worse or better can be very useful. Topical decongestants and topical steroids may be particularly useful if waiting to see whether a problem improves over time and for children who just have intermittent problems such as with inter-current respiratory infections. They may start treatment and find it helpful during a period of a few weeks and then stop the treatment when things have got better.

The next treatment really is tonsillo-adenoidectomy and then nasal CPAP. Nasal CPAP has been shown in a number of series to be a very effective treatment for srUAO. It is non invasive and the equipment used is relatively simple and not phenomenally expensive. There is, however, a big issue with compliance and, particularly in children with Down's syndrome, this really can be quite an undertaking and really needs to be considered very carefully before starting. In addition there are side effects such as pressure sores around the nose and nasal bridge, nosebleeds, excessive drooling – which may already be a problem – and swallowing air leading to a lot of abdominal distension, but there are ways that these can be tackled. Using a variety of therapists and techniques it is possible to help the child learn to become

accustomed to wearing a mask, and it's important that they are aware of the mask while awake rather than thrusting it on them when they have fallen to sleep.

Nasopharyngeal tubes are particularly useful in young children and infants as a way of avoiding the need for a tracheostomy. They can be used until the child has grown and their airway is big enough not to cause problems. NP tubes need to be placed under endoscopy to make sure that the tip is in an appropriate position to overcome tongue based obstruction, and every so often this will need reviewing and replacing to account for growth.

A large number of ENT procedures are used:¹²⁻¹⁵

- Tonsillectomy
- Adenoidectomy
- Uvulopalatopharyngoplasty
- Tonsillar pillar plication
- Midface advancement
- Tongue hyoid suspension
- Anterior tongue reduction
- Laryngotracheostomy
- Tracheostomy

Tonsillectomy and adenoidectomy have a well proven place in this condition. Uvulopalatopharyngoplasty is being used in adults predominantly and along with many of these other procedures advice from an expert in paediatric ENT surgery should be sought. There isn't a vast experience with these procedures anywhere really and there aren't randomised trials of which one is a better option, clearly there are issues depending on the particular child's problems.

Sometimes despite some forms of ENT surgery a tracheostomy is needed and again this needs to be considered very carefully because it is a major burden for the child and the family because of increased lower respiratory secretions, infections etc. It does not necessarily follow that the more surgery that is done or can be done leads to

greater improvements. A review from Atlanta¹⁶ showed that the children who had some of the more sophisticated major surgery on the upper airway actually seemed to show less benefit, clearly they were the more severe cases and they had at least something to gain.

Hospital admission, even for tonsillo-adenoidectomy which has become an outpatient procedure in many places, is probably a good idea in children with Down's syndrome. Sedation as a pre-med for this or for endoscopy should be avoided because it can actually aggravate upper airway obstruction. From the surgical case series it looks like quite a large number of the children with Down's syndrome do have problems with their airway post surgery so considering having a place on the high dependency or paediatric intensive care unit is a good idea.

The series from Atlanta looked at 55 patients with Down's syndrome operated on over five years.¹⁶ Twenty-seven had relatively mild problems and responded well to tonsillo-adenoidectomy. Twenty-eight patients had more major problems and 40% of them had residual problems even with an aggressive surgical approach. So tonsillo-adenoidectomy and other measures aren't necessarily always effective and there is a certain morbidity and mortality – 4 had tracheostomies and there were 5 deaths including 3 because of problems related to the upper airway.

Finally there are some questions that are outstanding. Should children with Down's syndrome all undergo regular screening and at what sort of time intervals? Certainly all children with Down's syndrome would benefit from having a respiratory assessment on a regular basis. Who should be doing this, to what depth it should be done and whether it should always include sleep studies is a controversial point. Certainly in the field of respiratory sleep medicine we need to improve our methods to try and work out what are the simplest methods to use to diagnose these problems, which problems are relevant to the outcome for the child and which show some improvement with intervention. In addition for a small proportion of children there is still a need for improvement in techniques to allow better treatments to be provided which are tolerable for children.

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Question session

Rebecca Ferris (Winchester) On a very practical level, how do you analyse nine hours worth of sleep video?

Martin Samuels What we usually do is have a four hour video tape that we give to the parents and we ask them to record what they consider to be the worst period. Just as a way of using this as a screening method I usually take the opportunity when I'm in my office for a few hours to just have a tape running in the background and it's also possible to put it on fast forward so it goes 9 times real time. You can look for recession and oxygen saturation and I find this is a practical way of looking at the tapes without actually having to sit through 9 hours.

Sheila Macken (Dublin) What about allergy screening or treatment if we're talking about using nasal steroids? Have you found that to be useful?

Martin Samuels I would treat that in the same way that I do with other children and I suspect that my practice tends to vary somewhat dependent upon how much it is being pushed by the parents and how much their symptoms are amenable to other treatments. When you're looking at allergy there's always the big issue of being able to relate specific allergens to the child's symptoms and there are difficulties over knowing how to interpret allergy tests. There are major issues in actually trying to

undertake exclusion, but I think it's certainly one of the things that probably should be on the list as one possible treatment strategy for both lower and upper airway problems.

Figure 1: Physiological recording trace showing srUAO

Table 1: Snoring prevalence

Study	Ages (years)	n	Percentage snoring	Range (95% CI)
Corbo ¹	6–13	1615	7.3	6–9
Teculescu ²	5–6	190	10	7.8–14.3
Ali ³	4–5	996	12	9.7–14.3
Gislassan ⁴	0.5–6	555	3.2	1.7–5.1
Hulcrantz ⁵	4	325	6.2	3.8–9.3
Owen ⁶	0–10	260	11	7.8–16.5

Table 2: Hyperactivity and snoring (from Ali et al. 1993)

Snoring status	Restless sleep (%)	Hyperactivity (%)
Never	26	11.4
Ex	45	22
Recent	47	21
Always	60	36

Table 3: Pathophysiology

Compared with adults	Children without DS	Children with DS
Desaturate	More	++
Arouse	Less	+
Sleep architecture	Kept	–
Partial obstructions	More	+
Problems in REM	Mainly	–

Table 4: Sleep-related UAO in DS (from Stebbens et al. 1991)

Abnormality	Significance	DS (%)	Controls (%)
Snoring	p < 0.001	47	4
Chest wall recession	p < 0.001	34	0
Sudden wakening		0	0
Restlessness		47	35
Mouth breathing		25	12
Excessive sweating		16	15
> 2 signs	p < 0.01	31	4