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## “Saw-Tooth Sign” in upper airway disorders — a case report

Objaw „zębów piły” w chorobach górnych dróg oddechowych — opis przypadku

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### Abstract

Spirometry flow-volume loop measurement is the screening test of choice to rule out obstructive lung diseases. Flow oscillations occasionally seen on flow volume loops, referred to as a “saw-tooth” sign, are thought to be due to an upper airway obstructive processes associated with upper airway collapsibility. Widely described in obstructive sleep apnea syndrome, flow oscillations have also been linked to many other upper airway pathologies. The mechanism by which flow oscillations occur is centered on the inspiratory and expiratory flow of air. It has been theorized that the mechanism of flow oscillations result from rapid intermittent changes in driving pressure or airway resistance. Since visual inspection of the flow volume loop can reveal presence of flow oscillations clinicians should be aware of this phenomenon and the presence of flow loop oscillations should clue physicians to rule out upper airway pathology.

**Key words:** saw tooth sign, flow oscillations, spirometry, obstructive sleep apnea, upper airway disorder

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### Streszczenie

Pomiar spirometryczny pętli przepływu—objętość jest powszechnym badaniem umożliwiającym wykluczenie obturacyjnych chorób układu oddechowego. Pętla przepływu—objętość pokazuje przepływ powietrza, odnosząc się do objętości płuc podczas maksymalnego wdechu i maksymalnego wydechu. Uważa się, że widoczne sporadycznie na pętlach przepływu—objętość wahania przepływu, nazywane „zębami piły”, są spowodowane obturacyjnymi procesami zachodzącymi w górnych drogach oddechowych, związanymi z ich zapadaniem się. Obszernie opisane w związku z powstawaniem obturacyjnego bezdechu sennego, wahania przepływu są związane także z innymi chorobami. Uważa się, że objaw „zębów piły” powstaje na skutek nagłych zmian ciśnienia wewnątrz światła przewodu. Pętla przepływu—objętość dostarcza istotnych informacji dotyczących wzorów wentylacji, ponadto, mogą wskazywać na ukryte choroby górnych dróg oddechowych. W pracy opisano przypadek pacjenta, u którego wystąpił objaw „zębów piły” na pętli przepływu—objętość.

**Słowa kluczowe:** objaw „zębów piły”, wahania przepływu, spirometria, obturacyjny bezdech senny, choroba górnych dróg oddechowych

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### Introduction

Spirometry flow-volume loop measurement is a common outpatient procedure that is the screening test of choice to rule out obstructive lung diseases. Flow-volume loops display air-

flow as it relates to lung volume during maximal inspiration and maximum expiration [1]. The principal advantage of the flow-volume loop is that it can show whether airflow is appropriate for a particular lung volume. In addition certain other aspects of flow-volume loops can be clinically

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relevant [2]. Flow oscillations occasionally seen on flow volume loops, referred to as a "saw-tooth" sign, are thought to be due to an upper airway obstructive processes associated with upper airway collapsibility and may be a helpful indicator of an upper airway disorder [3]. We present here a case in which a patient presented with a classical saw-tooth pattern on flow-volume loop and was diagnosed with OSA along with a short review of the literature of this flow volume loop finding.

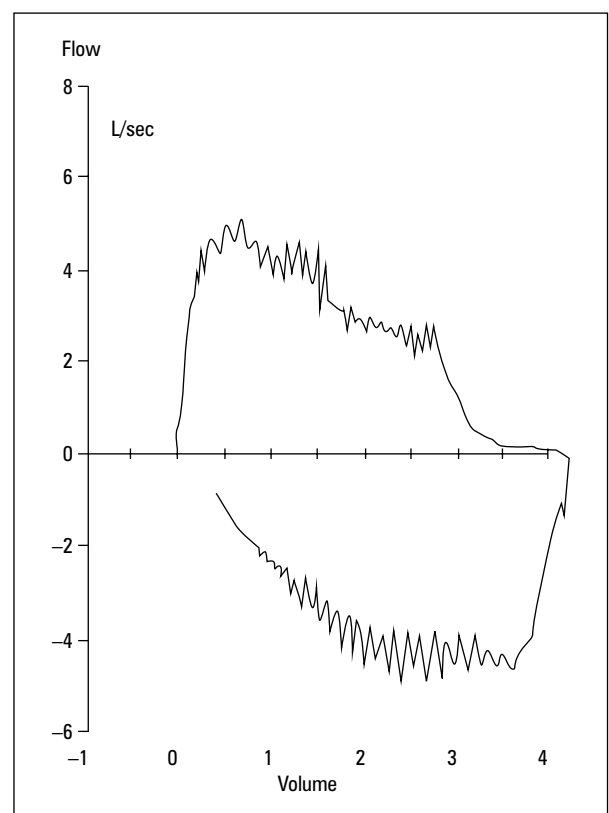
### Case Presentation

A 47-year-old obese male with history of Type II diabetes mellitus was evaluated at our outpatient clinic for recently worsening dyspnea on exertion, fatigue and headache. Blood pressure was 130/80, heart rate was 85 beats per minute, respirations of 18 a minute and oxygen saturation of 98% on room air. He was found to have a BMI of 30.4 and an increased waist to hip ratio. To assess pulmonary status patient underwent a spirometric flow volume measurement. The patient was observed to have a forced vital capacity (FVC) of 3.92 L (105% predicted), a forced expiratory volume in 1 second (FEV<sub>1</sub>) of 3.16 L (106% predicted) and a Tiffenau index (FEV<sub>1</sub>/FVC) of 81%. Despite relatively normal spirometric values, flow oscillations were observed on inspiratory and expiratory phases (Figure 1). The patient was further evaluated by Epworth Sleepiness Scale (ESS) due to history of sinus pauses assessment, which revealed a score of 20/24, consistent with poor quality sleep and possible sleep disorder. Because of the patient's history, high ESS Score and increased body mass index he underwent a Polysomnography (PSG) and was found to have severe obstructive sleep apnea (OSA) with an apnea-hypopnea index (AHI) of 30.4 events per hour. He subsequently underwent continuous positive airway pressure (CPAP) titration and therapy was initiated. To rule out any mechanical causes of flow oscillations the patient underwent

indirect laryngoscopy which showed oropharyngeal crowding (Mallampati Score; 4/4). Computer tomography of the soft tissues of the neck was unremarkable. A neurological exam was also found to be normal. The patient was followed in our pulmonary outpatient clinic for his sleep apnea and was maintained on optimal CPAP pressure.

### Discussion

The saw-tooth sign on flow-volume loops was first described by Sanders as a possible diagnostic modality for upper airway obstruction associated with obstructive sleep apnea syndrome (OSA) [4].



**Figure 1.** Flow-volume loop showing inspiratory and expiratory flow oscillations

**Table 1. Sensitivity and specificity of "saw-tooth" sign in obstructive sleep apnea**

Reference	N	Sex	N with known OSA	N with saw-tooth	Sensitivity	Specificity
[4]	21	19 (m) 2 (f)	13	11	0.85	1.00
[8]	30	22 (m) 8 (f)	17	12	0.47	0.85
[9]	57	52 (m) 5 (f)	30	18	0.61	0.54
[3]	360	360 (m) 0 (f)	—	26	—	—
[10]	858	87 (m) 53 (f)	134	36	—	—

**Table 2. Clinical conditions and causes of flow oscillations**

Clinical condition	Physiologic cause	Reference
Obstructive sleep apnea syndrome	Fluttering of tissue due to adiposity	4–10]
Neuromuscular disorders	Weakening of bulbar muscles	[14]
Extrapyramidal disorders	Weakening of bulbar muscles	[15–17]
Upper airway stenosis	Mechanical blockage	[13]
Burn injury	Damage to supporting structures of upper airways	[18, 19]
Herpes zoster	Inflammation of nerves innervating the diaphragm	[22]
Leeuwenhoek's disease	Diaphragmatic myclonus	[23, 26]
Tracheobronchomalacia	Chronic airway inflammation	[12, 20, 21]
Artifact	Due to equipment, patient cooperation	[3]

It is defined as three or more consecutive peaks and troughs occurring at regular intervals of no greater than 300 cm<sup>3</sup>, during the middle half of the vital capacity on a spirometry [4]. It represents a series of brisk oscillations on a spirometric flow volume curve which creates a characteristic saw-tooth like pattern that are thought to be due to airway collapsibility [5]. A more clinical definition was provided by Vincken [2] who described flow oscillations as “a sequence of alternating decelerations and accelerations of flow, creating a »saw-tooth« pattern superimposed on the general contour of the flow volume loop produced by an awake subject that are reproducible” [2]. Though Sanders originally defined the saw-tooth pattern, the authors of this article feel that Vincken's definition is easier and more practical for clinicians to follow.

The flow oscillations pattern has been widely described in obstructive sleep apnea syndrome [5–9] though sensitivity of this test in OSA is variable (Table 1). In a study by Levant et al. it was found that all OSA patients that exhibited a saw-tooth sign were male, smokers and had a larger than normal neck circumference [10]. On polysomnography they also exhibited longer duration of apneas and oxygen desaturation and had a greater risk of coronary artery disease [10]. Flow oscillations have also been linked to many other upper airway pathologies (Table 2). In a large retrospective survey of 2800 flow-volume loops the incidence of flow oscillations has been found to be up to 1.4% [11]. The presence of flow loop oscillations should clue physicians to rule out upper airway pathology [3]. Since visual inspection of the flow volume loop can reveal presence of flow oscillations clinicians should be aware of this phenomenon [11].

Flow oscillations have been seen in the case of upper airway stenosis due to obstructive le-

sions<sup>13</sup> where there is a mechanical blockage of the airways. Other clinical conditions in which this phenomenon is seen are neurological defects where supporting muscles of the upper airway become dysfunctional such as Parkinson's disease and other neuromuscular disorders [14–17] in which weakening of the bulbar muscles allow for this rhythmic airflow. Though rare, they have also been described in patients who have suffered from burns [18, 19] and tracheobronchomalacia [12, 20, 21] in which structural integrity is compromised. Cases of abdominal herpes zoster and Leeuwenhoek's disease have also been described to produce such flow volume curves [22, 23].

### Mechanisms of “saw-tooth pattern”

The mechanism by which flow oscillations occur is centered on the inspiratory and expiratory flow of air. It has been theorized that the mechanism of flow oscillations result from rapid intermittent changes in driving pressure or airway resistance [2]. The intermittent changes in airway resistance may have many etiologies. One of the etiologies may be due to structural upper airway lesions leading to a narrowing. The end result of these lesion cause a dynamic upper airway compression which in turn may cause fluttering of tissue due to transmural pressure change, synonymous with Bernoulli's principle [4]. There may be an excess of adiposity leading to fluttering of redundant tissue, which also changes the airway pressure. Upper airway instability has also been culprit in producing flow oscillations. This may result from loss of striated muscle function surrounding the upper airway or due to intrinsic factors [24, 25]. Upper airway muscle dysfunction, such as the bulbar muscles is also seen in neuromuscular disorders and may

lead to changes in airway resistance. Abnormal phasic activity of the upper airway muscle can also lead to intermittent airway narrowing and airflow reduction. This has been clearly shown to occur in various extrapyramidal disorders, such as Parkinson's disease and essential tremor [15].

Intermittent changes in driving pressure may also result in the pathogenic mechanism of flow oscillations. Rapid changes of driving pressure may be due to abnormal phase activity of respiratory pump muscles [2]. Though not commonly seen in Leeuwenhoek's disease, causing a rhythmic myoclonus of the diaphragm may also cause myoclonus of the upper airway muscles leading to flow oscillations [23, 26].

Lastly flow oscillations may be present without an underlying pathology. Spurious flow oscillations have been observed as a result of sound production, cough or glottis closure [2, 11, 27].

## Conclusion

Spirometric flow-volume loops provide clinicians with important data regarding ventilatory patterns. However, clinicians should be aware of the saw tooth pattern on the flow-volume loop tracing itself, as it may also indicate underlying upper airway disorder. As its mechanism suggests presence of this sign indicates some upper airway pathology that should be further investigated with polysomnography, endoscopy or radiological measures.

## Conflict of interest

The authors declare no conflict of interest.

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