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SLEEP MEDICINE PEARLS

Confusing Signals During a Positive Airway Pressure Titration

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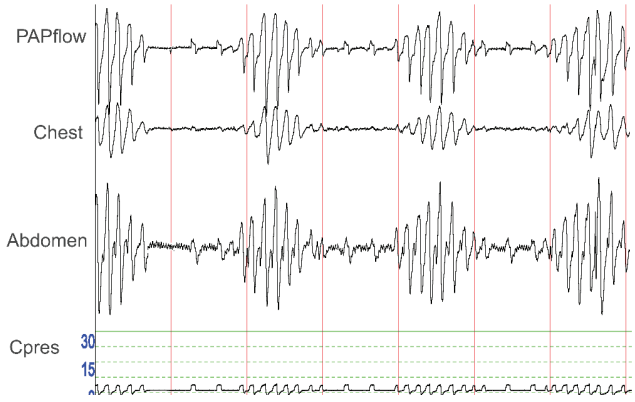
A 60-year-old man with congestive heart failure (preserved ejection fraction) and atrial fibrillation was referred for ongoing treatment with adaptive servoventilation (ASV). The only medical record available was a single clinic note summarizing his previous testing and treatment. A split sleep study performed approximately 4 years prior to clinic presentation revealed obstructive sleep apnea in the diagnostic portion and central sleep apnea of the Cheyne-Stokes type during the positive airway pressure (PAP) titration. After a subsequent ASV treatment study, the patient responded well with this therapy until the device stopped working. After an unsuccessful attempt at obtaining prior sleep study reports, a split-night sleep study was ordered to qualify the patient for new equipment. The diagnostic portion again documented obstructive sleep apnea and a titration with continuous positive airway pressure (CPAP) was initiated. Frequent respiratory events as illustrated in **Figure 1** and **Figure 2** were noted on CPAP of 9 cm H_2O with expiratory pressure relief (C-Flex+ of 3) using an Omnilab Advanced PAP device (Philips Respironics, Murrysville, Pennsylvania, United States). The PAP flow is the flow signal from the PAP device (inspiration upward), chest and abdomen are the respiratory inductance plethysmography effort belt signals, and Cpres is the airway pressure signal from the PAP device.

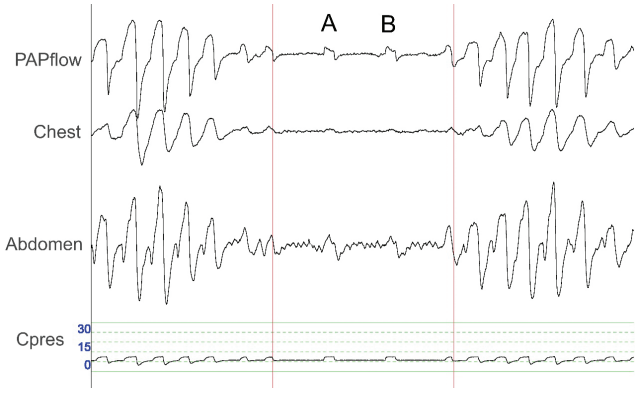
QUESTION: What type of respiratory events are illustrated in Figure 1 and Figure 2?

Figure 1—A 210-second tracing on treatment with CPAP of 9 cm H_2O (C-Flex+ mode).



PAP flow is the PAP flow signal (inspiration upward), chest and abdomen are respiratory inductance plethysmography effort belt signals, and Cpres is the airway pressure signal from the PAP device. The vertical time lines are 30 seconds apart. CPAP = continuous positive airway pressure, PAP = positive airway pressure.

Figure 2—A 90-second tracing (an enlargement) of the second event shown in Figure 1.



Note the small amounts of airflow at points **A** and **B**. PAP flow is the flow signal from the PAP device, Chest and abdomen are the respiratory inductance plethysmography effort belt signals, and Cpres is the PAP device airway pressure signal. PAP = positive airway pressure.

ANSWER: Central apneas of the Cheyne-Stokes type with artifact from device pressure pulses.

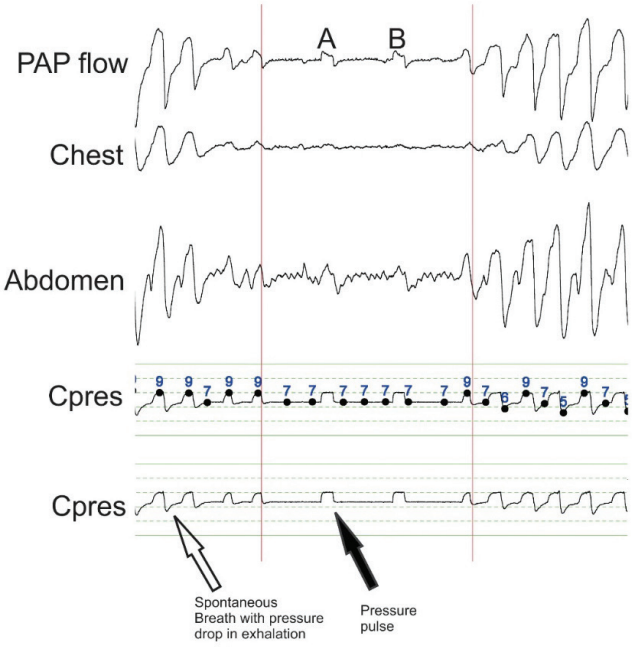
DISCUSSION

Advanced PAP device technology can be confusing when interpreting PAP titration studies. The events depicted in **Figure 1** and **Figure 2** are central apneas. The small amounts of airflow at points A and B are coincident with 2 cm H_2O pressure pulses delivered by the PAP device to classify the apnea (clear airway versus obstructive airway).[1] The small deflections in the chest and abdomen tracings might appear to be patient effort, but the "respiratory rate" would be very slow and the deflections coincide with the pressure pulses. The pressure pulse option (for apnea classification) is usually turned off for most polysomnography titration studies (respiratory effort tracings are recorded). However, the option was inadvertently turned on during this study.

Certain PAP devices classify apneas as clear airway or obstructive airway based on the airflow response to either a small pressure pulse (Philips Respironics, Murrysville, Pennsylvania, United States) or forced oscillation (ResMed, Poway, California, United States). When a period of near-absent airflow is noted by the PAP device, either a small pressure pulse or airway pressure oscillation is delivered. Clear airway apneas are characterized by a small amount of flow associated with the pressure pulse (**Figure 3**, points A and B) or airway pressure oscillation. Because the absence of respiratory effort is not monitored by the PAP device, the apneas are not device-classified as central but rather as "clear airway." The duration of the absent airflow before the pressure pulse is delivered is based on a proprietary algorithm but in general is 6 to 8 seconds. Although pressure pulses occur after a relatively short period of reduced flow, a given event is not scored as an apnea by the device unless the airflow falls below 80% of the preceding average airflow for at least 10 seconds. A study comparing device apnea classification with manual classification based on polysomnography[1] showed that only 62% of device scored "clear airway apneas" were manually scored as central during polysomnography with 16% being scored as obstructive apneas, 15% as hypopneas, and 7% as respiratory effort-related arousals. However, 21% of device-classified "obstructed airway apneas" were manually scored as central by polysomnography, which is consistent with a previous study showing that the upper airway is occluded during some central apneas.[2]

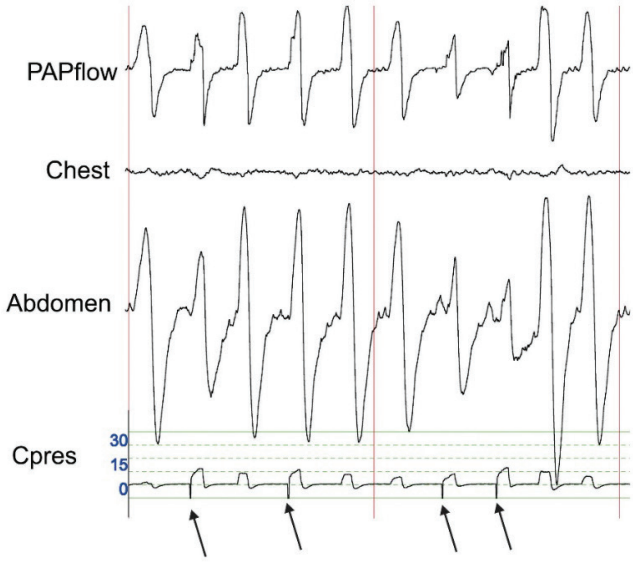
The PAP treatment delivered in **Figure 1** and **Figure 2** is CPAP but may appear at first glance to be bilevel PAP with a small inspiratory to expiratory pressure gradient. However, the mode used was C-Flex+ (Philips Respironics), which drops the airway pressure at the start of exhalation according to a proprietary algorithm (the greater the expiratory flow the greater the pressure drop) returning to a pressure 2 cm H_2O below the inspiratory pressure at end exhalation. In **Figure 3**, note the difference between spontaneous breaths with C-Flex+ exhibiting a pressure drop on exhalation (hollow arrow) and the lack of pressure drop in early exhalation following a pressure pulse

Figure 3—A 70-second tracing (vertical time lines are 30 seconds apart) showing the event in Figure 2 with enlargement of the Cpres (airway pressure) tracings.



Tracings with and without pressure values in cm H_2O are shown. The hollow arrow identifies a spontaneous breath exhibiting a pattern consistent with the C-Flex+ mode and the dark arrow identifies the device-triggered small pressure pulse for apnea classification. Airflow at **A** and **B** is consistent with a "clear airway apnea."

Figure 4—A 60-second tracing showing treatment with adaptive servoventilation.



The arrows identify the downward pressure artifact added to the pressure signal to identify a device-triggered breath.

(solid arrow). Later in the study, the patient was started on ASV. In **Figure 4**, the arrows show the artifact introduced into the Cpres signal by the device to signify machine-triggered breaths. The tracing illustrates that recording and observing the device airway pressure signal is clinically useful for understanding the treatment being delivered.

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1. Some current PAP devices classify apneas as clear airway or obstructive airway based on the flow response to a device-triggered small pressure pulse or pressure oscillation. If the pressure pulse in the laboratory PAP device is turned on, this can result in confusion in classifying respiratory events as central or obstructive.
2. Machine-triggered pressure pulses can result in some degree of chest or abdominal signal deflection, sometimes giving the appearance of active patient respiratory effort. This phenomenon can be identified by noting that the timing of the deflections in the chest and abdominal tracings coincide exactly with the device-triggered pressure pulse.
3. Recording and carefully observing the device airway pressure signal (here labeled Cpres) can help the clinician better understand the type of treatment being delivered by the PAP device during polysomnography.

CITATION

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DISCLOSURE STATEMENT

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