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The Batman sign: Graphical representation and pedagogical strategy for teaching ventilator asynchronies

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Abstract

Introduction
Patient–ventilator asynchronies (PVA) are common in intensive care units and are associated with adverse outcomes, such as increased work of breathing, higher sedation requirements, and prolonged mechanical ventilation. Despite the availability of ventilator waveform monitoring, clinical recognition of PVA remains low. This highlights the need for innovative educational strategies to improve interpretation and response.
Objective
To propose a visual analogy termed the "Batman sign" as a mnemonic tool to support the teaching and recognition of complex PVA.
Methods
Clinical waveform data were analyzed to identify a distinctive pattern in the pressure–time curve caused by the simultaneous presence of two asynchronies: excessive flow and delayed cycling. The resulting morphology resembles the frontal silhouette of the fictional character Batman, with two symmetrical peaks evoking his ears. This analogy served as the foundation for a visual teaching strategy aimed at improving PVA recognition among clinicians in training.
Results: We describe the physiological and waveform features of each asynchrony, their clinical implications, and their combined presentation as the "Batman sign." By incorporating dual coding theory and principles of meaningful learning, this visual resource enhances the understanding of complex ventilatory events. Illustrative figures support the practical application of the concept.
Conclusion
The "Batman sign" represents an innovative pedagogical approach that integrates visual and clinical reasoning to improve mechanical ventilation education. Its application may enhance diagnostic competency, foster knowledge retention, and support clinical decision-making in high-acuity care settings. Further validation in training programs is recommended.

Keywords: Mechanical ventilation, Critical care, Patient-Ventilator Asynchrony, Education, Learning Curve

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Introduction

Patient ventilator asynchronies (PVA) are a common phenomenon in the intensive care unit (ICU). They occur when there is a mismatch between the patient's spontaneous breathing efforts and the mechanical ventilator's cycles, leading to clinically significant consequences such as increased work of breathing, higher sedation requirements, prolonged mechanical ventilation, and ultimately, an increased risk of mortality. [1-3]

Timely recognition of these asynchronies is a key clinical skill in the management of critically ill patients. However, the literature reveals a concerning scenario: international studies indicate that fewer than 30% of healthcare professionals can correctly identify asynchronies using conventional monitoring, [4] and multicenter studies conducted in our country show even lower rates. [5] This gap in recognition not only underscores an educational need but also highlights a pedagogical shortfall in clinical training related to the interpretation of ventilator waveforms.

Given this context, it is essential to rethink the educational strategies used to teach mechanical ventilation. Tools such as mnemonics and visual analogies have proven effective in facilitating the understanding of complex clinical concepts, especially in environments where learning must be rapid, meaningful, and applicable. These strategies promote knowledge integration by creating symbolic, visual, or cultural associations that connect with pre-existing cognitive structures. [6-8] From the perspective of meaningful learning and dual coding theory, the combination of verbal and visual information enhances retention, clinical reasoning, and decision-making. [9,10]

While similar resources have been successfully incorporated in various areas of medicine, their application to the analysis of ventilator waveforms remains limited. In clinical practice, visual observation of pressure and flow waveforms continues to be the primary method for detecting asynchronies. [11] Therefore, incorporating visual pedagogical tools can serve as a valuable bridge between theoretical knowledge and clinical application.

In response to this need and recognizing that rare cases can involve the simultaneous presence of multiple asynchronies within a single breath we propose a visual analogy called the "Batman sign." Inspired by the distinctive morphology of certain ventilator waveforms that resemble the silhouette of the fictional character, this representation aims to facilitate the identification of complex patterns, fostering active learning and visual memory in real-world intensive care settings. With this proposal, we not only offer an innovative teaching tool but also contribute to building a more accessible, creative, and clinically useful educational approach.

Description

Excessive flow asynchrony occurs when the ventilator delivers an inspiratory flow that exceeds the patient's actual demand. This mismatch results in an initial over pressurization of the airway, observable as an abrupt and prominent rise in the pressure-time curve at the beginning of the inspiratory cycle. This graphical morphology represents a transient, undesired pressure caused by the rapid inflow of gas and serves as a useful marker for identifying this type of asynchrony.

This phenomenon is commonly referred to as "overshooting," characterized by an early peak in the pressure-time curve that reflects the mismatch between the ventilator's flow delivery and the patient's real effort. As shown in Figure 1, this initial prominence precedes the stabilization of the waveform, indicating a disproportionate flow delivery that can disrupt ventilatory synchrony and contribute to respiratory discomfort.

From a didactic perspective, this initial prominence has been associated, through a visual analogy, with the right ear of the "Batman sign," as seen in a side profile of the character facing left to right. This symbolic representation does not correspond to the complete pattern of the sign but rather to its first morphological manifestation on the curve of the ear that appears before the rest of the figure and is proposed as a mnemonic resource to facilitate clinical recognition. By linking this shape to a widely recognized visual icon, the dual (verbal-visual) coding of learning is reinforced, promoting a more intuitive and meaningful identification of the excessive flow asynchrony pattern.

Delayed cycling asynchrony occurs when there is a mismatch between the patient's neural inspiratory time defined as the moment when their respiratory center determines that inspiration should and the mechanical inspiratory time set on the ventilator by the clinician. In this scenario, the ventilator keeps the expiratory valve closed for longer than the patient physiologically needs, preventing the timely onset of exhalation. This discrepancy creates a brief "struggle" between the patient's physiological need to exhale and the persistence of the imposed inspiratory cycle, resulting in an over pressurization of the airway towards the end of the breath cycle.

From a graphical perspective, this asynchrony appears on the pressure-time curve as a late prominence, corresponding to the patient's effort to initiate exhalation while the ventilator continues to sustain the inspiratory phase. This late rise is a characteristic pattern of this type of mismatch and has additional educational value due to its distinctive morphology. From a pedagogical standpoint, this prominence can be interpreted as the "left ear" of the Batman sign, this time seen in reverse as if the character were facing from right to left.

This visual analogy not only illustrates the mismatch between the neural expiratory impulse and the ventilator's programmed cycle but also serves as an effective mnemonic strategy, facilitating the clinical recognition of this asynchrony and promoting meaningful learning in the interpretation of complex ventilator waveforms, as depicted in Figure 2.

Figure 1: Excessive flow asynchrony.

Figure 2: Delayed cycling asynchrony.

A prominence is observed in the final phase of the pressure-time curve, reflecting the over pressurization caused by the patient's effort to initiate exhalation before the expiratory valve opens. This shape represents the "left ear" of the Batman sign, seen from right to left, and serves as a visual marker for the clinical identification of this asynchrony.

Composite asynchrony: the Batman sign

In certain clinical scenarios, the two previously described asynchronies excessive flow and delayed cycling can coexist within a single breath cycle. This occurs when, at the start of inspiration, the ventilator delivers a flow that exceeds the patient's demand (producing the first prominence, or "right ear"), and subsequently, the ventilator maintains the inspiratory phase beyond the patient's neural expiratory time (creating a second prominence, or "left ear"). This double asynchrony generates a distinctive silhouette on the pressure-time curve, morphologically resembling the frontal outline of Batman's face, with both "ears" projected towards the outer edges of the waveform.

We refer to this composite graphical pattern as the "Batman sign asynchrony," a visual representation that clearly and didactically summarizes the simultaneous presence of two clinically relevant asynchrony events. This analogy not only simplifies recognition but also provides clinicians with an intuitive tool for the early detection and timely correction of ventilatory mismatches that, if left unaddressed, can significantly impact morbidity and mortality in critically ill patients.

When a single breath simultaneously includes both asynchronies, a highly characteristic pressure-time curve can be observed, as illustrated in Figure 3. This waveform bears a striking resemblance to the silhouette of the animated character "Batman sign" giving rise to its name.

Although uncommon, this asynchrony can occur repetitively, particularly in ventilatory modes that allow greater spontaneous participation by the patient, such as CPAP with pressure support (PSV) or BILEVEL modes. In these contexts, the Batman sign asynchrony may persist across consecutive cycles, as shown in Figure 4.
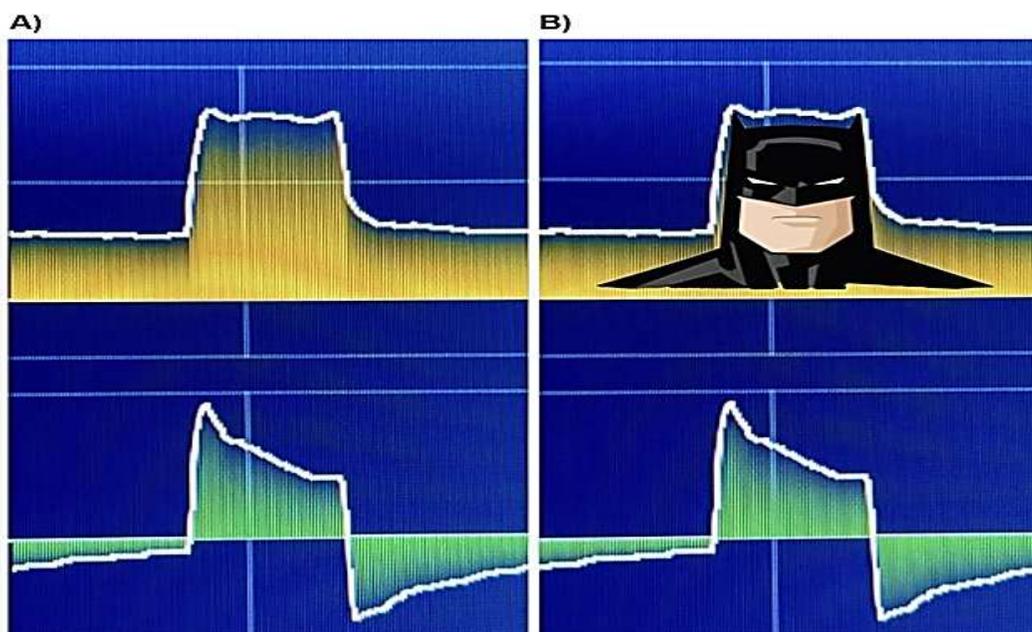

Figure 3. Batman sign – Composite ventilatory asynchrony.
A: Pressure and flow waveforms from a real case demonstrating simultaneous excessive flow and delayed cycling asynchronies.
B: Visual comparison between the waveform morphology and the frontal silhouette of the Batman character, highlighting the two prominences as "ears."
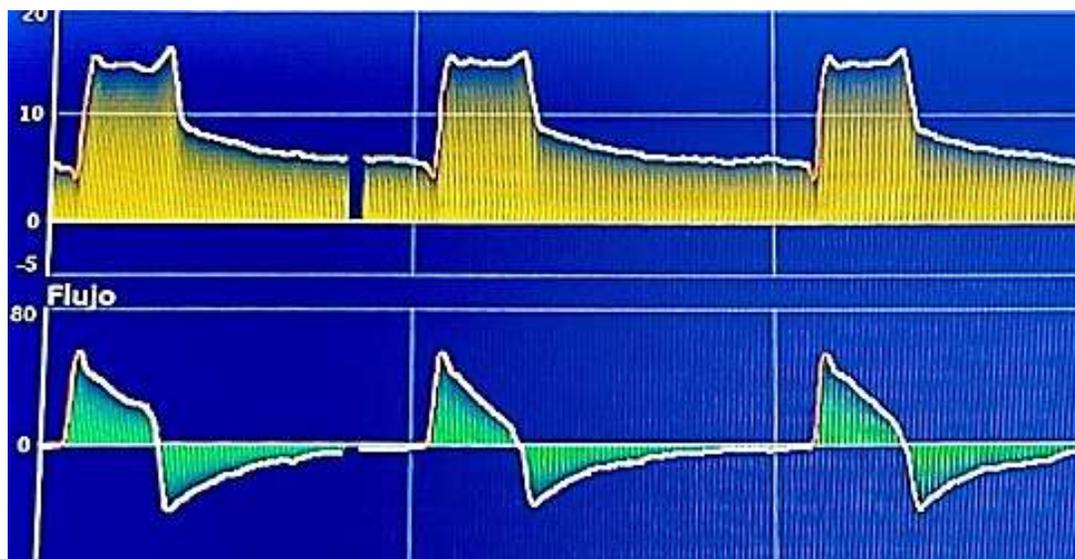
Figure 4. Consecutive Batman sign. Consecutive Batman sign: Representation of multiple consecutive ventilatory cycles in which the composite asynchrony of excessive flow and delayed cycling is observed, generating the repeated silhouette of the Batman sign.

Discussion

Graphical monitoring of mechanical ventilation has long been recognized as an essential tool for the early detection of PVA. However, the literature has also shown that the ability of clinical staff to recognize these asynchronies remains limited, even in highly specialized intensive care units (ICUs). Recent studies report correct identification rates of less than 30% among ICU professionals, both in high-resource settings and in resource-limited contexts. [12-14]

This diagnostic gap has significant clinical implications, including increased work of breathing, prolonged ventilation and ICU length of stay, as well as higher risks of tracheostomy and associated morbidity. [3]

Despite access to real-time monitoring technologies, interpretation errors persist. This can be partially explained by the lack of specific training in ventilator waveform analysis. Zelalem et al [12] found that only 10.5% of professionals assessed demonstrated a good level of knowledge about asynchronies using graphic monitoring, and this competency was strongly linked to specialized training in mechanical ventilation and the number of dedicated educational sessions attended. Similarly, Colombo et al [13] showed that even among intensivists, the sensitivity for detecting specific asynchronies through direct waveform observation did not exceed 28% in breath by breath analyses, improving only slightly in post-hoc reporting assessments.

In this context, our document corresponds to the first publication that associates ventilatory waves with mnemonics as an innovative strategy, the "Batman sign" is more than a curious graphic representation it has an explicit educational purpose: to introduce a visual mnemonic strategy that facilitates the recognition, understanding, and intervention in complex asynchrony patterns. Mnemonics, and visual analogies in particular, have been widely recognized as effective resources for meaningful learning, as they allow for the association of complex clinical concepts with familiar cultural or symbolic references.[6,8] These types of strategies activate dual coding processes (verbal and visual), which strengthen information retention and real-time retrieval during clinical analysis. [15]

By associating the typical waveform prominences of excessive flow asynchrony and delayed cycling asynchrony with the "ears" of Batman seen in profile or frontally this approach proposes a visual code that enhances practical recognition. This tool is especially valuable in training healthcare professionals who are still developing their ventilatory analysis skills, and it addresses the need for pedagogical strategies tailored to high cognitive and emotional demands in critical care settings. [16]

Therefore, the Batman sign is not merely a graphic curiosity but rather a didactic tool applicable to real-world clinical training scenarios. Its value lies in offering a meaningful visual representation that facilitates the identification of complex asynchronies, particularly among trainees. This proposal aligns with contemporary educational models that promote the integration of visual, symbolic, and experiential learning to strengthen clinical competencies in cognitively

demanding environments like the ICU. Nevertheless, this strategy should be considered as a complement to, not a replacement for, structured mechanical ventilation training. Future studies could explore its effectiveness in terms of knowledge retention, diagnostic performance, and clinical decision-making.

Conclusion

The identification of ventilatory asynchronies remains a significant clinical challenge in intensive care units, despite the growing availability of graphic monitoring tools. This article proposes a pedagogical strategy based on a visual analogy: the Batman sign, as a mnemonic resource to intuitively and meaningfully represent the coexistence of two common asynchronies: excessive flow and delayed cycling.

Beyond its value as a graphical pattern, this proposal has an explicitly educational purpose. It is presented as a didactic tool that facilitates the understanding of complex physiological phenomena, promotes dual coding (verbal-visual), and enhances the ability of healthcare professionals in training to identify and address asynchrony patterns in real time. Its design is aligned with principles of meaningful learning and can be integrated as a complementary resource in clinical training programs for mechanical ventilation.

The model is replicable and adaptable to various educational settings, particularly in cognitively demanding environments such as the ICU. Formal validation of its application is recommended through studies assessing its impact on knowledge retention, diagnostic accuracy, and clinical decision-making. Ultimately, the Batman sign represents an innovative and clinically useful educational strategy with the potential to strengthen the competencies of healthcare professionals in analyzing and interpreting ventilator waveforms.

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