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Not All Breaths That Follow a Ventilator Cycle Are Reverse Triggering

To the Editor:

We read with great interest the article by Shimatani and colleagues (1), in which the authors sought to describe the frequency of reverse triggering (RT) and its associated risk factors among pediatric patients with acute respiratory distress syndrome. The authors have conducted a colossal work, analyzing the patient–ventilator synchronization in 36 patients. Their main conclusion is that RT is highly prevalent in this population, as it was observed in 41.6% of patients and associated with breath stacking in 25% of the cases. This finding is quite surprising, as only one case of RT has been previously reported in children (2).

We completely agree that patient–ventilator asynchrony was very frequent in their series, in line with previous findings (3). However, we respectfully disagree with the diagnosis of RT in this study and, therefore, its prevalence. As initially described by Akoumianaki and colleagues (4), the notion of RT implies that the patient's effort is triggered by the ventilator, with the patient's respiratory drive being entrained by the ventilator rate. Differentiating a patient's spontaneous breath from a breath triggered by the ventilator is difficult. To allow this distinction, important criteria have been proposed (4): the RT breaths should occur according to a stable and repetitive pattern, with minimal variability (as assessed by the coefficient of variation) of both the neural respiratory time and the phase difference, and at least five breaths with a fixed mechanical/patient effort ratio (1:1, 1:2, or 1:3) should be present.

Shimatani and colleagues did not use these discriminant criteria. All patients' breaths occurring after the beginning of insufflation were defined as RT breaths, with no criteria related to the phenomenon's regularity and predictiveness (see Table E1 in the online supplement). They observed a single patient with a clear repetitive pattern of RT (1:1), which is a worthy and significant result, as descriptions of RT in pediatrics are scarce. However, there is no evidence that the "RT" breaths observed in the 14 remaining patients were really triggered by the ventilator. No regular pattern was observed in these patients, in contradiction with recent adult studies in which the absence of an identified pattern was very rare (5) or simply excluded by definition.

Except for the patient with a 1:1 entrainment pattern, our interpretation is that most asynchronous breaths observed after the beginning of the ventilator cycle are not RT but instead reflect severe

patient–ventilator asynchrony, with a complete "dissociation" between the ventilator's and patient's rates. This is well illustrated in their Figure 3, in which patient B exhibits regular spontaneous breaths. It seems quite probable that the first and sixth breaths (considered RT) were not triggered by the ventilator but rather occurred at this time fortuitously. In the absence of a convincing demonstration of entrainment by the ventilator, we believe that this type of asynchronous event should rather be classified as "premature triggering" (3) or complete desynchronization.

Is this distinction important? As pointed out by Shimatani and colleagues, a theoretical risk of ventilation-induced lung injury exists in cases of breath stacking with increased tidal volume. We fully agree that detecting these events is primordial, whether they are considered RT breaths or not. However, we believe maintaining a rigorous definition and differentiating RT from other types of asynchrony is essential because the pathophysiology and management likely differ. Adjusting the ventilator settings to the patient's breathing effort or innovative ventilation modes such as neurally adjusted ventilatory assist can markedly improve severe asynchrony, whereas the management of RT is not well established. Observing the patient's response to a prolonged expiratory hold can help facilitate the distinction between RT episodes and simple asynchronous effort (6).

Author disclosures are available with the text of this letter at www.atsjournals.org.

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Reply: Not All Breaths That Follow a Ventilator Cycle Are Reverse Triggering

From the Authors:

We thank Dr. Levy and colleagues for posing a debate about our definition of reverse triggering (RT) (1), contending that RT breaths should occur with minimal variability of neural respiratory time and phase difference, with a fixed mechanical/patient effort ratio (1:1, 1:2, or 1:3). We agree that RT should include a stable phase difference, but we do not believe that a fixed pattern of mechanical/patient effort should be used in RT definitions.

First, in most previous reports, Assist/Controlled (AC) was used (2), with a fixed pattern for breath delivery and cycling. This is more likely to produce RT with a predictable pattern of entrainment. Nevertheless, RT can still be irregular in AC because the reverse breaths lead to incomplete exhalation, air trapping, or double cycling. A recent study (3) in adult patients used a similar definition for RT as ours, using electrical activity of the diaphragm to confirm patient effort. Although these adult patients were mostly on AC, a consistent pattern of entrainment was not always present, with nearly 90% of patients having at least a few RT breaths and RT occurring in 2–8% of breaths. Although not a requirement for their definition, RT breaths without clear entrainment patterns had a stable phase angle (difference between timing of machine inflation and patient effort), which would argue against them being “premature triggering” of the ventilator.

In our study, synchronized intermittent mandatory ventilation pressure control–pressure support (SIMV PC-PS) was used, in which time cycled breaths (pressure control) are mixed with flow cycled breaths (pressure support), which may predispose to an even more irregular pattern of RT. In our cohort, the phase angle for RT breaths for patients with an “inconsistent” pattern of entrainment was nearly always constant within the patient with low coefficient of variation. Although the overall median phase angle from patient to patient with RT ranged from 20 to 140, the median coefficient of variation of the

phase angle among RT breaths within a patient was 20.2 (interquartile range, 13.6–25.1). This demonstrates that patients with RT had internally consistent and minimally variable timing of respiratory effort after lung inflation.

Furthermore, RT with 1:1 entrainment had median tidal volume (V_T) of 9 ml/kg, inconsistent RT had V_T of 8.9 ml/kg, and no RT had V_T of 6.0 ml/kg. RT with 1:1 entrainment had a median difference between neural respiratory rate and set ventilator rate of 0 breathing per minutes (bpm), inconsistent RT 5.3 bpm, and no RT 13.5 bpm. It seems that risk factors for RT with an “inconsistent” pattern are very similar to RT with a consistent pattern.

We also believe set ventilator rate is integral to understand why RT does not always have consistent entrainment (4). We recently had cases of RT with consistent entrainment and modified the respiratory rate. Figure 1A1 is from a 2 year old on SIMV PC-PS with a set ventilator rate of 21 and RT with 1:1 entrainment with a positive phase angle of 48°. After reducing the ventilator rate to 15 (Figure 1A2), he continued to breathe 21 bpm with no RT and a negative phase angle of –16°. RT was abolished by lowering the ventilator rate. Figure 1B1 shows a 2-year-old girl with 1:1 entrainment with a phase angle of 68° and consistent double cycling. Interestingly, dropping the ventilator rate did not completely eliminate RT, but it did convert it from 1:1 entrainment to an irregular entrainment pattern (Figure 1B2). She still had irregular RT 24 hours later, but the phase angle of her RT breaths remained similar to the day before at 64° (Figure 1B3). It is hard to argue that irregular patterns of RT do not represent RT when we could convert RT with 1:1 entrainment to an irregular pattern of RT by manipulating the ventilator rate. However, we could not eliminate RT completely, speaking to its complex physiology.

Importantly, irregular RT can cause harm from breath stacking and eccentric contraction of the diaphragm with myotrauma, making it important to have clear definitions for RT to create targeted treatment strategies. These definitions should not mandate a consistent respiratory entrainment pattern given the multitude of variables that affect this and that risk factors for RT are similar between those with and without consistent entrainment. However, it is important to ensure a stable phase relationship in the timing of patient effort after ventilator insufflation to label a breath as an RT, and perhaps low coefficient of variation of phase angle within RT breaths should be required.

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