Patient-Ventilator Interaction

Poor patient-ventilator interaction (patient-ventilator asynchrony) has been increasingly recognized during both invasive and noninvasive ventilation. The importance of optimizing patient-ventilator interaction has been most evident from the studies that showed that asynchrony is associated with adverse outcomes, including increased time on mechanical ventilation. Patient-ventilator interaction depends upon the complex interplay of patient pathophysiology and the delivery of a mechanical breath, with the latter integrating the characteristics of the ventilator and the settings chosen by the clinician. Modern ventilators provide sophisticated monitoring with graphic representations that allow the clinician to assess patient-ventilator interaction at the bedside. In addition, these devices increasingly provide new modes and other tools that automatically adjust settings to optimize the interaction between the patient and ventilator.

The purpose of this Journal conference was to review all facets of patient-ventilator interaction. Therefore, we convened a distinguished group of clinicians, including physicians and respiratory therapists, and investigators to address these crucial issues. Each presentation was followed by spirited discussion that, more often than not, highlighted appropriate areas of consensus and important areas of contention.

The conference got off to a strong start, with Rich Branson placing the patient-ventilator interaction in historical context. He reminded us of the evolution from early ventilators that made little provision for the patient-ventilator interaction to a new generation of machines where this has become a design priority.

Scott Epstein then discussed the epidemiology of patient-ventilator interaction, noting that (depending on the patient population, ventilation mode employed, and method of detection) patient-ventilator asynchrony is a common phenomenon. He further detailed the association between asynchrony and numerous adverse effects (eg, increased patient discomfort, longer intubation and stay) and noted that whether asynchrony *causes* poor outcomes or is, instead, a marker remains to be proven.

Sai Parthasarathy then discussed control of breathing, how it affects patient-ventilator interaction, and how ventilators alter the control of breathing. He then explored the complex interaction between various stimuli (eg, chemoreceptors, mechanoreceptors) and the respiratory controller and emphasized the differences between the asleep and

the awake states and the resulting effect on patient-ventilator interaction.

Catherine Sassoon completed the first session by elegantly examining the influence of ventilator triggering, triggering delay, and the post-triggering effects on work of breathing and patient-ventilator interaction. In so doing she elucidated the mechanisms underlying trigger asynchrony (untriggered breaths or ineffective efforts), auto-triggering, and flow asynchrony.

The second session opened with Mike Gentile, who described the complex cycling mechanisms that determine how and when the ventilator transitions from inspiration to expiration. He discussed criteria employed by different ventilators (time, pressure, volume, flow) to determine the mechanical inspiratory time, and the challenge in matching the mechanical inspiratory time to the patient's neural inspiratory time; a mismatch between the mechanical and neural inspiratory time results in cycle asynchrony. He further demonstrated how the effect on patient-ventilator interaction depends on the underlying respiratory pathophysiology.

Marjolein de Wit then discussed how clinicians can use ventilator graphics (predominantly flow, volume, and airway pressure signals) to analyze the patient-ventilator interaction at the bedside. Using a large personal database of tracings, she demonstrated how these waveforms can be systematically analyzed to identify patient-ventilator asynchrony.

With factors that determine patient-ventilator interaction and the various types of asynchrony defined, Neil MacIntyre launched into a discussion of how this interaction can be optimized in patients on conventional modes of mechanical ventilation. Specifically, he described how changes in triggering, flow, cycling, and the level of support during pressure support, and volume-control and pressure-control continuous mandatory ventilation can be optimized.

Rob Chatburn then wrapped up the second session with a discussion of the taxonomy of closed-loop ventilation, focusing on a practical approach to classification using 6 basic ventilator targeting schemes: set-point, dual, servo, adaptive, optimal, and intelligent. He then discussed how these control systems are designed to promote effective patient-ventilator interaction, with an emphasis on safety, comfort, and liberation.

With the basis for closed-loop control thus defined, Bob Kacmarek kicked off the third session with a discussion of 2 innovative ventilator strategies: proportional assist ven-

tilation, and neurally adjusted ventilatory assist. He emphasized that these modes were developed to improve patient-ventilator synchrony by proportionally unloading ventilatory effort and allowing the patient to control the ventilatory pattern.

Dean Hess next tackled the pathophysiology, detection, and treatment of patient-ventilator asynchrony during non-invasive ventilation. He emphasized how cycling asynchrony often directly results from leaks at the interface. He also noted that higher patient comfort with noninvasive ventilation, which is a determinant of patient tolerance and success, has been associated with good synchrony.

Bill Hurford then discussed when sedation, analgesia, and neuromuscular blockade should be used in mechanically ventilated patients to improve patient-ventilator synchrony. He demonstrated the importance of using standard rating scales and unit-based guidelines to direct such pharmacologic therapy, with a goal of achieving optimal comfort and safety.

Rich Kallet closed the third session with a detailed description of spontaneous breathing during mechanical ventilation. He reviewed respiratory muscle function during mechanical ventilation, emphasizing that both insufficient unloading and excessive rest (ventilator-induced diaphragm

dysfunction) can result in muscle injury. He then turned to a discussion of airway pressure release ventilation, a mode that allows for spontaneous breathing during acute lung injury, and its effect on asynchrony.

Due to unforeseen circumstances, Alex White was unable to attend the conference. His paper, which will appear in the February 2011 issue of *RESPIRATORY CARE*, discusses the importance of patient-ventilator interaction in patients requiring prolonged mechanical ventilation in the long-term acute care setting.

Dave Pierson then expertly summarized the 12 lectures and the ensuing discussions. In so doing, he provides a number of take-home messages that will be invaluable to clinicians caring for mechanically ventilated patients.

It was a pleasure chairing this 46th *RESPIRATORY CARE* Journal Conference. We would like to thank the speakers who, in the custom of these highly interactive conferences, provided considerable expertise and a thorough review of the literature. We believe the papers from this conference, in this and the next issue of *RESPIRATORY CARE*, will provide clinicians with the tools to improve patient-ventilator interaction.

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