HANDOUT 2 – COMPARING MODES

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Background Issues

The appropriate use of current modes, or the development of new modes, relies on the ability to compare and contrast their relative advantages (assuming that we can identify and understand the functionality of modes in the first place; see Handout 1). In the larger context of medicine, patients are linked to their data by the process of assessing their needs (diagnosis). They are also linked to treatment options (biomedical innovation). But the fundamental responsibility of caregivers is to appropriately match patient needs to available treatments (planning). In the more restricted context of mechanical ventilation, patient needs can be expressed as three fundamental goals of mechanical ventilation (safety, comfort, and liberation). Treatment options can be viewed as the technological capabilities of various modes to serve these goals. Thus, appropriate matching of technology to needs reduces to identifying which of the available modes best serves the immediate clinical goals; see Respir Care. 2013;58(2):348-66

Why Compare Modes?

We need to compare modes because there are so many of them and because they differ enough in technological capability that they cannot possibly all offer the same benefits to the patient. Hence, there is a need for comparison and choice. The issue is whether the comparisons are based on logic and information or on personal bias. Unfortunately, the amount of good animal and clinical data is relatively small. Thus, we tend to use mechanical ventilation based on tradition and the available technology rather than on evidence-based medicine. In fact, after decades of clinical research, the only thing we seem to know is that smaller tidal volumes are better than larger ones.

Which Modes Should be Compared?

As with any technology of sufficient complexity, the ability to compare and contrast objects requires a shift of focus away from names to tags, using a formal classification system, or taxonomy. To briefly recap our discussion of taxonomy, all modes can be divided into two broad orders, volume control and pressure control. Within these orders are families based on the breath sequences (possible combinations of mandatory and spontaneous breaths). There are only 3 possible sequences of breaths a mode can generate: all spontaneous breaths, called continuous spontaneous ventilation (CSV), mandatory breaths with the possibility of spontaneous breaths between them, called intermittent mandatory ventilation (IMV), and mandatory breaths with no possibility of spontaneous breaths between them, called continuous mandatory ventilation (CMV). Within the families are genus and species, identified by the targeting schemes used for primary breaths (for CMV and CSV) and secondary breaths (for IMV). Major benefits accrue from using this classification system; It allows us to start with a relatively large set of unique mode names on common ventilators and greatly reduce it to a more manageable set of mode tags (classifications). In that set, redundancies are easily recognized and eliminated, leaving only unique mode tags (at least to four or five levels of discrimination) that are amenable to comparison.

How Can Modes be Compared?

Despite the availability of a wide variety of modes, only the simplest set-point targeting schemes (mainly volume control continuous mandatory ventilation) are used most of the time in daily practice. Such practice may be justified by the uncomplicated reliability of these modes and the lack of evidence that any other mode is better in terms of major clinical outcomes. Yet we could also argue that "lack of evidence is not evidence of lack of differential effectiveness". And it takes little effort to understand why there will never be enough clinical evidence to appropriately compare modes. Consider, for example, randomized controlled trials of 50 modes (approximately the number of unique modes currently available), would require 1,225 head-to-head comparisons (ie, combinations of 50 modes taken 2 at time). Using the ARDSnet experience to estimate the resource cost per study of about 4 years and 38 million dollars (in 1999), gathering evidence would take 4,900 labor years and over 46 billion US dollars! Thus, a complete set of clinical evidence required to compare all modes of ventilation does not exist, and never will. Thus, to rationally compare the relative merits of various modes, we must resort to deductive reasoning from first principles. We posit that a mode of mechanical ventilation has certain design features that implement a general **technological capability**. These capabilities (identified in the next section) are defined on the basis of an extensive analysis of all modes such that they can be used as unique identifiers whose benefits are intuitively obvious (again, we have no data to prove their merits). Each technological capability serves a clinical aim. Each clinical aim, in turn, serves specific objectives and general goals of mechanical ventilation based on the clinician's assessment of the patient (Figure 1). Using this rubric, any current or proposed feature of a mode should have a direct and logical link to specific patient needs.

Figure 1. Hierarchy of priorities showing how specific features of modes ultimately serve the goals of ventilation for the patient.

The utility of this hierarchical approach is that we can start on familiar ground (the general goals of mechanical ventilation) and progress deductively to a linkage with specific ventilator capabilities and features, some of which might seem questionable without such a line of reasoning to justify their existence. More to the point, the capabilities form the basis for comparing the relative benefits of modes to guide appropriate selection for a given patient at a given time. The capabilities as described here are, by definition, beneficial (given that the underlying assumptions of the targeting schemes are not violate). It follows that the more capabilities a mode has, the better it serves the specific goals of mechanical ventilation that are judged to be most important in any given clinical situation. *Note that this approach explicitly ignores the issue of how modes are used*. This conceptual distinction is essential because of the huge variation in outcomes that can be attributed to the different knowledge base and skill levels of clinicians. Few would argue that given current technology, a highly skilled clinician using a technologically simple mode would likely achieve better results than, for example, a naïve clinician using a complex mode.

The Three goals of Mechanical Ventilation

Any number of indications for mechanical ventilation may be found in the literature, but they can all be condensed into three goals and their associated objectives:

1. Promote **Safety**
    a. Optimize ventilation/perfusion of the lung (maximize ventilation and oxygenation)
    b. Optimize pressure/volume curve (minimize risk of atelectrauma and volutrauma)
2. Promote **Comfort**
    a. Optimize patient-ventilator synchrony (minimize occurrence of trigger, flow, and cycle asynchronies)
    b. Optimize work demand versus work delivered (minimize inappropriate shifting of work from vent to patient)
3. Promote **Liberation**
    a. Optimize the weaning experience (minimize duration of ventilation and risk of adverse events)

Technical Capabilities of Modes

The procedure for identifying the most appropriate mode for a particular clinical goal starts with a list of available modes (eg, on ventilators owned by a particular institution) identified by applying the mode taxonomy. Next, we construct a matrix that allows the identification of the presence or absence of the technological capabilities that fulfill a clinical goal as described above. Finally, we simply tabulate the capabilities for each mode. Three of the most common modes used in the world for adults are Volume Assist/Control (classified as VC-CMVs), Pressure Control SIMV (classified as PC-IMVs,s) and Pressure Support (classified as PC-CSVs). We will contrast these modes more sophisticated modes, AutoMode PRVC-VS (classified as PC-IMVa,a) and IntelliVent, classified as PC-IMVoi,oi; not available in the US). Ideally, this type of analysis should be applied to all unique modes for a complete comparison. Note that there are some capabilities that are not matched to the modes in this example but do match other modes.

Goal	Technical Capability	A/C	PC-SIMV	PS	AutoMode	IntelliVent
Safety	Automatic minute ventilation target adjustment					x
	Automatic Support adjustment with changing lung mechanics				x	x
	Automatic frequency and/or tidal volume adjustment				x	x
	Manual frequency and tidal volume settings	x			x	
	Automatic FiO_2 adjustment					x
	Automatic PEEP adjustment					x
	Automatic lung protection limits					x
	Minimizes tidal volume					
Comfort	All breaths can be spontaneous			x	x	x
	Trigger and cycle on diaphragm movement					
	Coordination of mandatory and spontaneous breaths		x		x	x
	Automatic limits to avoid autoPEEP					x
	Unrestricted inspiratory flow		x	x	x	x
	Automatic adjustment of flow based on frequency					
	Automatic adjustment of support based on breathing pattern					
	Automatic adjustment of support to meet inspiratory effort					
Safety	Ventilator initiated weaning					x
	Ventilator initiated spontaneous breathing trial					x
	Automatic reduction of support with increased inspiratory effort				x	x

From this type of analysis we can identify a logical reason for preferring one mode over others on the basis of how well it serves the clinical goal of mechanical ventilation for a particular patient at a particular point in time.