

Marcus J. Schultz
Peter E. Spronk

Should mechanical ventilation care be centralized and should we thus transfer all ventilated patients to high volume units? Take a breath first

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M. J. Schultz (✉) · P. E. Spronk
Department of Intensive Care C3–415, Academic Medical Center,
University of Amsterdam, Meibergdreef 9, 1105 AZ Amsterdam,
The Netherlands
e-mail: marcus.j.schultz@gmail.com

M. J. Schultz
Laboratory of Experimental Intensive Care and Anesthesiology,
Academic Medical Center, University of Amsterdam, Amsterdam,
The Netherlands

P. E. Spronk
Department of Intensive Care, Gelre Hospitals, Apeldoorn,
The Netherlands

For years, many critical care physicians considered mechanical ventilation as an easy and harmless intervention in intensive care unit (ICU) patients. Nowadays, preclinical and clinical researchers and critical care physicians increasingly appreciate the potential harmful effects of ventilation, in both patients with the acute respiratory distress syndrome (ARDS) [1] and those with uninjured lungs [2]. Ventilation turns out to be everything but safe, as it can cause so-called ‘ventilator-induced lung injury’ (VILI) [3] and ‘ventilator-induced diaphragm dysfunction’ (VIDD) [4]. Mitigating this harm is far from simple. It requires skill, which like all skills improves with experience.

One steady observation in ICU medicine is the finding that ICUs that care for high volumes of patients

experience improved outcomes. This finding, also known as the ‘volume-outcome relationship,’ has been demonstrated in several cohorts of patients [5], including those who are ventilated [6]. However, the latter finding is far from settled since half of the studies on this matter could not confirm this relationship [7–11]. In an attempt to further evaluate the potential effect of ICU volume on the outcomes of ventilated admissions, Shahin et al. [12] retrospectively evaluated the volume-outcome relationship for ventilated patients to adult, general ICUs. They extracted data for the years 2008–2010 from the case mix program database (CMPD), a registry that contains pooled case mix and outcome data on consecutive admissions to ICUs in England, Wales, and Northern Ireland. The primary exposure of interest was annual volume of ventilated admissions per ICU per year; the primary outcome was ultimate acute hospital mortality.

After adjusting for potential confounders including, but not restricted to, age, gender, disease severity, and comorbidities, Shahin et al. found a significant relationship between annual volume and ultimate acute hospital mortality, with a higher volume of ventilated admissions associated with lower mortality. Interestingly, a stronger interaction was found for non-surgical patients, but the relationship was not affected by the severity of respiratory failure.

Do these results suggest that we should centralize mechanical ventilation care in the hope to improve ICU outcome? This suggestion, in itself an obvious one, may be misleading for several reasons. First of all, Shahin et al. report on the relationship between ICU volume and hospital outcome, while the relationship with ICU outcome is not reported. If the found volume-outcome relationship depends on differences in ventilation practice, as suggested by the authors themselves, a relationship between ICU volume and ICU length of stay and maybe even ICU mortality would exist as well [1, 2]. Furthermore, the analysis did not correct for important

potential confounders, such as the availability of around the clock critical care physicians, the intensity of staffing, the presence of multidisciplinary care teams, the use of sedation, blood transfusion and fluid resuscitation protocols, and availability of intervention radiologists and cardiologists, to name a few (Fig. 1) [13, 14]. All of these have a strong potential to affect outcomes, and differences between centers, depending on size, can be presumed. Indeed, one major unknown in the context of many volume-outcome relationships is the underlying mechanism [15]. Future studies should address this issue, although this may be very hard if not impossible.

Second, one important challenge with studies using registries is that ‘registries register what they register’ and as such could miss important information. The CMPD collects important information such as admission and physical data during the first 24 h of admission and ICU and hospital outcome data, but fails to capture data during stay in the ICU and hospital beyond 24 h [16]. For instance, the clinical presentation of VILI may take some time, appearing after the first day of ventilation [17, 18]. Could this be the reason why Shahin et al. did not find a stronger relationship in patients with more severe respiratory failure? Again, if the found volume-outcome relationship depends on differences in ventilation practice, a larger effect would have been expected in these high-risk patients. This is not found, though.

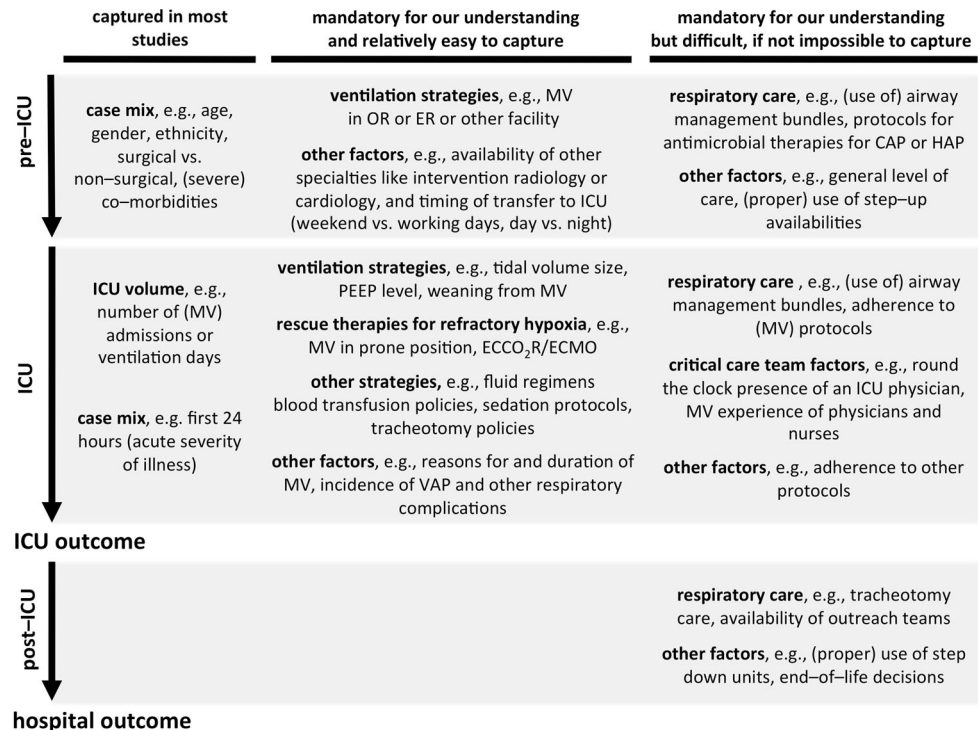
Let us assume that an independent effect of case volume on the final outcome does exist; this bears the question: what would happen if we transfer ventilated

patients to a larger center—does this actually improve outcome? Understandingly, to avoid confounding results with outcomes from other units, Shahin et al. excluded the admissions transferred either directly into a unit from another critical care unit or those transferred out (within 24 h) directly to another critical care unit. As the authors themselves suggest, transference of ICU could have important negative effects as well. A case-control study of those patients would have provided us with an answer to this important question, though. And which patients would benefit most from such transfers—patients who need ventilation for more than 24 h, 48 h or 1 week? We do not know the answer to these important questions.

Two essential things should not be forgotten in the discussion of centralization of ventilation care. First, admissions to the ICU are almost always unplanned, and harm by ventilation can already be achieved within a short period, that is: within hours [2]. This means that if we really wanted to centralize mechanical ventilation care, many patients would remain at risk for harm by ventilation, i.e., before ICU transfer—unless we close those hospitals with low volume ICUs, which will probably never happen. Second, a lower ICU occupancy rate with inherent lower exposure to ventilated patients, such as in many areas of the USA or Australia [19, 20], bears the risk of losing experience with safe ventilation with a concomitant increased risk of unwanted side effects.

If the rule ‘practice makes perfect’ indeed applies for ventilation, what else can we do to improve the outcomes of ventilated ICU patients? A more practical solution

Fig. 1 Schematic view of factors that potentially affect the ‘volume-outcome relationship’ for ventilated ICU patients. Most studies of the ‘volume-outcome relationship’ restricted confounders to those like case mix and admission volume, while numerous factors before, during and after stay in the ICU can have a substantial effect on ICU or hospital mortality. This schematic largely focuses on factors associated with (reasons for) mechanical ventilation. *MV* mechanical ventilation, *ECCO₂R* extracorporeal CO₂ removal, *ECMO* extracorporeal membrane oxygenation, *VAP* ventilator-associated pneumonia, *CAP* community-acquired pneumonia, *HAP* hospital-acquired pneumonia



might simply be to intensify education on safe ventilation and to implement practicable protocols of protective ventilation. And last but not least, all critical care team members, i.e., critical care physicians, critical care nurses, and respiratory therapists, must understand that ventilation is a potentially harmful intervention, regardless of admission type and duration of ventilation.

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