Volume-Outcome Relationship in Mechanically Ventilated Children: How Much Practice Makes Perfect (or at Least Good Enough)?

Permalink
https://escholarship.org/uc/item/4c5056w5

Journal
Pediatric Critical Care Medicine, 17(11)

ISSN
1529-7535

Authors
Natale, JE
Marcin, JP

Publication Date
2016-11-01

DOI
10.1097/PCC.0000000000000967

Peer reviewed
Volume-Outcome Relationship in Mechanically Ventilated Children: How Much Practice Makes Perfect (or At Least Good Enough)?*

JoAnne E. Natale, MD, PhD
James P. Marcin, MD, MPH
Department of Pediatrics
Davis School of Medicine
University of California
Sacramento, CA

*See also p. 1041.

Key Words: mechanical ventilation; pediatrics; quality; volume-outcome relationship

The association between the quantity of care that a physician or hospital provides and the quality of care that patients receive has been rigorously studied for years by a variety of clinical and health service researchers (1–4). In the majority of the published reports investigating this relationship, researchers have generally found that the higher the number of patients a physician or hospital treats with a specific condition, the better patients’ health outcomes (4). This “volume-outcome” relationship has been documented for a wide variety of medical conditions and surgical procedures, particularly among the adult patient population, at the physician, clinical team, and hospital level of care (5–10). Fewer studies, however, have been conducted among the pediatric patient population and in particular the pediatric critical care

patient population. Further research is important to better understand factors associated with variability in quality and outcomes among critically ill and injured infants and children.

In this issue of Pediatric Critical Care Medicine, Sasaki et al (11) conducted secondary analyses of administrative data to examine whether 30-day mortality among ventilated pediatric patients was associated with the volume of ventilated patients in more than 641 hospitals in Japan. Strengths of this study include a focus on a clinically meaningful group of patients characterized by their need for mechanical ventilation and associated critical care, as well as a highly reliable and valid outcome measure, 30-day mortality. The results demonstrated that mortality among pediatric patients treated in hospitals with the lowest quartile of volume of ventilated pediatric patients was significantly higher than among children treated in medium- and high-volume hospitals. Interestingly, there is no dose-response relationship between the volume of ventilated patients and mortality above this bottom quartile. This is an important point as the authors suggest that high volume confers a protective effect as opposed to the fact that just the exceptionally low-volume hospitals (equivalent to < 34 mechanically ventilated pediatric patients per year) confers a significant risk of 30-day mortality.

As important as this article is, there are questions that need to be raised about both the analyses and the conclusions provided by the authors. First, readers will be generally unfamiliar with referral patterns for critically ill children in Japan and resulting hospital case-mix differences. In light of this, risk adjustment to control for any differential burden of illness/injury severity by volume quartile is especially important. Most relevant is the fact that low-volume hospitals may typically treat children who are less critically ill if referral and regionalization practice patterns favor their admission and transfer to higher volume and more experienced facilities. Unless valid and reliable illness adjustment is provided, the experience of 30-day mortality in such low-volume hospitals would actually be worse than described. Unfortunately, Sasaki et al (11) do not adjust for illness severity using standardized and validated measures. Furthermore, as demonstrated by a 2006 report by Tsai et al (12), conclusions based on the use of administrative data may frequently be biased by selective referral effects. When considering data from a health system using policies that are unfamiliar to readers, this risk is only increased.

Second, the thoughtful reader will want to draw conclusions regarding volume-outcome relationships in their own clinical setting. Examining the tables provided in this article, it is difficult to generalize the findings across the broad range of pediatric critical care settings. For example, in this Japanese National Inpatient database, more than 50% of mechanically ventilated pediatric patients receive muscle relaxants and almost 39% receive vasopressors. It should be noted that no information is provided regarding the timing, duration, or intensity of these interventions. Specifically, does administration of muscle relaxants just after intubation qualify a patient as receiving a muscle relaxant? Similarly, almost 50% of ventilated pediatric patients are surgical, a proportion that seems relatively high unless these data include patients receiving brief ventilation immediately postoperative. These factors should be considered if readers wish to generalize these findings, particularly across international borders.

Finally, we urge careful consideration of the authors’ inference that variability in outcome by volume “may result for more effective practices by medical staff who have gained greater experience.” This focus on individual clinician clinical and procedural expertise is less consistent with the more contemporary understanding of ways in which clinical quality and patient safety are affected, including system factors and more broadly team-based staff competence (e.g., respiratory therapy and intensive care nursing) (1, 4, 13). Factors to consider in addition to simply volume include intensivist staffing and ICU nurse-to-patient ratios, the responsiveness of ancillary services such as radiology and laboratory, effective implementation of evidence-based practice guidelines, and patterns of interdisciplinary and interprofessional communication and decision making. Indeed, such organizational factors may be particularly important in situations where medical staff experiences more tenuous or variable. As suggested by Kahn (14) in a previous issue of this journal, outreach, collaboration, and sharing of best practices could significantly contribute to the foundation for regional quality improvement initiatives. It is important to the readers of this study that they do not merely focus on volume but instead realize that other very important and potentially modifiable factors could be contributing to their findings. As a word of caution, other research studies conducted on the volume-outcome relationship in the PICU have actually found that very high-volume centers may perform “less well” than medium- and moderately high-volume centers (8, 15).

We congratulate the work done by Sasaki et al (11). It is clear that there is a pressing need for this research, as well as future pediatric-specific health service research designed to optimize care for our most vulnerable and seriously ill patients. It is our hope that such work can not only elucidate differences in outcomes but also shed light on how healthcare teams and institutions can assure the highest quality outcomes for children wherever they obtain care.

REFERENCES
5. Hewitt ME, Pettit DB; National Cancer Policy Board (U.S.); National Research Council (U.S.); Division on Earth and Life Studies: Interpreting the Volume–Outcome Relationship in the Context of Cancer Care. Washington, DC, National Academy Press, 2001
Insights to Improve Postcardiotomy Extracorporeal Membrane Oxygenation*

Stephen A. Stayer, MD
Department of Anesthesiology; and
Department of Pediatrics
Baylor College of Medicine
Texas Children’s Hospital
Houston, TX

Erin Gottlieb, MD
Department of Anesthesiology
Baylor College of Medicine
Clinical Operations, CV Anesthesiology
Texas Children's Hospital
Houston, TX

Extracorporeal membrane oxygenation (ECMO) is reported to be used in 2–5% of all children undergoing corrective or palliative heart surgery. The indications for postcardiotomy ECMO include failure to wean from cardiopulmonary bypass, low cardiac output state, cardiac arrest, refractory hypoxemia, and pulmonary hypertension. The survival of neonates supported with postcardiotomy ECMO is known to be lower compared with other age groups (1, 2).

In this issue of Pediatric Critical Care Medicine, Howard et al (3) publish a retrospective review of survival in neonatal patients supported with ECMO after cardiac surgery. This review is authored by the pediatric cardiac anesthesia group at Boston Children’s Hospital, who were early proponents of the ABCDE approach to resuscitation when a patient does not regain adequate circulation after intubation, ventilation, chest compressions, and medication administration, survival is improved by the rapid initiation of ECMO (4, 5). This new report is the largest single-center experience of neonates undergoing postcardiotomy ECMO reported to date, and it adds new insights into improved survival in this population. First, a persistently elevated lactate or inability to clear lactate on ECMO is associated with decreased survival; thus, every effort should be made to ensure adequate flow and oxygen delivery during ECMO. Second, residual anatomic lesions are often present in this population requiring ECMO. These residual lesions should be identified and addressed early as a delay is associated with increased mortality.

Lactate is often elevated before ECMO deployment because of inadequate organ and tissue perfusion. Restoration of output through mechanical support should lead to a return in lactate levels to normal. Although lactate levels before ECMO cannulation have not been shown to affect outcome (6), early lactate behavior has been associated with prognostic guidance in both neonatal and adult patients supported with postcardiomyotomy ECMO (6–8). In the study by Howard et al (3), unresolved lactate values of greater than 2 mmol/L after 72 hours of ECMO support were associated with increased mortality.

An unresolved lactate level on ECMO likely represents inadequate oxygen delivery to tissues, and modifications of the conduct of ECMO should be considered. For example, flows that are often initiated at 100–125 mL/kg/min may need to be augmented, hematocrit may require optimization, and residual lesions need to be identified and addressed. At our institution, we would advocate an initial target flow of 150 mL/kg/min. Discontinuation of vasoconstrictive agents and administration of vasodilators are often required to achieve these flows. Single-ventricle lesions including hypoplastic left heart syndrome comprise a substantial percentage of neonatal patients undergoing postcardiomyotomy ECMO, and the management of systemic to pulmonary artery shunt flow during ECMO varies at different congenital heart programs. Some centers leave the shunt completely open and compensate for pulmonary runoff with increased flow (200 mL/kg/min) (9, 10). Other centers partially occlude the shunt in the presence of unresolving lactate in an effort to improve systemic perfusion (3, 11). At

*See also p. 1045.

Key Words: congenital heart surgery; extracorporeal life support; extracorporeal membrane oxygenation

The authors have disclosed that they do not have any potential conflicts of interest.

Copyright © 2016 by the Society of Critical Care Medicine and the World Federation of Pediatric Intensive and Critical Care Societies

DOI: 10.1097/PCC.0000000000000959