Commentary: Fontan survivor—outwit, outlast, outplay but do not overstay (your welcome)

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Central Message

Intensive care unit length of stay is a surrogate for underlying patient characteristics and morbidities. It is those challenges that require clinical focus and, if possible, modification to affect outcome.

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Cardiac care teams have long sought factors that impact both short- and long-term outcomes of patients with univentricular physiology who undergo the Fontan procedure.¹⁻⁴ The surgical advances in performing the Fontan procedure, including staged palliation and its modification (ie, fenestration), have further complicated our quest for understanding. In this issue of the *Journal*, Ono and colleagues⁵ approach this question by focusing on intensive care unit length of stay (ICU-LOS), factors associated with ICU-LOS, and the relationship between ICU-LOS and late outcomes. The study suggests that longer ICU-LOS was associated with preoperative factors (anatomic factors [hypoplastic left heart syndrome, anomalous systemic venous drainage] and elevated preoperative transpulmonary gradient), operative factors (concomitant atrioventricular valve procedure, cardiopulmonary bypass [CPB] time, and surgical era) and postoperative factors (lower aortic saturation, pleural effusion, chylothorax, ascites, and infection). Furthermore, ICU-LOS was found to be associated with late mortality and cardiac reoperation.

Although these findings are of interest, there are various aspects of the analysis and its interpretation thereof that warrant reflection and consideration. Preoperative, intraoperative, and postoperative analyses did not include variables previously associated with ICU-LOS, such as postoperative ventricular function, acute kidney injury (AKI), and fluid overload.⁶⁻⁸ Likewise, these analyses were performed separately, thus, not controlling for confounders, and the impact may be overstated, given the focus on univariate analyses and phrasing that implies causation. The late outcomes analysis is also difficult to interpret because it includes both ICU-LOS and the factors the study associated with ICU-LOS while omitting other variables (ie, heterotaxy syndrome). There were additional issues with variable selection, such as exclusion of 30-day mortality patients in ICU-LOS calculations, lack of a definition for “longer ICU-LOS,” and lack of definition/baseline for low arterial

oxygen saturation. Furthermore, it is unclear why the patients needed to remain in the ICU other than the presence of chest tubes, which may be mandated by policy, rather than hemodynamic need. Therefore, hospital LOS rather than ICU-LOS may have been a more accurate reflection of the intended variable of interest. Nonetheless, ICU-LOS is merely a surrogate for underlying issues (ie, chylothorax), and it is those problems that require clinical focus and, if possible, modification to affect outcome.

Regardless of the limitations, clinically important questions remain. (1) What factors are related to short-term outcomes and thus potentially to long-term outcomes? (2) Which of these factors are modifiable? The answers may lie in surgical innovation. As we moved from classic atrio-pulmonary to lateral tunnel and extracardiac Fontan, staged palliation and surgical advancement were central drivers of improved outcomes.¹ What is the next phase of surgical improvement? This study as well as the literature suggest CPB time is associated with ICU-LOS.^{1,3,5} It is also one of the few preoperative (previous bidirectional Glenn [BDG] performed with CPB) and intraoperative factors that is directly modifiable. As such, the merits of performing the BDG and extracardiac Fontan anastomoses without CPB should be considered. CPB and the ensuing cascade of inflammatory cytokines and fluid shifts are associated with worse immediate outcomes, including increased bleeding, medium-term outcomes,

such as low cardiac output syndrome, fluid overload, and AKI, and long-term outcomes, including LOS and neurodevelopmental outcomes. At centers using this “off-pump” innovation, LOS post-BDG and post-Fontan are shorter than the national aggregate.⁹

Postoperative management factors that this study does not address but are important include duration of mechanical ventilation, early chest tube removal, AKI, and fluid overload. If a patient is not extubated in the operating room (OR), this can prolong ICU-LOS.¹⁰ Another factor that plays a role in overall Fontan LOS is chest tube output and removal criteria. In this study, routine fenestration was not used; however, Lemler and colleagues¹¹ demonstrated that nonfenestration is associated with prolonged chest tube output and hospital LOS. Both OR extubation and early chest tube removal have the additional benefit of allowing early mobilization and cardiac rehabilitation, which may decrease postoperative complications and LOS.¹² Finally, AKI and fluid overload, common after the Fontan operation, have an association with longer LOS and should be proactively prevented (ie, avoidance of CPB) or, if not, identified and treated.^{13,14}

Surgical innovation to improve both short- and long-term outcomes after Fontan repair is possible. Avoiding CPB for BDG and Fontan anastomoses addresses CPB as a contributor to poor outcomes. OR extubation, strategies to promote early chest tube removal, and prevention or avoidance of AKI and fluid overload may also improve LOS and ultimately long-term Fontan outcomes.

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