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RESEARCH LETTER

Intensive care unit improves dialysis care quality while reducing costs

Tara Greenleaf Nichols[a], David Doman[a], Sherrie Mullen[a], Senthil Ramaiyah[a], Sandy Rowe[a], Cynthia J. D'Alessandri-Silva[b] and Stephan Dunning[b]

[a]Department of Nephrology, Covenant HealthCare, Saginaw, MI, USA; [b]Department of Nephrology, Outset Medical, San Jose, CA, USA

ABSTRACT

Aims and background: The current report details transition of outsourced conventional dialysis therapy in the ICU services to an in-house prolonged intermittent renal replacement therapy (PIRRT) service model as a quality improvement project using the Tablo Hemodialysis System, Outset Medical, Inc. The goals were aimed at maintaining or improving clinical outcomes, while also reducing dialysis-related nursing staff burden and dialysis-related treatment costs.

Methods: A descriptive comparative analysis was conducted of renal replacement therapy (RRT) of ≥6 hours in duration performed in the 1 year prior and 1 year after the ICU's in-house program launch using a PIRRT model including sequential 24-h treatments when medically necessary.

Results: Overall, there were 145 intensive care unit (ICU) stays among 145 patients with 13,641 h of conventional ICU dialysis in the year prior to program transition. In the year post, there were 116 ICU stays among 116 patients with 5,098 h of PIRRT. By employing a PIRRT and sequential 24-h treatment strategy vs. the prior outsourced model, the mean dialysis treatment hours per patient were reduced (Pre, 94.1 h with 214 treatment starts; Post, 43.9 h with 370 treatment starts), increasing ICU nurse productivity by 50.2 h per patient. Overall, ICU length of stay and ICU mortality declined post-service transition by 4.8 days and 9.8 percentage points (pp), respectively, overall, and in the non-COVID subset by 1.6 days and 3.1 pp, respectively.

Conclusions: Insourcing RRT with an innovative technology that can provide both PIRRT and 24-h sequential treatments can maintain or improve clinical outcomes in critically ill patients requiring RRT in the ICU, while reducing dialysis-related costs.

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Introduction

A recent report on hospital finances by Kaufman Hall revealed 2022 as the worst financial year for hospitals and health systems across the US since the COVID-19 pandemic began[1]. The report states, "The increases were driven in part by a competitive labor market, as well as hospitals needing to rely on more expensive contract labor to meet staffing demands. Increased lengths of stay due to a decline in discharges also negatively affected hospital margins". Here we report on our Intensive Care Unit (ICU) experience at a medium-sized hospital in Michigan, which began offering renal replacement therapy (RRT)[2] to critically ill patients indicated for such treatments in 2019. The dialysis program was originally launched using a dialysis services provider who provided supplies and staffing support for either bedside ICU conventional dialysis therapy or intermittent hemodialysis (IHD). The health system's ICU nurses monitored patients at bedside on a 1:1 patient-to-nurse staffing ratio. The COVID-19 pandemic, nursing staff shortages, increasing patient volumes all together challenged the ICU's ability to provide high-quality, cost-efficient care.

In November 2021, the ICU ended its contract for outsourced services and transitioned to an in-house prolonged intermittent RRT (PIRRT) service model as a quality improvement project using the Tablo Hemodialysis System, Outset Medical, Inc.[i] PIRRT has been shown to be clinically effective in treating ICU patients and offers flexibility in scheduling and resource utilization[3,4]. Hemodialysis treatments with session lengths less than 6 hours remained outsourced to a dialysis services provider. The goals were aimed at maintaining or improving clinical outcomes, while also reducing dialysis-related nursing staff burden and dialysis-related treatment costs. In this research letter, we provide a descriptive comparative analysis of RRT of ≥6 hours in duration performed in the 1 year prior and 1 year after the ICU's in-house program launch using a PIRRT model including sequential 24-h treatments when medically necessary.

Methods

A 12-month pre/post analysis was employed to compare treatment volumes, patient demographic and baseline

CONTACT Cynthia J. D'Alessandri-Silva csilva@outsetmedical.com Department of Nephrology, Outset Medical, 3052 Orchard Drive, San Jose CA 95134, USA

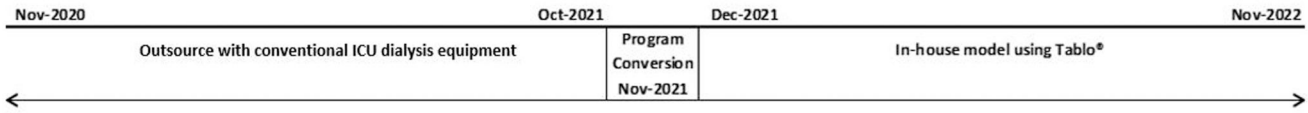

Figure 1. Study design.

Table 1. Dialysis treatment characteristics.

	Overall		Non-Covid	
	Pre-period (outsourced) Nov 2020–Oct 2021 *N* (%)	Post-period (In house) Dec 2021–Nov 2022 *N* (%)	Pre-period (outsourced) Nov 2020–Oct 2021 *N* (%)	Post-period (In house) Dec 2021–Nov 2022 *N* (%)
Patients	145	116	89	93
Long-duration dialysis treatment starts	214	370	121	277
CID or 24-h sequential (Tablo)	214 (100.0)	106 (28.6)	121 (100.0)	100 (36.1)
PIRRT	0 (0.0)	264 (71.4)	0 (0.0)	177 (63.9)
Total (mean) duration of Tx (hrs)	13,641 (63.7)	5,098 (13.8)	7,173 (59.3)	4,279 (15.4)
CID or 24-h sequential (Tablo)	13,641 (63.7)	2,544 (24.0)	7,173 (59.3)	2,400 (24.0)
PIRRT	0 (0.0)	2,554 (9.7)	0 (0.0)	1,879 (10.6)
Mean duration of dialysis per patient	94.1	43.9	80.6	46.0
Patient to nurse ratio during Tx	1:1	1:1	1:1	1:1

Abbreviations. CID, Conventional ICU dialysis; PIRRT, prolonged intermittent renal replacement therapy; Tx, treatment.

clinical characteristics, clinical outcomes, and dialysis-related nursing hours and treatment costs (Figure 1). Treatment and electronic health record data were queried by ICU nursing staff with authorized data access. Outsource treatment costs in the "Pre" period include third-party set-up fees, consumables (e.g. bags, cartridges) and nursing labor rates per hour for monitoring treatments at bedside on a one nurse to one patient ratio. In-house treatment costs in the "Post" period include mean internal set-up costs based on nurse labor rates, consumables (e.g. acid and bicarbonate jugs, cartridges) and nursing labor rates per hour for monitoring treatments at bedside on a one nurse to one patient ratio. Data were compiled and summary statistics were calculated by ICU staff using MS Excel. Results are reported overall and for COVID and no-COVID subgroups to isolate the influence of changing COVID care and severity during the analysis periods. Categorical patient characteristics were compared using Chi-square tests.

Results

Overall, there were 145 ICU stays among 145 patients with 13,641 h of outsourced conventional ICU dialysis in the year prior to program transition. In the year post, there were 116 ICU stays among 116 patients with 5,098 h of PIRRT, including sequential 24-h treatments. Similar mean age (Pre = 64.4; Post = 64.3 years), gender (Female: Pre = 37.2%; Post = 32.8%, $p = .4513$) and race (Non-white patients: Pre = 26.9%; Post = 28.5%, $p = .7805$) characteristics were observed in both periods. The distribution of kidney disease (AKI-D only, CKD with AKI-D and ESRD) among ICU patients requiring RRT >6 h was similar in both periods (47.6%, 40.0%, and 12.4% in the pre period, and 44.0%, 36.2%, and 19.8% in the post period, respectively, $p = .2618$). Other clinical conditions captured included the proportion of patients with COVID (Pre = 38.6%; Post = 19.8%, $p = .0010$), sepsis (Pre = 40.1%; Post = 23.3%, $p = .0029$), or heart failure (Pre = 24.8%; Post = 23.3%, $p = .7710$). Directionally similar results were seen in the "Pre" and "Post" periods among the no-COVID subset, though none reached the $p \leq .05$ level of statistical significance.

By employing a PIRRT and sequential 24-h treatment strategy vs. the prior outsourced model, the mean dialysis treatment hours per patient declined (Pre = 94.1 h with 214 treatment starts; Post = 43.9 h with 370 treatment starts), increasing ICU nurse productivity by 50.2 h per patient. In the no-COVID subset, the mean dialysis treatment hours per patient declined 42.9% (Pre = 80.6 h with 121 treatment starts; Post = 46.0 h with 277 treatment starts) increasing nurse productivity among no-COVID patients by 34.6 h per patient (Table 1).

Length of ICU stay and mortality in the overall cohort were 13.2 vs. 8.4 days and 60.7% vs. 50.9% in the pre and post periods, respectively. Dialysis-related costs per treatment hour declined 51.7% (Pre = $97.15; Post = $46.93) overall and 53.6% (Pre = $99.50; Post = $46.16) in the non-COVID subset (Table 2).

Discussion

In 2021, the ICU transitioned its outsourced critical care dialysis program to an in-house PIRRT program using an innovative dialysis technology. Overall, ICU length of stay and ICU mortality declined post-service transition by 4.8 days and 9.8 percentage points (pp), respectively, overall and in the non-COVID subset by 1.6 days and 3.1 pp, respectively.

Insourcing RRT with an innovative technology that can provide both PIRRT and 24-h sequential treatments can maintain or improve clinical outcomes in critically ill patients requiring RRT in the ICU, while reducing dialysis-related

Table 2. Clinical outcomes and costs.

	Overall		No Covid	
	Pre-Period (Outsourced) Nov 2020–Oct 2021 *N* (%)	Post-Period (In House) Dec 2021–Nov 2022 *N* (%)	Pre-Period (Outsourced) Nov 2020–Oct 2021 *N* (%)	Post-Period (In House) Dec 2021–Nov 2022 *N* (%)
Mean LOS (days)				
ICU LOS All Stays	4.2	3.2		
ICU LOS Stays with RRT ≥6 hours	13.2	8.4	9.0	7.4
Hospital LOS among ICU stays with RRT ≥6 h	20.0	15.5	15.6	13.5
ICU Mortality	88 (60.7%)	59 (50.9%)	42 (47.2%)	41 (44.1%)
Total Dialysis Costs Per Treatment Hour	$97.16	$46.93	$99.5	$46.16

Abbreviations: ICU, intensive care unit; RRT, renal replacement therapy; LOS, length of stay; PIRRT, prolonged intermittent renal replacement therapy.

costs. Specifically, mean dialysis treatment hours per patient improved between pre- and post-service transition, increasing ICU nurse productivity by 50.2 h. This increase in staff efficiencies provided ICU staff with greater ability to focus on patient needs, opportunities for didactic and simulated continuing education and increasing subject matter excellence which is key to high-quality patient care. Quality improvement in the ICU often translates to fiscal improvement with, in this case, the ICU reporting a reduction in dialysis-related costs per treatment hour post-service transition. As ICU costs continue to be determined largely by labor and materials (e.g. dialysate, anticoagulation, and dialyzer), having dialysis services delivered by hospital employees using an innovative technology can increase staff productivity, enable better oversight of quality, staffing, education, and training, and improve fiscal sustainability.

Conclusions

Converting from an outsourced conventional ICU dialysis program to an in-house, more flexible PIRRT program provides consistent high-quality dialysis care and patient outcomes, while substantially reducing dialysis-related costs and increasing nurse productivity.

Note

i. Outset Medical headquarters is located at 3052 Orchard Drive, San Jose, CA USA. A manufacturing facility, referred to as Outset Medical Mexico (OMM) is located at C. Vecinal #20601, Módulos J y K, Col. Presa Rodriguez Sub Urbana, Tijuana, B. C. C.P. 22124.

Transparency

Declaration of funding

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Declaration of financial/other relationships

CD and SD are employees of Outset Medical, Inc. The rest of the authors have no conflicts of interest to declare.

Author contributions

TGN: Conceptualization, Methodology, Data curation, Validation, Formal analysis, Supervision, Writing – Reviewing and Editing.
DD: Writing – Reviewing and Editing.
SM: Data curation, Writing – Reviewing and Editing.
SRH: Writing – Reviewing and Editing.
SR: Data curation, Writing – Reviewing and Editing.
CD: Writing – Reviewing and Editing.
SD: Conceptualization, Methodology, Project Administration, Validation, Original draft preparation, Writing – Original Draft.

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Availability of data and materials

The datasets generated are available from the corresponding author upon reasonable request.

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ORCID

Cynthia J. D'Alessandri-Silva http://orcid.org/0009-0002-0374-9212
Stephan Dunning http://orcid.org/0000-0003-3109-0136

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