




The added value of the advanced practice provider in paediatric acute care cardiology

Amanda J. Willis¹ , Amanda Hoerst², Stephen A. Hart³, Diana Holbein⁴, Kristyn Lowery⁵, Ashraf S. Harahsheh⁶ , Alaina K. Kipps⁷, Nicolas Madsen², Sonali S. Patel⁸, Ronn E. Tanel⁹  and on behalf of the Paediatric Acute Care Cardiology Collaborative (PAC³)

Original Article

Cite this article: Willis AJ, Hoerst A, Hart SA, Holbein D, Lowery K, Harahsheh AS, Kipps AK, Madsen N, Patel SS, and Tanel RE (2021) The added value of the advanced practice provider in paediatric acute care cardiology. *Cardiology in the Young* **31**: 248–251. doi: [10.1017/S1047951120003789](https://doi.org/10.1017/S1047951120003789)

Received: 12 May 2020
Revised: 16 September 2020
Accepted: 10 October 2020
First published online: 4 November 2020

Keywords:

Nurse practitioner; physician assistant; care model; front-line provider; collaborative

Author for correspondence:

A. J. Willis, DNP, Texas Children's Hospital, Department of Paediatrics, 6651 Main Street, Suite E.1920, Houston, TX 77030, USA.
Tel: 832-826-5949; Fax: 832-825-9637.
E-mail: amjones5@texaschildrens.org

¹Texas Children's Hospital, Department of Paediatrics, Baylor College of Medicine, Houston, TX, USA; ²Cincinnati Children's Hospital Medical Center, Department of Paediatrics, University of Cincinnati College of Medicine, Cincinnati, OH, USA; ³Nationwide Children's Hospital, Department of Paediatrics, The Ohio State University College of Medicine, Columbus, OH, USA; ⁴Department of Paediatrics, Children's Hospital of Philadelphia, Philadelphia, PA, USA; ⁵Department of Paediatrics, Children's Hospital of Pittsburgh, Pittsburgh, PA, USA; ⁶Children's National Hospital, Department of Paediatrics, The George Washington University School of Medicine, Washington, DC, USA; ⁷Lucile Packard Children's Hospital, Department of Paediatrics, Stanford University School of Medicine, Palo Alto, CA, USA; ⁸Children's Hospital of Colorado, Department of Paediatrics, University of Colorado School of Medicine, Aurora, CO, USA and ⁹UCSF Benioff Children's Hospital, Department of Paediatrics, UCSF School of Medicine, San Francisco, CA, USA

Abstract

Objectives: Advanced practice providers (APPs) are being employed at increasing rates in order to meet new in-hospital care demands. Utilising the Paediatric Acute Care Cardiology Collaborative (PAC³) hospital survey, we evaluated variations in staffing models regarding first-line providers and assessed associations with programme volume, acuity of care, and post-operative length of stay (LOS). **Study design:** The PAC³ hospital survey defined staffing models and resource availability across member institutions. A resource acuity score was derived for each participating acute care cardiology unit. Surgical volume was obtained from The Society of Thoracic Surgeons database. Pearson's correlation coefficients were used to evaluate the relationship between staffing models and centre volume as well as unit acuity. A previously developed case-mix adjustment model for total post-operative LOS was utilised in a multinomial regression model to evaluate the association of APP patient coverage with observed-to-expected post-operative LOS. **Results:** Surveys were completed by 31 (91%) PAC³ centres in 2017. Nearly all centres (94%) employ APPs, with a mean of 1.7 (range 0–5) APPs present on weekday rounds. The number of APPs present has a positive correlation with surgical volume ($r = 0.49$, $p < 0.01$) and increased acuity ($r = 0.39$, $p = 0.03$). In the multivariate model, as coverage by APPs increased from low to moderate or high, there was greater likelihood of having a shorter-than-expected post-operative LOS ($p < 0.001$). **Conclusions:** The incorporation of paediatric acute care cardiology APPs is associated with reduced post-operative LOS. Future studies are necessary to understand how APPs impact these patient-specific outcomes.

Hospital-based care of congenital heart disease patients continues to evolve to meet the increasing demands of volume and acuity. In particular, coordination of complex care systems, prioritisation of efficient resource utilization, and re-evaluation of traditional care delivery systems, including provider team composition, have become common considerations of modern practice.^{1,2}

Advanced practice providers, including nurse practitioners and physician assistants, were first employed to address the shortage of paediatric rural health providers in 1965.³ Neonatal nurse practitioners, employed in the 1970s, were the first group of nurse practitioners to work in critical care.³ Resident work-hour restrictions and a decrease in subspecialty training hours have more recently increased the utilisation of advanced practice providers in subspecialty and critical care areas within paediatric hospital systems.^{3,4} Several examples exist demonstrating the utility of the advanced practice provider care model, including adult cardiology practices which have shown an improvement in access to care, productivity, and efficiency.^{5,6} Implementation of advanced practice providers in both emergency medicine and intensive care units has been associated with improved patient outcomes.^{7,8} Similarly, Newhouse and Stanik-Hutt performed an 18-year systematic review of advanced practice provider-patient care involvement and found that patient outcomes were similar, if not better, than when physicians alone were responsible.⁹ Lastly, nurses have acknowledged the value of advanced practice providers in regard to assessing the needs of patients and their families, communicating with multidisciplinary teams, and acting as a resource for their nursing colleagues.¹⁰

The variable composition of the paediatric acute care cardiology team (acute care should be interpreted as synonymous with inpatient or ward-based care) has only recently been described, and to date, analysis of the impact of advanced practice provider presence on practice patterns or outcomes has not been performed.^{1,2} Our study aims to evaluate the role of advanced practice providers as part of the care team in the emerging and distinct subspecialty of paediatric acute care cardiology utilising the Paediatric Acute Care Cardiology Collaborative (PAC³) as a data resource. PAC³ was founded in 2014 with the goal of improving outcomes in the paediatric acute care cardiology population, and with this aim in mind, member sites recently conducted a hospital survey to assess practice variation and acute care cardiology unit team composition.^{1,11} This hospital survey developed an inventory of the specific team members and their respective roles in the acute care cardiology unit and provides an opportunity to measure the associations between the advanced practice provider service lines and the desired patient outcomes affecting this discrete population.

Materials and methods

PAC³ is a voluntary quality improvement organisation comprised of 37 institutions primarily focused on improving acute care cardiology outcomes delivered on the acute care cardiology unit.¹¹ In 2017, a PAC³ member survey examined practice and environment variation across participating institutions. Data elements included hospital demographics, staffing, available resources and therapies, use of standard care practices, and patient transfer and discharge practices. The survey and its results have been reported previously.¹ The survey included 12 stem questions pertaining to staffing by advanced practice providers, cardiology fellows, and residents, with numerous branching questions following positive responses. The survey data was collected and managed using Research Electronic Data Capture (REDCap) tools hosted at the Cincinnati Children's Hospital Medical Center. REDCap is a secure, web-based application designed to support data capture for research studies.¹² The study was approved by the Institutional Review Board at the Cincinnati Children's Hospital Medical Center.

Surgical volume per institution was obtained utilising The Society of Thoracic Surgeons (STS) database, and was previously found to correlate with unit size and census.¹ A resource acuity score of 0–4 was derived for each unit, calculated as the sum of up to four potential therapies utilised on the acute care cardiology unit (each deemed by expert opinion amongst PAC³ clinical champions to be uniquely representative of elevated acuity): inhaled nitric oxide, high-flow nasal cannula, ventricular assist devices, and intravenous antiarrhythmic agents. Pearson's correlation coefficients were used to evaluate the relationship between staffing models across the collaborative and centre volume, as well as unit acuity.

Eighteen PAC³ survey sites also submitted data to the Paediatric Cardiac Critical Care Consortium (PC⁴) database, which was used to determine post-operative length of stay analysis. PC⁴ is also a voluntary quality improvement organisation comprised of nearly 50 institutions primarily focused on improving cardiac critical care. All cardiac intensive care unit encounters at each participating centre are submitted to the PC⁴ database. Each case record includes patient demographics, clinical characteristics, data on cardiac surgical procedures and other interventions that occurred, critical care therapies, and complications, all with standard definitions. The registry shares common terminology and definitions with the International Paediatric and Congenital Cardiac Code, The Society of Thoracic Surgeons Congenital Heart Surgery

Table 1. Provider type present in the acute care cardiology unit.

	Weekday	Weeknight	Weekend day	Weekend night
	n (%)	n (%)	n (%)	n (%)
Advanced practice provider	29 (94)	8 (26)	24 (77)	6 (19)
Cardiology fellow	28 (90)	17 (55)	29 (94)	17 (55)
Paediatric resident	25 (81)*	22 (71)	24 (77)	21 (68)

*Paediatric interns present at 15 centres (48%), 12 of which had supervising residents (80%).

Database, and the American College of Cardiology Improving Paediatric and Adult Congenital Treatment Registry, as previously described.^{13,14} Trained data managers who have passed a certification examination abstract the data. The PC⁴ data auditing process has been previously described, with the most recent audit results suggesting the complete, accurate, and timely submission of data across centres, and a major discrepancy rate of 0.6% across 29,476 fields.¹⁵ The University of Michigan Institutional Review Board oversees the PC⁴ Data Coordinating Center and this study was approved with a waiver of informed consent.

A previous study has successfully combined hospital-level factors from the PAC³ survey with PC⁴ outcomes data with specific attention to post-operative length of stay.¹⁶ In summary, a case-mix adjustment model was developed for the total post-operative length of stay based on pre-operative and operative variables. The PAC³ survey data was categorised into predictor variables felt to impact post-operative length of stay. For our analysis, the percentage of patients covered by advanced practice providers on the acute care cardiology unit was categorised as low (<50%), moderate (51–75%), and high (>76%). These categories were selected based on the distribution of responses. Candidate variables were included in the final model if their association with total post-operative length of stay had a p-value less than 0.05. A complete list of categorised survey responses used in the multivariate analysis are provided in Supplementary Table S1. A multinomial regression model was then used to evaluate the effect of hospital-specific survey variables with an observed-to-expected post-operative length of stay at the patient level defined as a categorical variable: $\geq 25\%$ shorter-than-expected post-operative length of stay, as-expected, or $\geq 25\%$ longer-than-expected post-operative length of stay. Standard error adjustment for centre clustering was not performed since the survey variables for all patients at a particular hospital were the same.

All analyses were performed using SAS Version 9.4 (SAS Institute, Cary, NC) or STATA Version 14 (Stata Corp, College Station, TX).

Results

PAC³ surveys were completed by 31 (91%) of the 34 member centres at the time of survey distribution. Nearly all centres (94%) employ advanced practice providers, with a mean of 1.7 (range 0–5) advanced practice providers present on weekday rounds. These advanced practice providers cover $\leq 50\%$ ($n = 6$), 50–75% ($n = 6$), and $>75\%$ ($n = 6$) of acute care cardiology unit patients. Advanced practice providers provide weekend coverage in most centres but less often provide overnight coverage (Table 1). Most (90%) centres have a cardiology fellow on the acute care cardiology unit team, but fellows are often involved with other responsibilities, including weekday consults (58%), night and

Table 2. Advanced practice provider coverage and correlation with surgical volume and acuity.

	Unit bed size	Surgical volume	Acuity score
	r (95% CI)	r (95% CI)	r (95% CI)
	p-value	p-value	p-value
Presence of weekday APP	0.19 (−0.17 - 0.51)	0.03 (−0.06 - 0.59)	0.18 (−0.19 - 0.51)
	0.3	0.10	0.35
Average number of weekday APPs	0.06 (−0.30 - 0.41)	0.49 (0.16–0.72)	0.39 (0.04–0.66)
	0.74	<0.01	0.03
Percentage of ACCU patients covered by APPs	−0.04 (−0.41 - 0.33)	−0.20 (−0.53 - 0.32)	−0.06 (−0.42 - 0.32)
	0.82	0.29	0.77

Abbreviations: ACCU = acute care cardiology unit; APP = advanced practice provider; r = correlation coefficient.

Table 3. Multivariable analysis: association of patient coverage by advanced practice providers with post-operative length of stay.

	RRR for as-expected LOS*	p-value	RRR for ≥25% shorter-than-expected LOS*	p-value
Low coverage (<50% of patients)	reference	–	reference	–
Moderate coverage (51–75% of patients)	1.18	0.014	2.21	p < 0.001
High coverage (>75% of patients)	1.10	0.19	1.54	p < 0.001

*Relative risk ratio as compared to ≥25% longer-than-expected LOS.

weekend consults (94%), and performing after-hours echocardiograms (61%). Paediatric residents are involved with the care of acute care cardiology unit patients at 81% of centres, with a mean of 2 (range 0–5) residents present on weekday rounds. Only half of the 31 centres have paediatric interns (first-year residents) on the care team, and a majority have a junior or senior resident present. Residents provide weekend coverage as often as advanced practice providers (77%), but provide more frequent overnight coverage (71%) than advanced practice provider colleagues (26%).

Unit bed size, as well as surgical volume obtained from STS and the calculated acute care cardiology unit resource acuity score were assessed in relation to the categories of advanced practice provider practice (Table 2). The number of advanced practice providers present on weekday rounds has a positive correlation with surgical volume ($p < 0.01$, Table 2). The number of advanced practice providers present on weekday rounds also had a positive correlation with the calculated unit acuity score ($p = 0.03$), but not unit bed size.

At the time of the survey, there were 18 hospitals that provided both PAC³ survey data and PC⁴ clinical registry data. A total of 20,935 clinical encounters from PC⁴ were included in the development of the case-mix adjustment model for total post-operative length of stay. In the multivariate model (Table 3), as coverage by advanced practice providers increased from low to moderate or high, there was a greater likelihood of having a shorter-than-expected post-operative length of stay ($p < 0.001$).

Discussion

Utilising data from the North American inpatient collaboratives (PAC³ and PC⁴), we have demonstrated that an increased percentage of care provided by advanced practice providers on the acute care cardiology unit is associated with having a shorter-than-expected post-operative length of stay, as well as a capacity to provide care utilising more complex mechanisms as required by the higher acuity patient. Specifically, it is an increased overall

presence of advanced practice providers that was associated with these benefits rather than the mere presence of advanced practice providers or a number of patients covered by advanced practice providers.

This study is the first to describe in detail the role of various providers in the paediatric acute care cardiology environment. Certainly, there are the traditional members of the care team, including interns, residents, cardiology fellows, and cardiology attending faculty. However, there is a significant variation amongst PAC³ programmes, partly owing to the incorporation of advanced practice providers. Advanced practice providers have been contributing to inpatient care on many paediatric services over the last several decades, but their presence in the acute care cardiology unit has not been previously described to this extent.^{2,3}

The centres that responded to the PAC³ hospital survey represent diversity in geography, unit structure, and surgical volume. These factors underlie some of the diversity that was observed in the responses of the survey. A notable finding in this analysis was that the number of advanced practice providers employed by a centre correlated with surgical volume and a higher level of acuity handled by a unit, based on four representative advanced care therapies. Future analysis with additional contributing centres may help to elaborate on these findings.

The changing structure of the acute care cardiology team is consistent with some of the changes in health care delivery over recent years, but is also objectively validated by the results of this survey. Other subspecialties in paediatrics have utilised advanced practice providers for decades. For example, advanced practice providers have been central members of the neonatal intensive care unit team since the 1970s.³ We show that many centres seem to be appreciating the dedication and expertise of this provider group, as well as their measurable direct patient benefit.

As noted in this survey, nearly half of centres have advanced practice providers covering greater than 75% of acute care cardiology unit patients. This shift in acute care cardiology unit staffing with advanced practice providers involved with the majority of

care, rather than the traditional team consisting of paediatric interns and residents, recognises that specialised training and experience is necessary to care for complex paediatric cardiology patients. The seasoned advanced practice provider undoubtedly has the opportunity to develop greater familiarity and knowledge of the nuanced diagnoses and physiology of congenital heart disease than the rotational resident. In addition, advanced practice providers who are dedicated to the care of the acute care cardiology patients can be responsible when cardiology fellows are attending to tasks that take them off of the unit. We have observed that cardiology fellows are often also responsible for cardiology consultations, performing urgent echocardiograms, and addressing other acute cardiac issues in other areas of the hospital while on service or on call, potentially leaving a void of expertise on the acute care cardiology unit.

There are some important limitations to consider in regard to this study. The PAC³ hospital survey provides a look into the unit structure and practice patterns present at each of the representative PAC³ member institutions, and was intentionally administered before the beginning of acute care cardiology unit-specific registry data collection. As a result, there is a limited amount of granular acute care cardiology outcome data to examine at this time. However, our partnership with PC⁴ allowed for a robust analysis of a critical variable of interest, post-operative hospital length of stay. In addition, the model to determine higher acuity forms of acute care cardiology unit care is built on the consensus of experts and is not a validated tool at this time. The aim is to refine the PAC³ models of case-mix analysis over time as the data from the PAC³ acute care cardiology unit-specific registry becomes available. Lastly, given the retrospective design of this study, the length of stay finding could be explained by other unmeasured factors that confounded the exposure of interest (the increasing presence of advanced practice providers). Further studies are necessary to confirm the association described here, and if confirmed, to then determine the precise nature of how advanced practice providers might facilitate shorter-than-expected post-operative length of stay.

The results of this study support the notion that acute care cardiology is a distinct subspecialty within paediatric cardiology by demonstrating that a dedicated front-line workforce is associated with improved outcomes. This work is central to the mission of PAC³ and would not have been possible without the collaborative efforts of all participating centres.¹¹ Future improvement efforts and research amongst PAC³ centres will undoubtedly lead to improved outcomes and patient experiences. This study also demonstrates substantial variation between centres in front-line providers. This variation may provide important insights into how advanced practice providers impact patient care and outcomes in future studies.

Acknowledgements. None.

Financial support. The authors have indicated they have no financial relationships relevant to this article to disclose. No external funding for this manuscript was received.

Conflicts of interest. None.

Supplementary material. To view supplementary material for this article, please visit <https://doi.org/10.1017/S1047951120003789>

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