Cardiology in the Young

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Evaluating variation in pre-operative evaluation and planning for children undergoing atrial or ventricular septal defect repair

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Abstract

Background: CHD care is resource-intensive. Unwarranted variation in care may increase cost and result in poorer health outcomes. We hypothesise that process variation exists within the pre-operative evaluation and planning process for children undergoing repair of atrial septal defect or ventricular septal defect and that substantial variation occurs in a small number of care points. *Methods:* From interviews with staff of an integrated congenital heart centre, an initial process map was constructed. A retrospective chart review of patients with isolated surgical atrial septal defect and ventricular septal defect repair from 7/1/2018 through 11/1/2020 informed revisions of the process map. The map was assessed for points of consistency and variability. *Results:* Thirty-two surgical atrial septal defect/ventricular septal defect repair patients were identified. Ten (31%) were reviewed by interventional cardiology before surgical review. Of these, 6(60%) had a failed catheter-based closure and 4 (40%) were deemed inappropriate for catheter-based closure. Thirty (94%) were reviewed in case conference, all attended surgical clinic, and none were admitted prior to surgery. The process map from interviews alone identified surgery rescheduling as a point of major variability; however, chart review revealed this was not as prominent a source of variability as pre-operative interventional cardiology review. *Conclusions:* Significant variation in the pre-operative evaluation and planning process for surgical atrial septal defect/ventricular septal defect patients was identified. If such process variation is widespread through CHD care, it may contribute to variations in outcome and cost previously documented within CHD surgery. Future research will focus on determining whether the variation is warranted or unwarranted, associated health outcomes and cost variation attributed to these variations in care processes.

CHD occurs in approximately 1 in 100 live births and is a resource-heavy specialty.[1–4] While only accounting for 4% of total paediatric hospitalisations, CHD admissions account for 15% of total hospital spending.[2] Improving the value of healthcare, understood broadly as outcomes / cost,[5] requires a clear understanding of the resources utilised to provide CHD care.

Time-Driven Activity-Based Costing is an approach to costing introduced by Kaplan and Anderson at Harvard Business School in 2004 that combines process mapping used in electrical engineering with activity-based costing used in accounting.[6] It identifies the prominent activities and materials used to deliver a service and assigns time-based person costs and material costs to each activity in order to calculate overall cost. Identifying the prominent activities of a care process is the first step of Time-Driven Activity-Based Costing analysis.[7] Understanding variation, cost and outcomes allows identification of the most high-value processes in care.[5,8,9]

CHD outcomes, care processes, and resource utilisation vary by individual lesion, disease acuity, institution, and specific patient circumstances.[2,10–12] Variation can be categorised as either warranted variation, which is based on analysis of outcomes and guidelines, or unwarranted variation, based on clinician preference and not supported by data or research.[8] The high variability in costs for CHD procedures cannot be explained solely by case type or volume of procedures performed at a particular institution, which would constitute unwarranted variation[13]. It is likely that numerous other factors contribute to the wide range of outcomes and costs. While care appropriately varies based on specific, heterogeneous patient needs, process variation, particularly unwarranted variation, is a prominent contributor to variability in outcomes and costs.[8,9,14–18]

Care improvement through variation reduction is mainly described among high-risk procedures; however, substantial variation has been identified in lower-risk lesions as well.[11] It is likely that a large amount of process variation is idiosyncratic and results from differences among individual clinician's processes and preferences.[19–21] Additionally, incentives that exist between providers and specialties may impact care processes.[22]

The identification of process variation enables comparing the outcomes of different processes with the goal to streamline care by increasing the use of processes found to provide the highest value (better outcomes and lower costs).[19] Only once variation is identified can it be analysed as warranted or unwarranted. For this study, outpatient isolated repairs of atrial septal defect and ventricular septal defect were selected as they constitute relatively low-risk procedures that tend to occur electively. The goal of this study was to map the process of pre-operative evaluation and planning of outpatients undergoing isolated repair of atrial septal defect or ventricular septal defect at a single institution and identify the presence of variations in the process as a pilot use of process mapping to address cost in CHD.

Materials and methods

Patient population

The study included all outpatients with a diagnosis of isolated atrial septal defect or ventricular septal defect that underwent surgical repair at a single institution from October 2018 through October 2020. Patients were excluded if they were inpatients during evaluation and surgical intervention, underwent successful atrial septal defect or ventricular septal defect device closure without surgical consultation or case conference presentation, were referred through sponsorship by an international non-governmental organisation, or carried additional CHD anomalies that necessitated surgical intervention. Patient demographic and clinical data were retrospectively extracted from patient charts. The Institutional Review Board at The University of Texas at Austin approved this study and waived the need for informed consent.

Care team interviews to build initial process map

A series of interviews with congenital heart surgeons, advanced practice practitioners, and nurse navigators was conducted to build the perceived pre-operative process map for patients who undergo surgical closure of an atrial septal defect or ventricular septal defect at the institution. The goal of the interviews was to ascertain the perceived flow of care for atrial septal defect and ventricular septal defect patients, including perceived points of variation and consistency within the process. The interviews were structured as an open discussion to build out all major points of care between a paediatric cardiologist's decision for necessary intervention and the patient entering the operating room for repair. The sequential points of care identified in these interviews were built into a process map and edited using Miro design software (www.miro.com). Each iteration of the process map was re-distributed to the cardiac care team at-large (including paediatric cardiologists and paediatric cardiac anaesthesiologists) for review and edited from the resulting feedback until the team agreed on the accuracy of the perceived process map. No patient data were utilised during initial process map building.

Initial retrospective chart review

After the perceived process map was complete, 5 patients within the overall study cohort were randomly selected for retrospective chart review to determine if there were areas identified in the review that required further group discussion. Their care processes were mapped onto the perceived process map.

Care team responses

The process map with 5 retrospective patient chart data was presented to the care team for review and discussion. Discussion of the process map centred on points of care that differed from the initial perceived process map built by the care team. The team assessed whether these deviations represented an outlier or a care variation (differences in the processes clinicians use for relatively similar patient situations).

Complete retrospective chart review

To further understand the process map and whether deviations seen in the initial patient chart review were outliers or represented process variation, we performed a retrospective chart review of all isolated outpatient atrial septal defect and ventricular septal defect surgical patients during the study period. A total of 32 patient charts were reviewed, which included the 5 patients analysed in the initial retrospective review. The care pathway for each patient was mapped onto the existing process map. Percentages were added to the process map at each care point to reflect the proportion of patients that underwent that point in care. Points of care that deviated from the perceived process map were added to the map.

Statistical analysis

Descriptive statistics were utilised, and data are presented as proportions for categorical variables and as a median [25 percentile–75 percentile] for continuous variables.

Results

Perceived process map

The initial process map aftercare team discussions determined five main care and/or decision points involved in the pre-operative course for CHD patients undergoing surgical repair of an atrial septal defect or ventricular septal defect (Fig. 1). These points include decision of necessary intervention by the cardiologist, case conference, surgical clinic visit, pre-operative anaesthesia testing, and clearance for the procedure (Fig. 1). During process mapping, the clinical team identified significant variation around surgical rescheduling, defined as any time between initial procedure scheduling and the patient entering the operating room. Pre-operative anaesthesia testing was thought to occur within the week before the scheduled surgery, and the day-of-surgery anaesthesia assessment to occur either the day of surgery, or the night before surgery for patients who were preadmitted.

Patient characteristics

A total of 32 patients were identified for inclusion in the analysis. There were 24 atrial septal defect patients and 8 ventricular septal defect patients. Median age at surgical intervention was 6.8 [2–9] years. Atrial septal defect patients had a median age of 4 [2–7.25] years, and ventricular septal defect patients had a median age of 8

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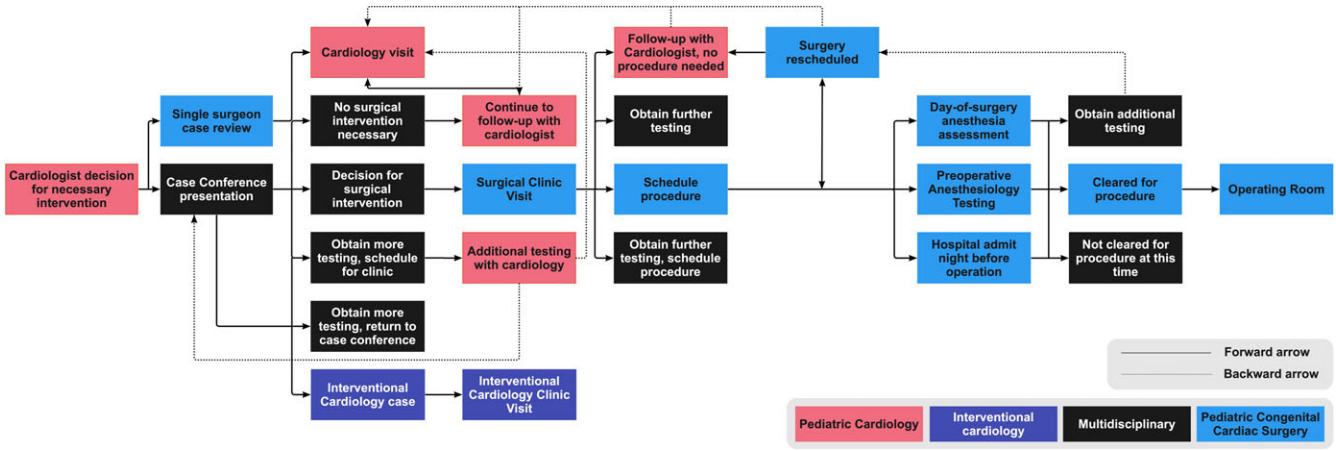

Figure 1. Perceived Process Map of the Preoperative Course for Surgical Closure of isolated ASD and VSD.

[4.25–9.25]. Overall, 16 (50%) patients were female; 24 (75%) patients carried a diagnosis of atrial septal defect. The most common procedure was atrial septal defect patch repair (22, 68.8%), followed by ventricular septal defect patch repair (6, 18.7%). During the study period, 100% of ventricular septal defect cases at our centre were closed surgically and 53% of atrial septal defect cases at our centre were closed surgically (Table 1).

Complete retrospective chart review

After review of all 32 eligible patients, points of variability identified included (1) interventional cardiology case review and intervention before heart centre case review, and (2) surgery rescheduling before pre-operative testing. Variation due to patient family preference included 3 (9.4%) families delaying surgical consult after decision for necessary intervention was made and 1 (3.1%) family seeking a second opinion after decision for necessary intervention was made (Fig. 2).

Percentage of patients at each care point

Of the 32 patients included in the retrospective chart review, 30 (94%) patients were reviewed in case conference, all attended surgical clinic, and all underwent both pre-operative and day-of-surgery anaesthesia testing (Fig. 2). Process variation occurred within interventional cardiology review, where 10 (31%) patients were reviewed prior to surgical review. Of these 10 patients, 4 (40%) were deemed amenable to catheter-based repair and subsequently underwent an unsuccessful attempt of catheter-based repair, the remainder were deemed poor candidates for catheter-based closure of the defect. Process variation was also seen in surgery rescheduling, where 3(9%) patients had their surgery rescheduled once and 2 (6%) had their surgery rescheduled twice. Of the 5 patients rescheduled, 2 (40%) had an additional cardiologist outpatient visit before their rescheduled surgical date.

Discussion

Care points

The majority of atrial septal defect and ventricular septal defect patients that were surgically repaired were presented in multidisciplinary case conference, had a surgical clinic visit, and underwent all pre-operative anaesthesia testing. Multidisciplinary case conference plays a central role in management decisions for congenital heart surgery patients who may require surgery at our centre. Multidisciplinary case conference likely has many benefits for patients and their families and allows for the most appropriate surgical candidates to be selected for operative management. Our study revealed surgical rescheduling to be a point of variability for patients, which was expected by our providers. While rescheduling may be warranted when emergent procedures arise, it likely causes distress for patients and their families. Minimising surgical rescheduling variability is a way to increase value for these patients.

Patient characteristics

The median age of our patient population is older than previously described, likely due to the fact that the cohort only included those diagnosed in the outpatient setting and excluded those with concomitant procedures.[23,24] The cohort of surgical patients analysed in this study comprises 100% of ventricular septal defect cases at our centre, and 53% of atrial septal defect cases at our centre. The additional 47% atrial septal defect cases were repaired in the catheterisation lab.

Process mapping

Porter and Teisberg define value in healthcare as the improvement in a patient's health outcomes for the cost of achieving that improvement.[5] The creation of a process map is an important first step in improving the value of care by allowing a clear understanding of variation in care processes and identification of high-impact and high-volume care points. These data can then be used to optimise and streamline those care processes.

The current study identified areas of variability and consistency within the pre-operative evaluation and planning of patients with isolated atrial septal defects and ventricular septal defects. During the initial process map building through interviews with care personnel, the team identified surgery rescheduling as a point with significant variability while identifying case conference and surgical clinic as points of consistency. The retrospective chart review confirmed the consistency at case conference and surgical clinic with almost all patients being presented at case conference and all being seen in surgery clinic. It further confirmed variation at surgery rescheduling but at a lower rate than initially expected. In addition, no patient was rescheduled after pre-operative anaesthesia testing requiring repeat testing. Two of the 5 patients

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Table 1. Patient characteristics.

Variable	Data
Total number of patients	32
Female, n (%)	16 (50)
Age in years at surgical intervention, median [25%tile–75%tile]	6.8 [2–9]
Atrial septal defect	4 [2–7.25]
Ventricular septal defect	8 [4.25–9.25]
Diagnosis, n (%)	
Atrial septal defect	24 (75)
Ventricular septal defect	8 (25)
Procedure, n (%)	
Atrial septal defect patch repair	22 (68.8)
Ventricular septal defect patch repair	6 (18.7)
Atrial septal defect primary repair	2 (6.3)
Ventricular septal defect primary repair	2 (6.3)
History of attempted catheter-based device closure, n (%)	4 (12.5)
Proportion of total repair cases	
Atrial septal defect	24 (53)
Ventricular septal defect	8 (100)

who were rescheduled had an additional cardiology outpatient appointment prior to their new surgery date.

Comparing the process map designed by the care team to patient records not only revealed new areas of variability and confirmed areas of perceived variability and consistency but more importantly provided insight into systematic assumptions about the care pathway that can be challenging to identify by single providers in a larger process. While routine points of care were expected, such as clinical pre-operative anaesthesia evaluation, more specific trends within that point in care were elucidated in this analysis. For example, all isolated atrial septal defect or ventricular septal defect patients in this chart review received clinical pre-operative anaesthesia evaluation the day of their procedure with none admitted the night before, thus confirming the care team's perception that this is a common pathway for these patients.

When developing these types of process maps, there are 3 different perspectives that providers may incorporate into the maps: (a) how they think the process happens at their centre, (b) the ideal way the process ought to happen, or (c) all the possibilities of how the process may happen. We found that simply asking providers how they think a process happens without further clarification is suboptimal because it conflates these 3 separate viewpoints. We recommend clarifying between actual, ideal, or all possible processes when asking providers how a particular process happens at their centre.

At the start of the study, the clinicians expressed the belief that there was minor variation in this process, and points of expected variation were known to exist but their magnitude was not clearly understood. This study illustrates the presence of process variation in the care of the less complex lesions in CHD and potentially indicates that even larger variations in care exist for more complex patients who require more steps in their care processes.

Assessing warranted and unwarranted variation

Variability in healthcare is not a novel realisation and occurs both among and within care institutions. Warranted variation is both unavoidable and necessary even within high-value clinical practice. For example, rescheduling a case due to infection or postponing a planned non-emergent case due to an emergent operation for another patient is likely desirable and/or unavoidable. The pertinent question regarding care variation is whether the variation is warranted (based on analysis of outcomes and guidelines) or unwarranted (based on clinician preference not supported by data or research). Unwarranted variation in care is associated with worse outcomes. This relationship is well-documented and explains why understanding areas of variability is critical to delivering high-value care.[8,9,14,16–18,29,30]

Within congenital heart surgery alone, variation in the management of specific diagnoses such as tetralogy of Fallot differs among providers and institutions.[31–34] While this example illustrates variation among different institutions, unwarranted variation often occurs in clinical practice within the same institution.[19]

Utah's state-wide Intermountain Healthcare network undertook large efforts to reduce unwarranted variation within their care processes. By identifying variation within their system and constructing team-based care processes to reduce it, they significantly improved patient outcomes and reduced costs, thus improving value.[19]

Care improvement through variation reduction relies on detailed process maps to identify where variation occurs.[35] The interventional cardiology pathway and surgical scheduling points reflected in Figure 1 are areas of high variability for atrial septal defect and ventricular septal defect patients at our centre. Determining the clinical care activities within each care point is the first step to tackling unwarranted variation in atrial septal defect and ventricular septal defect pre-operative evaluation and planning. Our study aims to point out where variation exists, but does not identify whether the variation is warranted or unwarranted. For future analyses, it is critical to determine if decisions made within highly variable care points are consistently based on analysis of outcomes and guidelines – warranted variation – or based on clinician preference not supported by data or research – unwarranted variation. Further analysis of various decision criteria is needed to assess whether the differences in outcomes are warranted, unwarranted, or a mixture of both.

Variation in care also affects patients and families in terms of time, monetary expenses, psychological burden, and trust in the healthcare system.[36] In routine paediatric emergency department visits for asthma exacerbation, variation in treatment not only causes significant differences in the length of an emergency department stay but also differences in the severity of patients that are admitted to the hospital and the patient's total cost of emergency department admission.[36] Discrepancies in treatment for the same condition may cause patients to avoid seeking care when it is needed because of the perceived waste of time or cost.

Redefining care processes for patients

From the patient and family perspective, the main outcome for atrial septal defect and ventricular septal defect repair is to have the defect closed. Currently, reported failure rates of catheter-based intervention range from 3.7% by Siddiqui at el to 4.3% by Du et al looking at secundum atrial septal defect closure alone.[37,38] As a result, a known proportion of patients are worked up by

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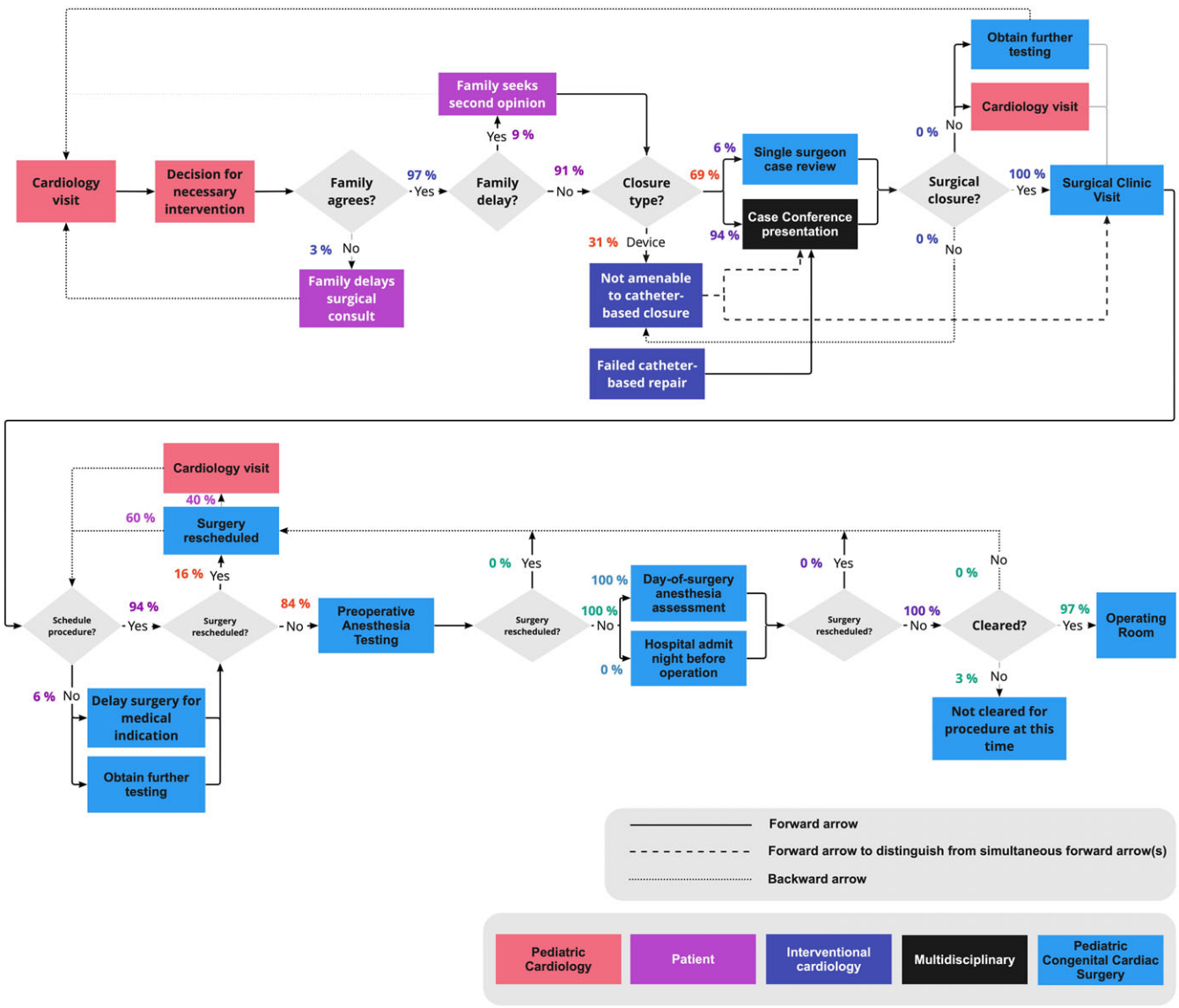

Figure 2. Process Map of the Preoperative Course for Surgical Closure of isolated ASD and VSD.

interventional cardiology, undergo general anaesthesia for a catheter-based procedure, fail closure, wake up from anaesthesia, and are forced to return home and start the same process again with the surgical team. Even with a high catheter-based closure success rate, a large absolute number of atrial septal defects undergoing catheter-based closure means that there are a large number of atrial septal defect patients that fail catheter-based closure and require surgical intervention. This means there is opportunity to improve value of care for these patients by improving efficiency. A more efficient, streamlined approach may result in reduced costs and higher value to the patient and their family as well as the providers and healthcare system. For example, an approach where patients are counselled pre-operatively for both catheter-based and possible surgical closure, undergo a single admission with a single anaesthesia induction and undergo the necessary repair as indicated, either by catheter or surgical intervention. A new streamlined approach would help families in accounting for the risk of redundancy and should be explored in greater detail. It is possible to envision a potential process map towards this end for patients and families. It is possible the time between cath and surgical procedures is beneficial for patients and families who have more time to mentally and emotionally process the need for surgery. However, it is also likely time between procedures heightens anxiety for patients and families. It is important to measure the effect time has on the patients and families waiting for a second closure attempt in order to inform the most high-value and efficient process. The development of high-value processes from the patient and family perspective may reduce patient burden and cost, and enhance outcomes.

Limitations

Limitations of our analysis include the small sample size of isolated atrial septal defect and ventricular septal defect patients analysed in the study. This analysis focused only on outpatients undergoing repair of atrial septal defect and ventricular septal defect as the process for inpatients would be different, thus limiting the generalisability of the process map and findings to this particular

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cohort. It is also possible that the patients included in the study do not accurately represent all patients requiring repair of isolated atrial septal defect and ventricular septal defect as part of a large cohort. The study encompasses findings in only one centre. It is possible that process variation may be different in other centres, thus also limiting the generalisability of the findings.

Conclusions and future directions

Process mapping using both care team interviews and retrospective chart reviews allows for points of variability to be identified so they can be addressed, analysed as warranted or unwarranted, and streamlined in order to provide higher-value care for patients and families. This small pilot study not only demonstrates how process mapping can be useful in quantifying variation and identifying opportunities to streamline care but also sets the stage to use Time-Driven Activity-Based Costing methodology to analyse the cost incurred at each care point within the process. The development of process maps that include other portions of the pathway (e.g., diagnosis, intraoperative, and post-operative periods) and other disease conditions will be necessary to gain a better understanding of CHD care processes. This methodology may be applied to analyse variation in other congenital cardiac conditions. Additionally, conducting multi-institutional assessments may elucidate inter-institutional variation and better define high-value care for CHD patients. We expect initiatives like this will help streamline the way CHD care is provided and ultimately improve outcomes and reduce cost.

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