Published in final edited form as:

Pacing Clin Electrophysiol. 2018 November ; 41(11): 1428–1434. doi:10.1111/pace.13477.

Cost Analysis of Combining Congenital Cardiac Catheterization and Electrophysiology Procedures in an Outpatient Setting

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Abstract

Background: Patients with congenital heart disease require multiple procedures over their lifetime. These procedures increase cost and time commitment. Previous studies in the field of medicine have shown that combining procedures is an effective method to reduce cost and time. There has been no such study to evaluate the cost and efficiency of combining pediatric cardiac procedures.

Objective: The objective of this study was to compare the cost and time commitment of combined cardiac catheterization (cath) and electrophysiology (EP) outpatient procedures against separate cath and EP procedure.

Methods: Outpatient combination procedures performed in the pediatric cardiac cath lab from 2013 – 2016 were matched to a control population of two or three similar single outpatient procedures from 2009 – 2016 for patients of similar age and cardiac anatomy. Procedure duration, recovery duration, length of stay, equipment charges, physician charges, all other hospital charges and total admission charges were analyzed. The two groups were compared using an unpaired t-test.

Results: A total of 92 subjects, 32 study subjects and 60 control subjects, were included in this study. Study group procedures had a significantly shorter recovery duration ($p = 0.04$) and length of stay ($p = 0.01$). Study group procedure duration trended shorter on average but statistically insignificant ($p = 0.20$). The total median savings for patients undergoing combined procedures in the study group was \$ \$13,181 (Inter Quartile Range (IQR) \$423.8-\$26710).

Conclusions: Combining cath and EP outpatient procedures reduces the time commitment and provides some economic advantage.

Keywords

Financial; pediatric; catheterization; electrophysiology

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Disclosures:

All authors have no actual or potential conflicts of interest with industry in relation to this research study.

Introduction/Background

Cardiac catheterization procedures are commonly performed on patients with congenital heart disease (CHD) in both inpatient and outpatient setting. Patients may undergo either a cardiac catheterization (cath) or an electrophysiology (EP) procedure. In many cases a patient will require both procedures either for diagnosis and/or treatment. These procedures are often performed on an outpatient basis following a recovery period of four to six hours (1, 2). A patient requiring both cath and EP procedures may have them combined into a single setting or performed separately. The accumulation of these procedures over a patient's lifetime can become costly and time-consuming.

Combining procedures may provide financial benefits and reduce the overall length of the patient's hospital stay. Children with special health care needs, such as those with CHD, are estimated to account for about half of all pediatric health care costs (3). Healthcare costs may also be reduced by efficiently combining care, services, and procedures (4). The objective of this study was to compare the cost and time commitment for the patient and hospital for cath and EP procedure performed separately or in combination.

Methods

A single center retrospective study was performed on CHD subjects who had undergone combination procedures (study subjects) and single cath or EP procedures (control subjects). Combined cath and EP outpatient procedures from the 2013–2016 calendar years were identified and selected as study subjects. Control subjects were identified and selected from the 2009–2016 calendar years. At least two controls were chosen for each study subject, one to match the cath procedure and one to match the EP procedure. Additionally, control subjects were chosen to reflect a similar age and cardiac anatomy of the study subjects. Since none of the combined procedures had any major complications we chose the control subjects also without complications. Institutional Research Board approval was obtained prior to the beginning of the study.

Demographic data included age, height, weight, cardiac anatomy/surgical repairs, and clinical diagnosis at the time of procedure. Procedural data included procedure duration, recovery duration, and length of stay. Procedure duration was defined as the time the patient entered the cath lab to the time they left the cath lab. Recovery duration was defined as the time from the end of procedure to discharge. Length of stay was defined as the time from outpatient admission to discharge.

In order to compare study subjects who had combination procedures to control subjects who had single procedures, the durations of the control subjects matching to a single study subject were summed. For example, the recovery durations of cath control and EP control subjects were summed and compared to the recovery duration of the corresponding study subject.

Financial data included physician charges, equipment charges, all other hospital charges and total admission charge. Physician charges included both cardiologist and anesthesiologist charges. Equipment charges consisted of sterile supplies, pacemakers, and all other implants

(revenue codes 272, 275, and 278)(5, 6). All other hospital charges were compiled into a single fee, which was considered as a combination of recovery, anesthesia, and facility fees. In order to normalize payments, all charges were converted to Medicare/Medicaid reimbursement rates according to the year of procedure. All charges, fees, and payments were adjusted for inflation to the 2016 fiscal year.

Similar to comparing procedural durations, the charges of control subjects were summed in order to compare them to the charges of their corresponding study subject. For example equipment charges of cath control and EP control subjects were summed and compared to the equipment charge of the corresponding study subject.

Median time and cost savings were calculated as the difference in time and cost for each study and their respective control subject. The difference was then calculated as positive or negative and then represented as mean difference. This was called as Median savings.

Statistical analysis

All statistical analysis was performed using GraphPad Prism (version 7.00 for Windows, GraphPad Software, La Jolla California USA, www.graphpad.com) and Microsoft Excel (2010) programs. All values were represented as median as the data was not normally distributed. Kruskal-Wallis tests were used to compare differences in age, height, and weight between the study and control group. Non-parametric Mann-Whitney U tests were performed to determine statistical significance between study and control durations and costs. A p value of <0.05 was considered statistically significant.

Results

A total of 92 subjects (55% male) were identified who had undergone cath and/or EP procedure. Thirty-two (44% male) were in the study group and 60 (62% male) were in the control group. There was no statistical difference in age, weight and height between the study and control groups (Table 1). Three study subjects had a combination procedure consisting of three procedures. These three patients had three procedures performed in one setting and were match to three controls each. One patient had a venous baffle angioplasty along with EP study, cryoablation and ICD placement. One patient had transcatheter pulmonary valve placement, EP study and Cardioversion, and one patient had diagnostic cath, EP study and loop recorder implantation. Control subjects were matched to each of these study subjects – one for each procedure of the combination case.

The most common clinical diagnoses (Table 2) was cyanotic heart disease (n=58) including transpositions of the great arteries (n = 28) and tetralogy of Fallot (ToF) (n = 18). The subject's with structurally normal heart were patients with cardiomyopathy, heart transplant or post cardiac arrest. The majority of patients (61%) has had previous surgical repair (n=66) with TOF repair as the most common surgical repair (n=14). Subjects may have had more than one clinical diagnosis and/or more than one repair.

The types of procedure performed are described in table 3. Sixteen subjects underwent a total of 31 intervention procedures. The most common interventional cath procedures were

angioplasty followed by stent placement and valve placement. The stent placement was in right ventricular outflow tract, pulmonary arteries and pulmonary venous baffle in a patient after atrial switch. The control patient had similar procedure performed. There was one patient with pulmonary who had MPA angioplasty and pulmonary valvuloplasty was also reported as the balloon used for MPA angioplasty would also dilate the pulmonary valve. We considered this as similar to MPA angioplasty in a control patient. The most common EP procedures were device generator replacements followed by ablations and diagnostic EP studies (Table 3).

Compared to the study group, control group subjects had longer hospital stays (table 4). Median procedure times were similar between study and control groups. In comparison to the control group, study group procedure duration was 6% shorter on average but was not statistically significant. The study group recovery duration was significantly shorter by 22% ($p = 0.04$) (Table 4). On average, the study group lengths of stay were more than 25% shorter. (Table 4)

Financial analysis shows difference in charges in multiple categories throughout the course of the patient's outpatient stay (Figure 1). Median equipment charges of study and control groups were \$27,139 (IQR \$10,777-\$43,070) and \$25,899 (IQR \$12,915-\$44,385) ($p = 0.70$), and median physician charges were \$13,330 (IQR \$9,632-\$18,365) and \$17,454 (IQR \$11,726-\$21,978) ($p = 0.08$), respectively. All other hospital charges were compiled together as a single value with medians of \$50,956 (IQR \$40,557-\$71,063) and \$63,759 (IQR \$42,760-\$78,924) ($p = 0.21$). Total charges calculated by the sum of each category of charges for the study and control groups revealed medians of \$94,849 (IQR \$76,865-\$121,530) and \$108,396 (IQR \$88,697-\$141,379) ($p = 0.11$).

Further cost analysis showed financial savings on average for study subjects in every category. Median equipment charge savings, physician charge savings, and all other hospital savings were \$3,351 (IQR -\$1152-\$8022), \$1,938 (IQR -\$235 – 6083), and \$ 5,025 (IQR \$ -175-\$18288), respectively. Total median charge savings were \$13,181 (IQR \$423.8-\$26,710) on average with a total of \$437,419 for all 32 patients (Figure 2). Statistically there was no significant difference in the cost between the 2 groups. There was direct relationship between the length of stay and cost incurred as expected ($P=0.0011$) (Figure 3).

Discussion

Outpatient cardiac catheterization is a safe and effective method of diagnosis and intervention for most patients with CHD (7–9). With the advances in the care of congenital cardiology patients, the number of procedures for this patient population has increased significantly. Expenses have been previously shown to be reduced by combining care, services, and procedures. This has been demonstrated by the combination of coronary angiography and angioplasty into a single procedure (10). In this study, significant reductions in post-procedure recovery time and expenses were seen. As a result, hospitalization times were shortened by about 30%, and about \$2,000 per patient was saved in total hospital charges.

Reduced expenses and hospitalization times have also been seen in fields outside cardiovascular medicine. A number of surgical services such as oral surgery, otolaryngology, and general surgery have been combined with dentistry under general anesthesia (11). In particular, combining dental treatment and services with oral surgery under hospital general anesthesia on average has been shown to save more than \$2,000 per case when compared with separate treatment and service cases. Shorter procedure times, anesthesia times, surgical times, and hospital stays led to lower inpatient charges and only a single recovery period was needed after anesthesia for multiple procedures. Similar results were seen in combined laparoscopic/endoscopic procedures in which patients were able to benefit from reduced exposure to anesthesia and a single hospitalization (12). Length of hospital stay for a patient who underwent a combined procedure was similar to the length of stay for a patient who underwent a single procedure.

Cost reduction has been seen in combining noninvasive tests as well. For patients that needed multiple noninvasive tests for coronary artery disease diagnosis, combining fluoroscopy, Stress electrogram, and stress thallium scintigraphy optimized the cost per diagnostic yield of the tests (13). It is important to note that combining these tests was not cost-efficient if all tests were not required.

We analyzed the time and financial implications of combining procedures for the CHD patient population. In this retrospective analysis of 92 subjects, we found both time and financial savings. As expected, procedure times were found to be statistically similar between the two groups since identical procedures were being performed. Any small variance in the procedure time could be attributed to the pre-anesthesia, anesthesia induction time and time needed to obtain access. Control group procedure time included pre-anesthesia time (patient entering lab to the induction of anesthesia) and anesthesia time, which reflects the time, expected if a patient was admitted for two separate procedures. A significantly shorter recovery time is in large part due to study subjects having a single recovery period, while control subjects had two separate recovery periods. Similar to recovery time, the length of stay was shorter for study subjects. This could reduce the burden on the hospital as well as the patient. If two procedures could be performed on the same day with one recovery time this would reduce the need for scheduling two procedures at different times.

Although not statistically significant, financial analysis showed savings on average in every category. Equipment charges, as expected, were similar and insignificant between groups. Theoretically, the exact same equipment and sterile tools would be used in a combined procedure as two separate procedures. Equipment costs vary and are often influenced by the physician's choice of equipment based on if they believe the extra costs of special equipment merit the benefits (14). Disparities may also be attributed to the increasing complexity and costs of equipment over the past decade.

Physician charges were lower for study subjects although statistically not different. Depending on the complexity and longevity of procedures, cardiologist charges can vary, whereas anesthesiologist charges are dependent on procedure length (15). We expected to see similar physician charges for similar procedures between the study and control groups.

Savings seen could be owed to a single anesthesiologist charge incurred instead of two separate charges.

The remaining hospital charges were compiled as a single sum. These charges included anesthesia, recovery, and facility fees. With shorter recovery times we would expect these charges to be similarly reduced for study subjects. But anesthesia for most procedures and surgeries generally comprises less than 6% of perioperative costs and can be further reduced with efficient preoperative care (16, 17). Even if it is a smaller portion of total costs, average savings of over \$6,000 for study subjects are substantial.

The total sum of all charges trended toward being lower for study subjects with a median of \$13,811 saved. A lack of statistical significance can be explained by the high median cost of a combination procedure. However, when including all 32 study subjects, there was substantial financial saving. Length of stay is often used as an indicator of total costs, but the last day of a patient's stay has been found to account for a smaller portion of total costs (18). The significance seen in reduced length of stay may not translate to the total admission to discharge charges.

Other potential savings for patients are more challenging to quantify. Often, patients must take time off work and some may have a considerable commute. Furthermore, a single appointment would alleviate any logistical burdens. Combination procedures would effectively decrease both time off and commutes in half, saving time and money for patients while minimizing stress involved in planning around an appointment.

There were no complication noted in the study subjects hence we did not include control subjects with complication as it would skew the data. A complication can (19) definitely adds to the cost of care. Previous studies have also proved that combining procedure does not always lead to increased risk of complications (20). Asaki et al reported an adverse event rate of 4.8%. None of the adverse events were deemed to be due to combining the procedures. Even then it is lower than reported 7.8% complication rate with 1.8% major complication rate from the high volume single pediatric center (21). Vascular complications due to adverse procedural events of diagnostic catheterizations have significantly decreased over the years (22, 23). Combining cath and EP procedures has long been a practice at our institution. It should be noted that healthcare costs of coordinated care are not always measured in the same way as clinical patient care and can lead to under-reimbursed costs (24). It is important to note that adequate communication between interventional cardiologists and surgical service is necessary to prevent procedural complications (25). A combined procedure may be contraindicated in certain patients, such as those with complex cardiac anatomy.

Limitations

As a single institution, retrospective study, it is recognized that these results will not be identical to similar studies from other institutions. Variations between institutions in catheterization lab setup, anesthesia set up time, providers, procedure times and other factors can influence results to an extent. However, a single institution study provides consistency.

The same physicians, anesthesia team, radiation technicians, and other cath lab staff regularly perform these procedures maintaining consistent methods and timing.

This study does not account for any additional time and costs incurred by the patient's need for other intangible services such as an interpreter, food, cleaning services, etc. Patient's requiring interpreters have been shown to have longer clinic times by about 20 minutes and slightly more expensive total costs (26). Combining two procedures would also reduce those costs and thereby reduce costs of medical care.

It is important to note possible fluctuating Medicare/Medicaid reimbursement rates for subjects gathered from over the past decade. Accessibility and costs of equipment may also have changed from year to year. Optimal analysis could be achieved by a prospective study involving patients requiring both a cath and EP procedure who are randomly assigned to receive a combined procedure or two separate procedures, though this may not be practical. A larger study group sample size would help refine results.

Lastly we did not assess the radiation dosage of combining EP and catheterization procedure. The radiation exposure for EP procedures has significantly decreased over years. In current era most EP procedure are performed with minimal or no radiation (27, 28). Hence we did not perform the radiation dose assessment and this was not the intent of the study.

Conclusion

Combining cath and EP procedures in the pediatric cath lab should be considered for the advantage of both the patient and hospital. Patients benefit from time savings, while also reducing the logistical burdens of creating multiple appointments. Future research should be focused on obtaining a larger sample size and expanding the study to multiple institutions and departments.

Acknowledgements

We wish to thank the University of Iowa Financial Department for collecting and documenting financial data used in this study. We greatly appreciate the generous funding provided by the University Of Iowa Carver College Of Medicine Summer Research Fellowship. Finally, we thank the support of the National Institute of Health Clinical and Translational Science Award Program, grant U54TR001356.

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Figure 1:

Box-Whiskers plot of charges for study and control patients

S- Study subjects

C- Control subjects

Figure 2:
Median cost savings for different types of charges.

Figure 3:

Time to cost relationship between the length of stay and the total admission charge of each subject.

Study = individual study subjects

Control = individual control subjects

Length of Stay = total time in hours from patient admission to discharge

Total Admission Charge = total charges incurred from admission to discharge

Table 1:

Demographics. Values represented as Median (IQR)

	Study	Control - cath	Control - EP	P-Value
Age (years)	27.2 (15.76–34.83)	18.5 (13.53–29.66)	20.6 (12.98–29.5)	0.30
Height (meters)	1.66 (1.525–1.733)	1.665 (1.548–1.773)	1.64 (1.573–1.78)	0.94
Weight (kilograms)	71.3 (58.08–82.23)	73.6 (45.7–82.68)	67.85 (50.68–82.38)	0.91

Cath- catheterization

EP- Electrophysiology

IQR- Interquartile range (25th-75th centile)

Table 2:**Subject's Primary Diagnoses**

Clinical Diagnosis	Study Subjects (n = 32)	Control Subjects (n = 60)	Total Subjects (n = 92)
Cyanotic Heart defects	22	36	58
Structurally Normal heart	5	18	23
Shunt lesions	7	12	19
Obstructive lesions	9	13	19
Single ventricle physiology	4	8	10
Hypertrophic Cardiomyopathy	1	2	3
Arrhythmogenic Right Ventricular Cardiomyopathy	1	1	2
Anomaly of Left Coronary Artery	1	0	1
Noonan Syndrome	1	0	1
Pulmonary Hypertension	0	1	1

One Subject may have had more than one diagnosis.

Table 3:**Procedures Performed**

Procedure	Study Subjects (n = 32)	Control Subjects (n = 60)	Total Subjects (n = 92)
Diagnostic Cath	24	22	46
Interventional Cath	8	8	16
• Angioplasty	5	5	10
• Stent Placement	5	5	10
• Valve Placement	3	3	6
• ASD Closure	1	1	2
• Biopsy	1	1	2
• Valvuloplasty	1	0	1
Generator Change	14	12	26
• ICD	9	7	16
• Pacemaker	5	5	10
EP Study (no ablation)	9	6	15
EP Study w ablation	8	8	16
New ICD	1	1	2
• Single	0	1	1
• Dual	1	0	1
Cardioversion	1	1	2
Loop Recorder Placement	1	1	2
New Pacemaker	1	1	2
• Dual	0	1	1
• BiV	1	0	1

Cath- catheterization

ASD: atrial septal defect

ICD: Implantable Cardioverter Defibrillator

EP- Electrophysiology

BiV: biventricular

Table 4:

Time Savings. Comparison of time spent between study and control groups

	Study Median (IQR)	Control Median (IQR)	Median Savings	p-value
Procedure Duration (min)	248.5 (186.8–378.8)	285.5 (232–364.8)	31 min	0.199
Recovery Duration (min)	405.5 (315.8–1093)	697 (581.3–1201)	211 min	0.044
Length of Stay (hr)	12.5 (10–27)	20 (18–32.25)	7 hours	0.007

IQR: interquartile range (25th – 75th centile)