

Resource reduction in pediatric chest pain: Standardized clinical assessment and management plan

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Abstract

Objective: Using a Standardized Clinical Assessment and Management Plan (SCAMP) for pediatric patients presenting to clinic with chest pain, we evaluated the cost impact associated with implementation of the care algorithm. Prior to introduction of the SCAMP, we analyzed charges for 406 patients with chest pain, seen in 2009, and predicted 21% reduction of overall charges had the SCAMP methodology been used. The SCAMP recommended an echocardiogram for history, examination, or ECG findings suggestive of a cardiac etiology for chest pain.

Design: Resource utilization was reviewed for 1517 patients (7-21 years) enrolled in the SCAMP from July 2010 to April 2014.

Results: Compared to the 2009 historic cohort, patients evaluated by the SCAMP had higher rates of exertional chest pain (45% vs 37%) and positive family history (5% vs 1%). The SCAMP cohort had fewer abnormal physical examination findings (1% vs 6%) and abnormal electrocardiograms (3% vs 5%). Echocardiogram use increased in the SCAMP cohort compared to the 2009 historic cohort (45% vs 41%), whereas all other ancillary testing was reduced: exercise stress testing (4% SCAMP vs 28% historic), Holter (4% vs 7%), event monitors (3% vs 10%), and MRI (1% vs 2%). Total charges were reduced by 22% (\$822 625) by use of the Chest Pain SCAMP, despite a higher percentage of patients for whom echocardiogram was recommended compared to the historic cohort.

Conclusions: The Chest Pain SCAMP effectively streamlines cardiac testing and reduces resource utilization. Further reductions can be made by algorithm refinement regarding echocardiograms for exertional symptoms.

KEYWORDS

chest pain, quality improvement, resource reduction, SCAMP

1 | INTRODUCTION

Chest pain in the pediatric population is one of the most common complaints presenting to primary caregivers as well as cardiology specialists. The majority of chest pain in this young population represents a benign symptom, with a paucity related to serious organic disease.¹⁻⁶ A cardiac etiology to chest pain in children is exceedingly rare (0.1-1%) and determining which child could be among those affected remains a challenge.^{1,2,5,7-11} As detailed in prior publications, the Pediatric Chest Pain Standardized Clinical Assessment and Management Plan (SCAMP)

was developed and implemented at Boston Children's Hospital in 2010 as a quality improvement initiative. The goals of the SCAMP are to reduce unnecessary resource utilization for chest pain assessment in the cardiology clinic and to aid in the detection of rare cardiac disease by decreasing practice variation and directing resources to signs and symptoms most suggestive of cardiac disease.^{2,8,12}

The Chest Pain SCAMP was developed based on review of the literature and analysis of a decade of patients presenting to Boston Children's Hospital with serious cardiac disease and chest pain as a major complaint.² The specific diseases reviewed included myocarditis,

pericarditis, dilated and hypertrophic cardiomyopathy, coronary artery anomalies, pulmonary artery hypertension, pulmonary embolism, aortic dissection, and Takayasu's arteritis. The algorithm elicits pertinent circumstances related to the chest pain, personal and family history components, and physical examination and electrocardiogram findings, which would raise the likelihood of a cardiac etiology. An echocardiogram is the test of choice for further evaluation of patients with noteworthy findings. Additional testing, including exercise stress test and rhythm monitoring, is not recommended by the SCAMP given the low yield of positive findings related to chest pain.¹³⁻¹⁶ Clinicians using the SCAMP are unhindered in their medical choices and are only asked to provide reasoning if they choose to divert from the algorithm. Data collected by the SCAMP are reviewed regularly and used to revise the algorithm in an iterative manner, including information gained from SCAMP diversion. During the duration of this study, recommendation for echocardiogram for exertional chest pain evolved to target those with symptoms at peak exertion or with ischemic type complaints, reducing recommended echocardiograms for early onset exertional chest pain suggestive of deconditioning.

Prior to implementation of the SCAMP, we analyzed a historic cohort of 406 patients who presented to our clinics in 2009 with chest pain, managed at the discretion of nearly 50 practicing cardiologists.⁸ Data were retrospectively collected by chart review in the 2009 cohort. The SCAMP algorithm was then theoretically applied to the 2009 cohort, with presumed complete adherence. Cardiac disease identified during the actual clinic visits in 2009 would have been similarly detected by the SCAMP algorithm, as detailed in our prior publication. Charges were predicted to be reduced by 21% if the patients were evaluated per the SCAMP algorithm, predominantly by decreasing echocardiogram use, reducing other ancillary cardiac tests, and eliminating return visits. In this study, we present an analysis of actual resource and charge reduction by use of the Chest Pain SCAMP in our cardiology clinics as compared to the 2009 historic cohort and that which was predicted by use of the SCAMP.

2 | METHODS

The Chest Pain SCAMP database at Boston Children's Hospital was analyzed over the first several years of implementation, from July 2010 to April 2014. All patients, age 7-21 years, requesting initial cardiology clinic assessment for chief complaint of chest pain, were prospectively enrolled in the SCAMP by a screening team. Patients with known heart disease or prior echocardiogram were excluded from enrollment in the SCAMP. The clinician was provided a Chest Pain SCAMP packet during the clinic visit. Data from the packets are collected and entered into the SCAMP database concurrent with the visit, and missing information is requested by the SCAMP team from the assessing clinician. Data were censored for follow up in June 2015.

The Chest Pain SCAMP algorithm recommends an electrocardiogram in all patients, and an echocardiogram in specified cases, with an anticipated echocardiogram testing rate of 35% based on calculations from the 2009 historic cohort. No other testing is recommended by

the SCAMP. However, in consideration of symptoms concurrent with chest pain, such as palpitations and syncope, a rate of testing with Holter monitors (6%) and event monitors (8%) was predicted to occur in SCAMP-enrolled patients and factored into the anticipated charge reduction calculation by use of the SCAMP. Likewise, a low rate of cardiac MRI (~1%) use was predicted, predominantly for further coronary artery investigation when echocardiogram is inconclusive. Exercise stress test and follow up visits were predicted to be eliminated with the SCAMP. As detailed in our prior publication⁸ on the 2009 cohort, a blended cost-to-charge ratio of 60% for technical and professional fees was applied to the cardiology visit (standardized to a medium level), return visit to cardiology clinic, and all cardiac testing performed, including electrocardiogram, echocardiogram, exercise stress test, rhythm monitors, and cardiac magnetic resonance imaging. Charges associated with primary care visits, emergency room visits or admissions to our institution and others, or additional cardiac assessments at other institutions were not included. For the purpose of comparison, adjusted charge rates established in 2009 for the historic cohort were applied to the SCAMP-enrolled patients without adjustment for inflation. Charges were extrapolated for the 2009 cohort to adjust for the total number of patients assessed by the SCAMP.

The SCAMP database was analyzed for presenting complaints, medical and family history, and physical examination and electrocardiogram findings for which an echocardiogram is or is not recommended by the algorithm. Follow-up clinic visits and other tests performed were tabulated. Compliance with the SCAMP algorithm was reviewed and reasons for clinician diversion were assessed. Results of testing and physician assessment of etiology of chest pain were ascertained from the SCAMP database, as well as review of the cardiology database when needed. The review of patient medical records was approved by the Boston Children's Hospital Committee on Clinical Investigation and Institutional Review Board. Oversight and management of the Chest Pain SCAMP is provided by the Institute for Relevant Clinical Data Analytics, a nonprofit, tax-exempt organization.

2.1 | Statistics

Summary statistics was used to present baseline demographics, types of cardiac testing, factors that prompted echocardiograms, SCAMP recommendations and reasons for non-SCAMP adherence. Chi-square and Fisher's exact tests were used to compare the historic cohort to the SCAMP cohort. All analyses were performed using SAS 9.4 (SAS Institute, Cary, NC).

3 | RESULTS

A total of 1517 patients (55% male) were SCAMP enrolled for initial evaluation of chest pain during the study period, average age 13 years (range 7-21). Compared to the 2009 historic cohort, patients enrolled in the SCAMP presented with higher rates of documented exertional chest pain and positive family history elements prompting an echocardiogram. On the contrary, the SCAMP-enrolled patients had fewer

TABLE 1 Factors prompting echocardiogram in 2009 historic cohort versus SCAMP enrolled

Pertinent finding ^a	2009 historic cohort (n = 406), n (%)	SCAMP enrolled (n = 1517), n (%)	P value
Exertional chest pain	150 (37)	689 (45)	<.01
Chest pain radiant to jaw or back	N/A	103 (7)	
Chest pain associated with fever	N/A	8 (0.5)	
Exertional syncope	0 (0)	17 (1)	.02
Positive medical history	4 (1)	30 (2)	.21
Positive family history	4 (1)	77 (5)	<.01
Abnormal examination	16 (4)	19 (1)	<.01
Abnormal electrocardiogram	25 (6)	47 (3)	<.01

^aPatients may have more than one factor which prompted an echocardiogram.

documented physical examination and electrocardiogram findings for which an echocardiogram was recommended (Table 1).

In the SCAMP-enrolled patients, an echocardiogram was recommended for positive findings in 798 (53%) patients and was actually performed in 622 (78%) patients. An echocardiogram was performed in an additional 65 of the 719 (9%) patients when not recommended by the SCAMP, at the discretion of the assessing clinician. Echocardiogram utilization, based on recommendations in the SCAMP algorithm, is compared between the 2009 historic cohort and SCAMP-enrolled patients in Figure 1. Factors prompting recommendation for an echocardiogram in SCAMP-enrolled patients is shown in Table 2, with comparison of adherence and nonadherence to recommendations shown. Major reasons that an echocardiogram was not performed when recommended, as best ascertained from the SCAMP form, included chest pain with minimal exertion and presumed musculoskeletal or pulmonary etiology based on history. Major reasons that an echocardiogram was performed when not recommended included abnormal examination ($n = 18$) or electrocardiogram findings ($n = 14$), which would not ordinarily trigger an echocardiogram for chest pain complaints, numerous patient complaints and symptoms ($n = 13$), screening for familial cardiac disease ($n = 4$), parental anxiety ($n = 4$), and others ($n = 12$).

Application of the SCAMP algorithm to the 2009 historic cohort, prior to SCAMP enrollment, predicted echocardiogram usage would

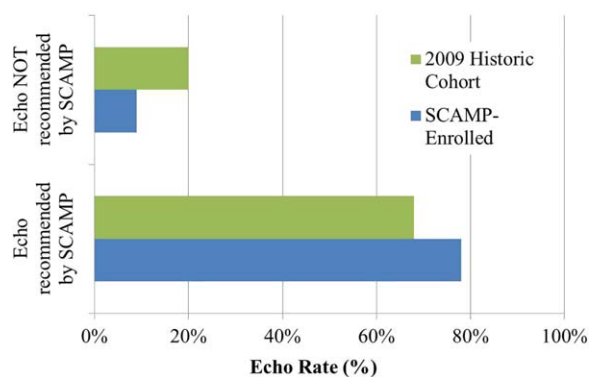


FIGURE 1 Echocardiogram utilization based on SCAMP recommendations

decrease with the SCAMP, ultimately to be recommended in approximately 35% of all patients.⁸ However, differences in documented presenting findings between the actual SCAMP-enrolled patients and the 2009 historic cohort would predict a 13% increase in echocardiogram use in SCAMP-enrolled patients. Actual echocardiogram resource utilization by SCAMP-enrolled patients rose by 4% compared to the 2009 historic cohort, despite the difference in groups. Figure 2 shows a comparison of testing and follow up visits between the 2009 historic cohort (without application of the SCAMP algorithm), as predicted in the SCAMP-enrolled cohort, assuming complete adherence to the SCAMP algorithm and considering demographic composition of SCAMP-enrolled cohort, and as actually occurred in SCAMP-enrolled patients. Change in total adjusted charges between the 2009 historic cohort, without application of SCAMP principles, and the SCAMP-enrolled patients are shown in Figure 3. Overall adjusted charges associated with testing and return visits were reduced by 22% (\$822 625) in SCAMP-enrolled patients compared to 21% predicted based on the 2009 historic cohort study.

In total, two patients among the 1517 were found to have a cardiac etiology for chest pain. One patient presented with exertional chest pain and was found to have diffused ST-T wave changes on electrocardiogram. Echocardiogram demonstrated moderate left ventricular dysfunction and the patient was diagnosed with myocarditis. Another patient presented with positional chest pain and shortness of breath. Electrocardiogram demonstrated intermittent flattening of T waves. An echocardiogram was normal with no evidence of pericardial effusion. A clinical diagnosis of pericarditis was given. Incidental findings on echocardiogram were frequent including mitral valve prolapse (5), bicuspid aortic valve (5), borderline left ventricular enlargement (4), atrial septal defect (3), mild aortic dilation (3), mild mitral regurgitation (2), minimally obstructive subaortic membrane (1), and coronary artery fistula (1).

4 | DISCUSSION

The Chest Pain SCAMP was designed to reduce resource utilization and streamline pediatric cardiology practice, while upholding diagnostic accuracy.² Prior to implementation, we theoretically applied the SCAMP to a cohort of patients managed at our institution by many

TABLE 2 Presenting factors in SCAMP-enrolled patients prompting echocardiogram and associated adherence and nonadherence to recommendation

Predominant factor prompting echocardiogram recommendation ^a	Echo completed (n)	Echo not completed (n)
Exertional chest pain	532	146
Chest pain radiant to jaw or back	27	23
Positive family history	24	26
Abnormal electrocardiogram	24	3
Abnormal examination	9	2
Exertional syncope	3	1
Positive medical history	2	9
Chest pain associated with fever	1	3

^aMore than one factor can be present.

providers, and predicted use of the SCAMP would reduce adjusted charges by 21%, while maintaining equivalent clinical care.⁸ Early analysis of the SCAMP suggested proposed aims were being met.¹² In the current study, we analyzed patients in the first several years of SCAMP implementation to assess resource utilization and adjusted charges by use of the algorithm compared to those predicted by the 2009 historic cohort. Cardiologists were free to follow or deviate from the algorithm as felt appropriate. Final analysis of testing and visits demonstrated a 22% reduction in overall adjusted charges by use of the SCAMP, just surpassing the 21% predicted. Charge reduction expected from a fall in echocardiogram usage was not realized, and in turn was compensated by more considerable decrease in other ancillary testing than anticipated. The Chest Pain SCAMP algorithm for echocardiogram recommendation is in line with the recently published appropriate use criteria for imaging of pediatric patients presenting with chest pain.¹⁷

There were differences in the SCAMP-enrolled and 2009 historic cohort, most notably in exertional complaints and relevant family history, that drove a higher rate of recommended echocardiogram testing

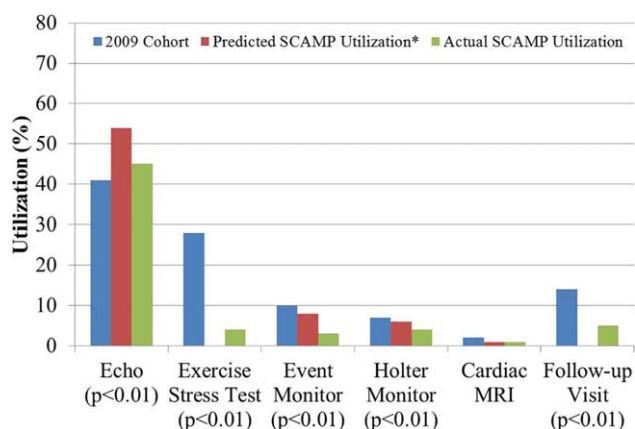


FIGURE 2 Comparison of testing and visits between 2009 historic cohort, predicted in SCAMP-enrolled patients, and actual SCAMP utilization. *Prediction based on demographics of SCAMP enrolled cohort. P values compare the 2009 historic cohort and actual SCAMP utilization

in the SCAMP-enrolled patients than was predicted. Likely, the cohorts of patients were more similar than different and the prospective collection of data with predefined questions yielded higher rates of positivity with the SCAMP. The retrospective nature of data collection from the 2009 cohort by default underestimates ascertainment of symptoms and history components used to triage testing by the SCAMP. Predictions of adjusted charge reduction from the 2009 historic cohort assumed a drop of 18% in overall echo use (a 6% rate reduction) by the SCAMP; echocardiogram rate actually rose by 4% with the SCAMP and would have risen by 13% if the SCAMP was perfectly adhered to, given the differences in cohorts noted above.

Adherence to the SCAMP recommendation for echocardiogram testing was high, around 80%, consistent with the goal of reducing practice variation. Though a “noncompliance” rate of 20% may seem high, the SCAMP process specifically encourages diversion as the subtleties of clinical care cannot all be captured in an algorithm. Indeed, the diversions, combined with periodic data analysis, are used to further refine the algorithm to potentially improve care. Similar to the high compliance with echocardiogram ordering, the SCAMP was also successful in discouraging the performance of other diagnostic tests for isolated chest pain complaints. Rhythm monitors, ordered at rates even less than predicted, are reported to yield little diagnostic benefit in assessing chest pain in the absence of other symptoms.^{8,13} Exercise stress test dropped drastically from pre-SCAMP use, though was not eliminated as predicted. Recent and prior studies continue to show that exercise stress test does not detect cardiac pathology in young people complaining of chest pain.^{14,15} In the study by Basso et al., even in elite athletes who died of coronary anomalies, pre-mortem stress testing did not demonstrate ischemia.¹⁶

The majority of echocardiograms continue to be ordered for exertional chest pain complaints. Though exercise-related complaints could signal cardiac pathology, only one of the 690 patients with such symptoms was found to have cardiac disease. This is similar to findings published by Nguyen et al., in which cardiac pathology responsible for chest pain symptoms was exceedingly rare, even when imaging was performed for vetted indications.¹⁸ Substantial additional savings from the SCAMP could be realized by honing exertional symptoms to reflect

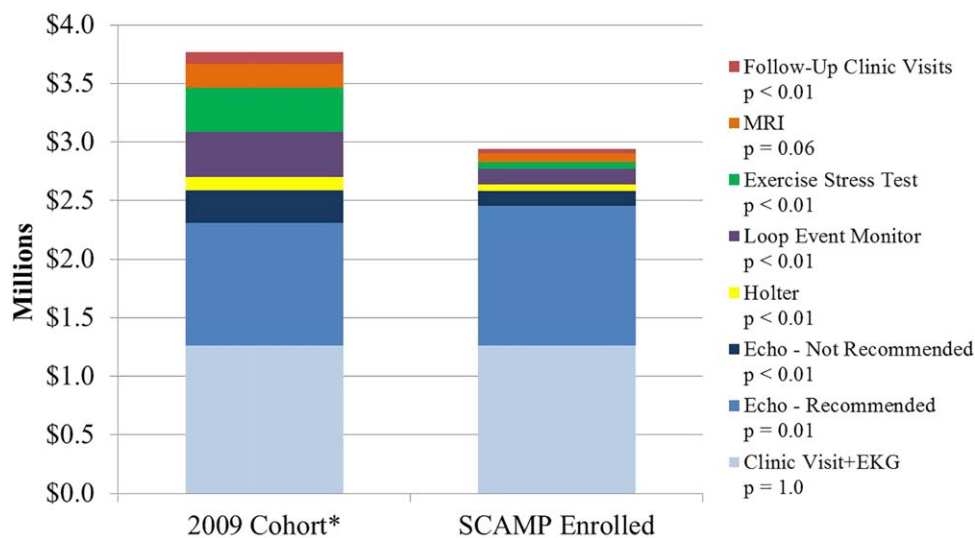


FIGURE 3 Comparison of total adjusted charges between 2009 historic cohort and SCAMP-enrolled. *Values for 2009 historic cohort extrapolated to 1517 patients, equivalent to SCAMP enrolled

ischemia or limitations of cardiac output, though provider fear of a “miss” challenges this effort. The iterative SCAMP process led to such a modification near the end of the study period, in which the algorithm was modified to discourage echocardiographic assessment with minimal and early exertional complaints, which likely signify deconditioning. Even greater reductions in cost of care could be realized by reducing referral of patients with nonexertional chest pain and no other concerning findings, reflecting nearly 50% of the SCAMP-enrolled population. Fleeting chest pain at rest is generally attributable to benign musculoskeletal pain.⁸

The increased documentation of positive family history in the SCAMP-enrolled patients almost certainly represents improved acquisition and should be acknowledged as an enhancement to care of these patients. Indeed, increased attention to detecting cardiac pathology through detailed family history has become a focus of quality improvement initiatives in the field of Pediatric Cardiology.¹⁹ In our earlier study, we demonstrated that hypertrophic cardiomyopathy, the leading cause of sudden cardiac death in the young in the United States, is often asymptomatic or minimally symptomatic with respect to chest pain.² In a study by Dalal et al., family history was instrumental in detecting pediatric patients with hypertrophic cardiomyopathy, as well as long QT syndrome.²⁰ Refining this history component is valuable to the pediatric cardiologist and primary care team alike.

The findings in this study would suggest that the SCAMP achieved the desired goals of reducing unnecessary testing and practice variation in the assessment of pediatric chest pain. The SCAMP can only be considered successful, however, if it also functions to detect cardiac disease when present. The paucity of cardiac disease in children, as well as the lag time to disease manifestation, makes missed pathology a possibility with use of the SCAMP. To mitigate this potential, we conducted a follow-up assessment, encompassing part of the time of SCAMP-enrollment in this study, in which all patients newly diagnosed with the nine

cardiac pathologies intended to be detected by the SCAMP were reviewed.¹⁰ Mode of presentation and means of diagnosis, as made at our institution, were assessed, and the SCAMP algorithm was again retro-actively applied. All patients with new cardiac diagnoses would have had an echocardiogram recommended with application of the SCAMP algorithm, the means by which the pathology was detected. Additionally, no patients enrolled in the SCAMP over the duration of the study and discharged with the presumption of no cardiac disease, returned to our hospital with a new cardiac diagnosis. Though this “double check” cannot entirely eliminate unrealized cardiac pathology in our patients, it provides some reassurance that the algorithm functions to its intended purpose. Potential cardiac diagnoses made at other institutions are not captured in this study.

There are several other important limitations to our study. Data were collected prospectively in the SCAMP-enrolled cohort and recorded by treating physicians on SCAMP forms, whereas data from the 2009 historic cohort were collected retrospectively from clinic notes. This discrepancy in data collection likely accounts for notable differences in the cohorts, making the direct application of the prediction model less robust. Intrinsic differences in the cohort, unrelated to data collection, are also possible. Testing and follow-up charges were assessed at Boston Children’s Hospital only and do not account for any care or testing sought at other facilities. Charges for electrocardiograms performed prior to the cardiology clinic visit are not factored. The financial burden of primary care and emergency room visits for chest pain is not accounted for in this study or the 2009 historic cohort.

In conclusion, the Chest Pain SCAMP has been shown to successfully reduce resource utilization and pediatric cardiology practice variation. Adjusted charge reduction of 22% was realized by SCAMP implementation as compared to 21% predicted. Though charge reduction was predicted to occur predominantly by decreasing recommended echocardiograms, echocardiogram use increased with the SCAMP, while other cardiac testing fell dramatically, ultimately

achieving the predicted decrease in overall adjusted charges. Future modifications to the SCAMP algorithm to refine recommendations for testing are necessary to continue to improve upon appropriate resource utilization.

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CONFLICT OF INTEREST

The authors have no conflicts of interest relevant to this article to disclose.

AUTHOR CONTRIBUTIONS

Conceptualized and designed the study: Saleeb, McLaughlin, Graham, Friedman, Fulton

Carried out the initial and final analyses: Saleeb

Completed initial data collection and analyses: Friedman.

Performed data collection and analyses through the SCAMP program:

McLaughlin, Graham

Reviewed data analyses: Fulton

Performed statistical analyses: McLaughlin, Graham

Drafted the initial manuscript: Saleeb, McLaughlin, Graham

Critically reviewed the manuscript: Friedman, Fulton

Approved the final manuscript as submitted: Saleeb, McLaughlin, Graham, Friedman, Fulton

DISCLOSURE

The authors have no financial relationships relevant to this article to disclose.

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