

Decreasing Overutilization of Echocardiograms and Abdominal Imaging in the Evaluation of Children with Fungemia

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ABSTRACT

Objective: Pediatric fungemia is associated with a low risk of fungal endocarditis and renal infections. The majority of current guidelines do not recommend routine abdominal imaging/echocardiograms in the evaluation of fungemia, but such imaging has been routinely ordered for patients on the pediatric gastroenterology service at our institution. Our goals were to assess the financial impact of this deviation from current clinical guidelines and redefine the standard work to reduce overutilization of abdominal ultrasounds and echocardiograms. Specifically, our goal was to reduce imaging by 50% by 18 months.

Methods: Root cause analysis showed a lack of familiarity with current evidence. Using this data, countermeasures were implemented, including practitioner education of guidelines and creation of a readily accessible clinical pathway and an electronic order set for pediatric fungemia management. Balancing measures were missed episodes of fungal endocarditis and renal infection.

Results: During the period January 1, 2016 to November 19, 2017, 18 of 21 episodes of fungemia in our pediatric institution occurred in patients admitted to the pediatric gastroenterology service. Abdominal imaging and echocardiograms were done 100% of the time, with no positive findings and an estimated cost of approximately \$58,000. Post-intervention from November 20, 2017 to April 3, 2019, 7 of 13 episodes of fungemia occurred on this service. Frequency of abdominal imaging and echocardiograms decreased to 43% and 57%, respectively. No episodes of fungal endocarditis or renal infection were identified.

Conclusion: Overutilization of abdominal imaging and echocardiograms in pediatric fungemia evaluation can be safely decreased.

Keywords: guidelines; cost; candidemia; endocarditis.

Practitioners may remain under the impression that routine abdominal ultrasounds (US) and echocardiograms (echo) are indicated in fungemia to evaluate for fungal endocarditis and renal infection, although these conditions are rare and limited to a subset of the population.¹⁻¹⁰ Risk factors include prematurity, immunosuppression, prior bacterial endocarditis, abnormal cardiac valves, and previous urogenital surgeries.¹¹

The 2016 Infectious Diseases Society of America (IDSA) guidelines do not recommend routine US or echo but rather provide scenarios in which *Candida* endocarditis should be suspected, and these include: persistently positive blood cultures, persistent fevers despite appropriate therapy, and clinical signs that may suggest endocarditis, such as a new heart murmur, heart failure, or embolic phenomena.¹¹ IDSA recommends abdominal imaging in neonates with persistently positive blood cultures to evaluate the urogenital system, in addition to the liver and spleen. They also recommend abdominal imaging in symptomatic ascending *Candida* pyelonephritis beyond the neonatal period and in chronic disseminated candidiasis; the latter is uncommon and seen almost exclusively in patients recovering from neutropenia with a hematologic malignancy.¹¹

We also reviewed guidelines on fungemia originating outside the United States. The 2010 Canadian clinical guidelines on invasive candidiasis do not explicitly recommend routine imaging, but rather state that various imaging studies, including US and echo among others, may be helpful.¹² The German Speaking Mycological Society and the Paul-Ehrlich-Society for Chemotherapy

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published a joint recommendation against routine US and echo in uncomplicated candidemia in 2011.¹³

The European Society for Clinical Microbiology and Infectious Diseases is the only society that recommends routine echo. Their 2012 guidelines on candidiasis recommend transesophageal echo in adults¹⁴ and echocardiography in children,¹⁵ as well as abdominal imaging in the diagnosis of chronic disseminated candidiasis in adults with hematological malignancies/hematopoietic stem cell transplantation.¹⁶

The 2013 Brazilian guidelines explicitly recommend against routine abdominal imaging and echo because of the low frequency of visceral lesions in adults with candidemia and recommend reserving imaging for those with persistently positive blood cultures or with clinical signs/symptoms suggestive of endocarditis/abdominal infection or clinical deterioration.¹⁷ The 2014 Japanese guidelines recommend ruling out chronic disseminated candidiasis in these patients with symptoms during the neutrophil recovery phase, but do not mention routinely imaging other patients. They do not address the role of echocardiography.¹⁸

Although physicians in the United States typically follow IDSA guidelines, abdominal US and echo were ordered routinely for patients with fungemia on the pediatric gastroenterology service at our institution, leading to higher medical costs and waste of medical resources. Our goals were to assess the current standard work for fungemia evaluation on this service, assess the impact of its deviation from current clinical guidelines, and redefine the standard work by (1) presenting current evidence to practitioners taking care of patients on this service, (2) providing a clinical pathway that allowed for variations where appropriate, and (3) providing a plan for pediatric fungemia management. Our SMART (Specific, Measurable, Attainable, Relevant and Timely) goal was to reduce overutilization of abdominal US and echo in pediatric patients with fungemia on the pediatric gastroenterology service by 50%.

Methods

Study, Setting, and Participants

We executed this quality improvement project at a quaternary care pediatric hospital affiliated with a school of medicine. The project scope consisted of inpatient pedi-

atric patients with fungemia on the pediatric gastroenterology service admitted to the wards or pediatric critical care unit at this institution, along with the practitioners caring for these patients. The project was part of an institutional quality improvement initiative program. The quality improvement team included quality improvement experts from the departments of medicine and pediatrics, a pediatric resident and student, and physicians from the divisions of pediatric infectious disease, pediatric critical care, and pediatric gastroenterology. This study qualified for Institutional Review Board (IRB) exemption based on the University's IRB stipulations.

Current Condition

Root cause analysis was performed by creating a process map of the current standard work and a fishbone diagram (**Figure 1**). We incorporated feedback from voice of the customer in the root cause analysis. In this analysis, the voice of the customer came from the bedside floor nurses, ultrasound clerk and sonographer, echo technician, cardiology fellow, and microbiology medical technician. We got their feedback on our process map, its accuracy and ways to expand, their thoughts on the problem and why we have this problem, and any solutions they could offer to help improve the problem. Some of the key points obtained were: echos were not routinely done on the floors and were not considered urgent as they often did not change management; the sonographer and those from the cardiology department felt imaging was often overutilized because of misconceptions and lack of available hospital guidelines. Suggested solutions included provider education with reference to Duke's criteria and establishing a clinical pathway approved by all concerned departments.

Prior to education, we surveyed current practices of practitioners on teams caring for these patients, which included physicians of all levels (attendings, fellows, residents) as well as nurse practitioners and medical students from the department of pediatrics and divisions of pediatric gastroenterology, pediatric infectious disease, and pediatric critical care medicine.

Countermeasures

Practitioner Education. In October 2017 practitioners were given a 20-minute presentation on the latest inter-

Imaging Utilization in Fungemia

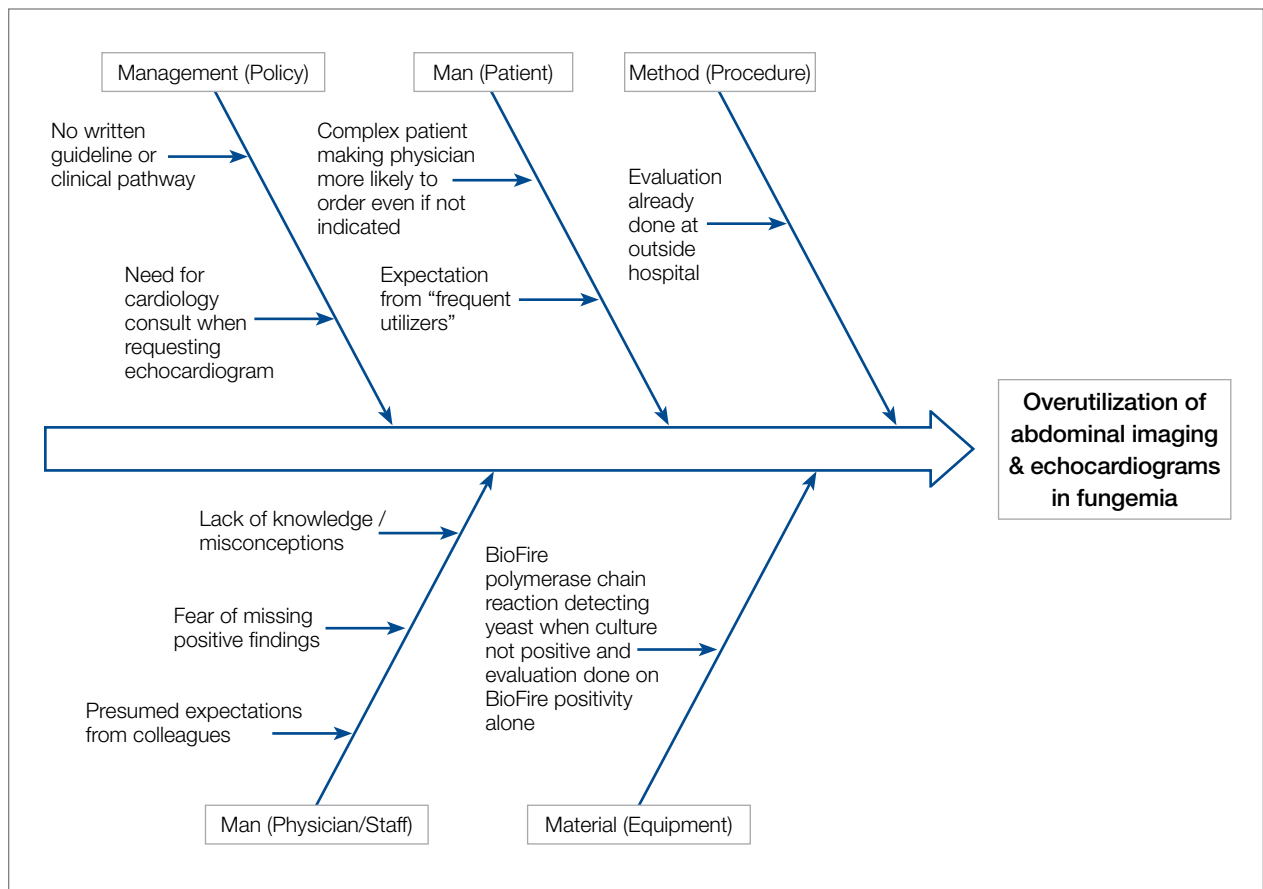


Figure 1. Root cause analysis: fishbone diagram.

national guidelines on fungemia. Fifty-nine practitioners completed pre- and post-test surveys. Eight respondents were excluded due to incomplete surveys. We compared self-reported frequencies of ordering abdominal imaging and echo before the presentation with intention to order post education. Intention to change clinical practice after the presentation was also surveyed.

Clinical Pathway. Education alone may not result in sustainability, and thus we provided a readily accessible clinical pathway and an electronic order set for pediatric fungemia management. Inter-department buy-in was also necessary for success. It was important to get the input from the various teams (infectious disease, cardiology, gastroenterology, and critical care), which was done by incorporating members from those divisions in the project or getting their feedback through voice of the customer analysis.

We redefined standard work based on current evidence and created a clinical pathway during March 2018 that included variations when appropriate (**Figure 2**). We presented the clinical pathway to practitioners and distributed it via email. We also made it available to pediatric residents and fellows on their mobile institutional work resource application.

Electronic Order Set. We created an electronic order set for pediatric fungemia management and made it available in the electronic health record May 2018.

Measurement

Cases of fungemia were identified through the electronic health record pre-intervention (January 1, 2016 through November 19, 2017) and post-intervention (November 20, 2017 through April 3, 2019). An episode of fungemia was defined as an encounter with 1 or more positive blood

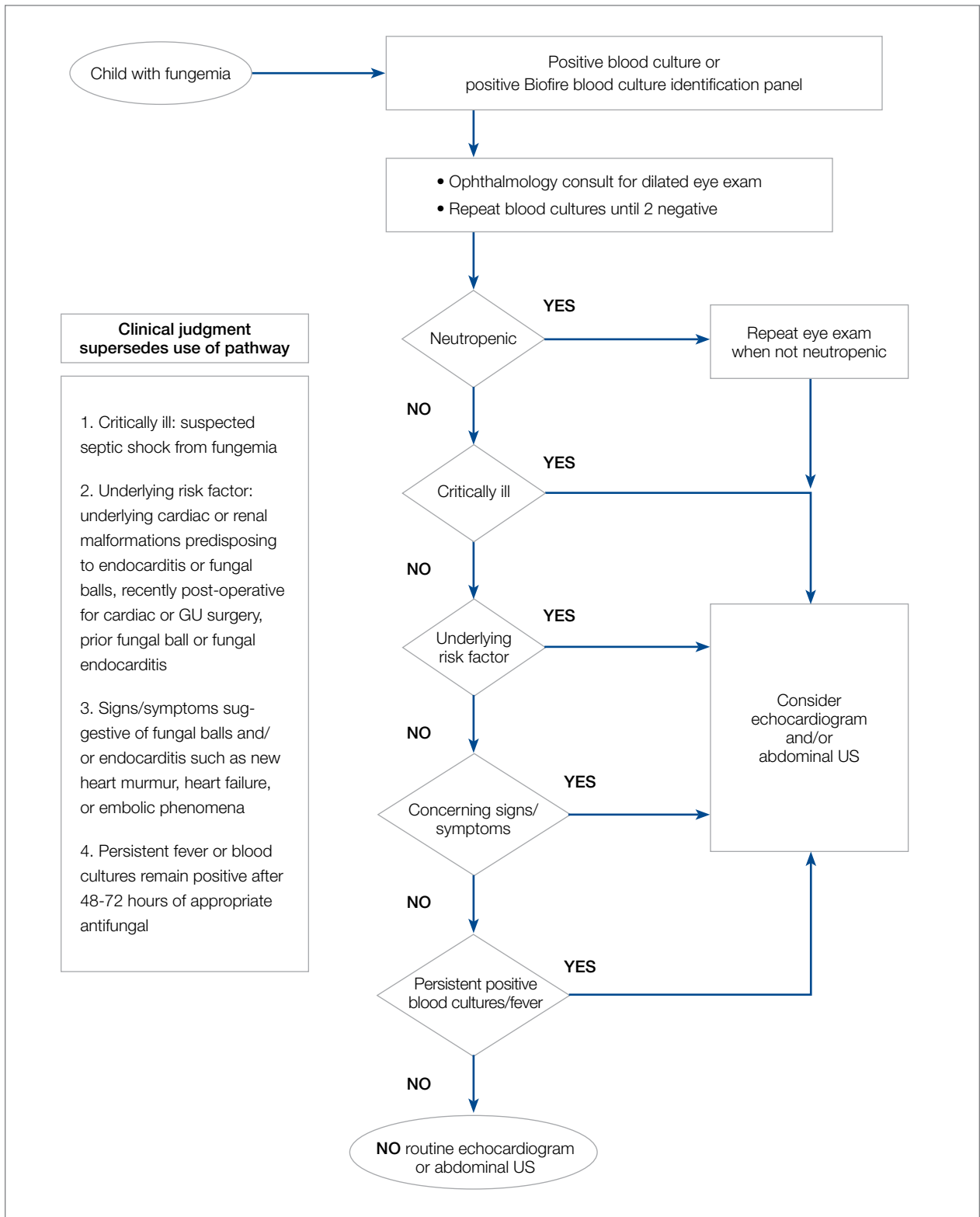


Figure 2. Clinical pathway for pediatric fungemia evaluation. This pathway applies to the immunocompetent host and excludes neonates, premature infants, bone marrow transplant recipients, and patients on immunosuppressive therapy.

culture(s) for *Candida* species or *Cryptococcus* species. We manually identified patients belonging to the pediatric gastroenterology service and reviewed these charts to determine the presenting complaint, organism isolated, transplant status, central lines status, risk factors, if abdominal imaging or echocardiography were done for the episode of fungemia, and their corresponding results. We calculated overall and per patient medical charges by using the average charges at our institution of US and echocardiography with a cardiology consult. These average charges were provided by patient financial services and the pediatric cardiology department, respectively. To address non-technical expenditures, we calculated the average time taken for transport to and from radiology and the echo suite for each identified patient. We identified missed fungal endocarditis and fungal balls as balancing measures.

Results

Survey

Among the 51 practitioners surveyed, 36% were performing routine echo and 22% self-reported performing routine abdominal imaging. After education, no respondents planned to routinely do echo or abdominal imaging. All but 1 respondent planned to change their practice for evaluation of fungemia patients based on the presentation (eFigure 1 [available at www.mdedge.com/jcomjournal]).

Baseline Data

Over the 23-month period from January 1, 2016 to November 19, 2017, there were 21 episodes of fungemia, 18 of which occurred in patients on the pediatric gastroenterology service (2 of the 18 were transplant recipients). For the 18 episodes on this service, abdominal imaging and echo were done 100% of the time, with 0 positive findings (eFigure 2 [available at www.mdedge.com/jcomjournal]).

Of those 18 episodes, the average age was 4.6 years, with two-thirds of the population being male. There were 3 patients with multiple episodes that accounted for 8 of the episodes (3, 3, and 2 episodes each). Fever was the most common presenting complaint. The most common organism was *Candida parapsilosis* (6 of the 18 episodes). All episodes but one involved a central line, and all central lines were removed when present except for one case. Of the risk factors, 3 episodes occurred

in neutropenic patients, and for 1 episode the patient had a questionable history of fungal endocarditis (and was on fungal prophylaxis). There were no patients with recent cardiac/urogenital surgery or prior fungal balls. No episodes had clinical symptoms suggestive of fungal endocarditis or fungal balls.

Post-Intervention Data

Over the subsequent 17-month period (November 11, 2017 to April 3, 2019), there were 13 episodes of candidemia. There were no episodes of *Cryptococcus* fungemia. Seven episodes occurred in patients on the pediatric gastroenterology service (2 of the 7 occurred in transplant recipients). Abdominal imaging was done in 3 of these episodes (43%), and in 2 of these 3 episodes, imaging was done at an outside institution prior to arrival, with no positive results (eFigure 2).

Echocardiography was done 57% of the time ($n = 4$), with echo being done at an outside institution prior to arrival half of the time ($n = 2$), with no endocarditis identified. The cases of abdominal imaging and echo done at outside institutions prior to arrival were not impacted by the countermeasures. Excluding those 2 patients who had both abdominal imaging and echocardiography done prior to arrival, the overall rate of imaging (both abdominal imaging and echo) done after countermeasures were instituted was 30% (Figure 3).

Of those 7 episodes, the average age was 6.8 years (57% female). There were no patients with multiple episodes. The most common presenting complaint was fever. The most common organism was *Candida albicans* (3 of the 7 episodes). All episodes involved a central line, which was removed in all cases except for one. Of the risk factors, 2 episodes were in neutropenic patients, and 1 episode had a history of bacterial endocarditis (not related to fungemia). No episodes occurred in patients with prior fungal renal infection, urogenital malformations, or recent cardiac/urogenital surgery. No episodes had clinical symptoms suggestive of fungal endocarditis or renal infection. No episodes of fungal endocarditis or renal infection were identified.

On average, a patient at our institution undergoing abdominal US and echo with a cardiology consult results in medical waste of approximately \$3200 per patient. This cost

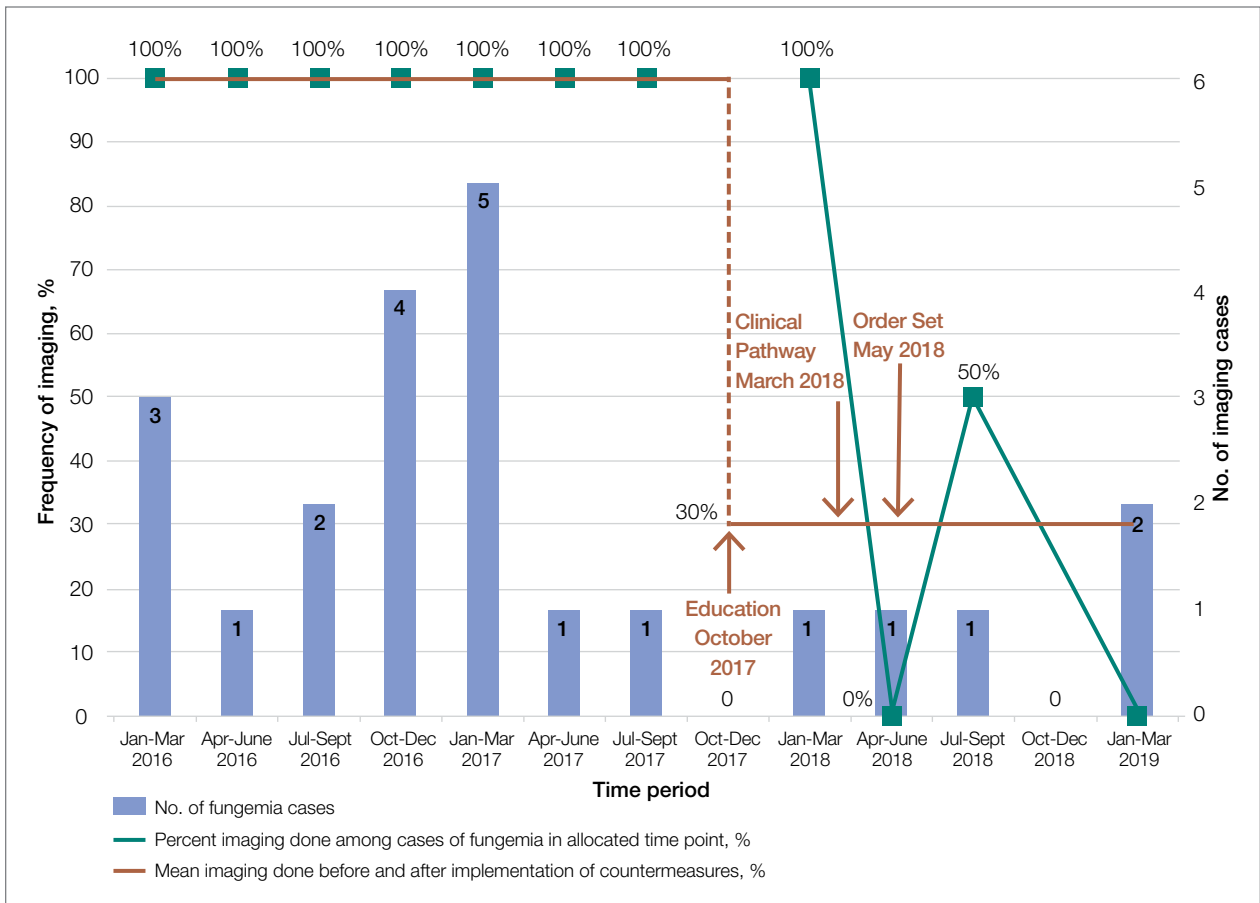


Figure 3. Run chart showing percentage of fungemia cases in which imaging (abdominal and echocardiography) was done.

does not take into account other miscellaneous charges possibly incurred, such as the radiologist interpreting the findings and transportation. Baseline data calculations show that patients waste on average 55 minutes in physical transport, and this does not take into account wait times.

Discussion

Candidemia contributes to 10% of central-line associated blood stream infections (CLABSI).¹⁹ Increased usage of indwelling central catheters for administration of parenteral nutrition will inevitably result in practitioners encountering cases of candidemia when caring for this population. As seen from our results, the majority of episodes of candidemia at our institution occurred on the pediatric gastroenterology service, and thus redefining standard work on this service will be impactful.

Candida parapsilosis and *Candida albicans* were

the most common causative agents before and after intervention, respectively, but overall the most common organism was *Candida albicans*, which is in keeping with that of CLABSI in the literature.¹⁹ Growth of *Candida parapsilosis* has been particularly linked to CLABSI.¹⁹ The third most common organism in our study was *Candida glabrata*, which is the second most common cause of candidemia in CLABSI.¹⁹

The cases of positive abdominal imaging in fungemia in the literature are limited to the neonatal population¹⁻⁴ and chronic disseminated candidiasis in patients with hematologic malignancies/neutropenia/immunosuppression.^{5,6} In fungal endocarditis, the reported cases were generally in neonates,^{1,3,7} critically ill patients,⁸ patients with hematologic malignancies/neutropenia/immunosuppression,^{6,9} or those with a cardiac history.^{9,10} This population differs from the patient population on the pediatric gastroenterology

service. Patients on this service may not need US or echo. Performing abdominal US and echo in fungemia patients in whom such imaging is not indicated may result in medical waste of approximately \$3200 per patient. There is also a waste of medical resources and time.

We found almost all practitioners are willing to change clinical practice once provided with current guidelines. Face-to-face oral presentations allowed for questions and interaction, making this form of information dissemination better than e-mails or handouts.

Though the numbers were small over the short study period, we were able to decrease overutilization of abdominal imaging and echo after implementing countermeasures. Frequency decreased from 100% to 43% and 57% for abdominal imaging and echo, respectively. Imaging that was done after the countermeasures were implemented was mainly attributed to imaging patients underwent prior to presenting to our institution. This reinforces the need for education at other institutions as well. Of the balancing measures assessed, there were no missed cases of fungal balls or fungal endocarditis. Additionally, of the total 34 episodes of fungemia assessed (21 before and 13 after), even among those with risk factors, there were no cases of fungal endocarditis or renal infection.

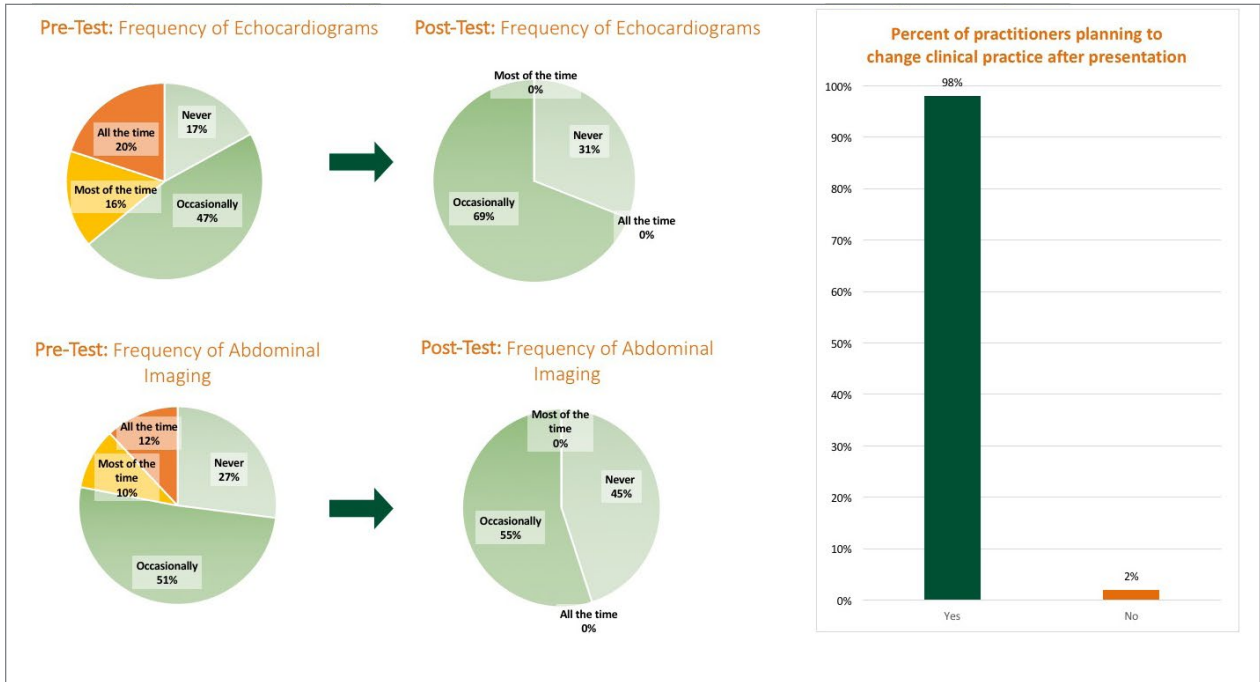
The findings from this quality improvement project underscore current recommendations that, despite common misconceptions, routine abdominal US and echo are not indicated in all cases of fungemia. Case-by-case assessment based on the clinical scenario remains key to management of fungemia to avoid unnecessary medical interventions.

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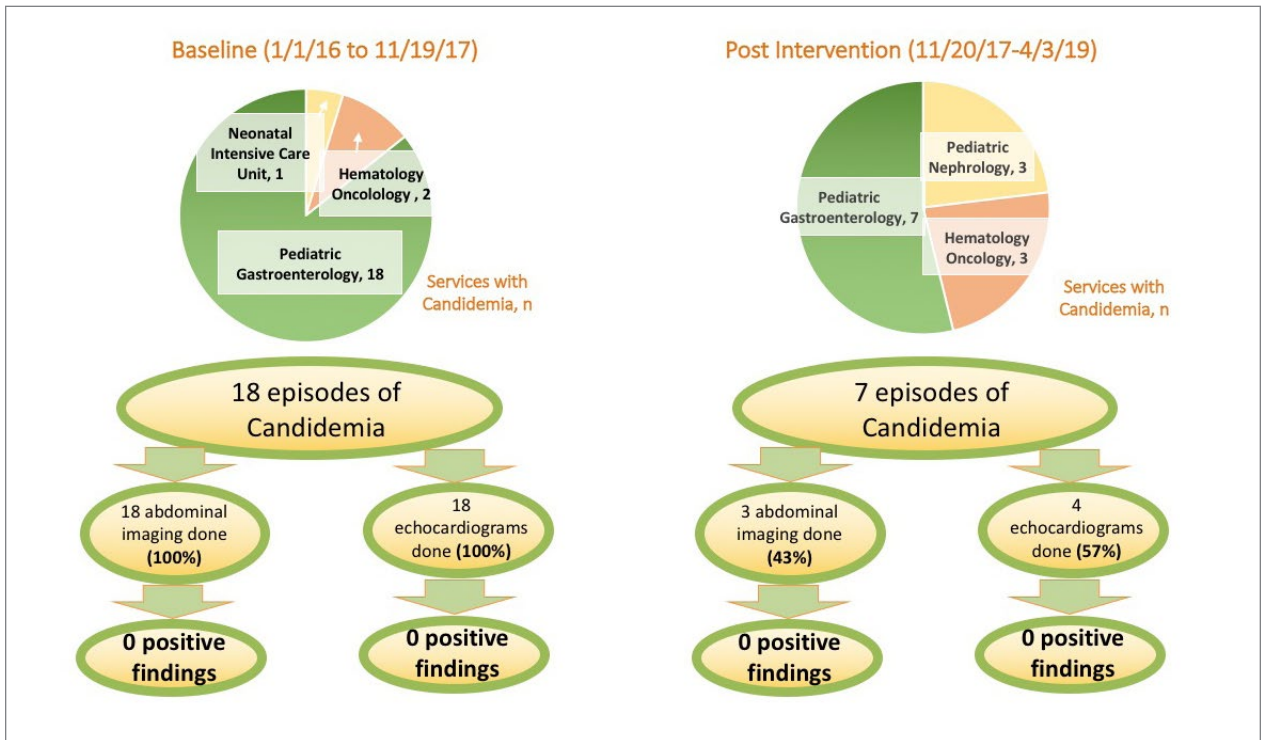
Financial support: None.

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eFigure 1. Results of survey: Pre- and post-test frequency pie charts of echocardiograms and abdominal imaging.



eFigure 2. Pie charts of services with episodes of candidemia and flow diagrams of abdominal imaging and echocardiogram on episodes on the pediatric gastroenterology service before and after countermeasures.