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Judicious Utilization of Healthcare Resources: Reducing Unindicated Pediatric Anaerobic Blood Cultures in a Pediatric Hospital

Ian Ong, Pooja A. Jayagobi, Pradeep Raut, Chia-Yin Chong

Abstract: The decline in anaerobic infections in the past 15 years has resulted in healthcare professionals questioning the need for routine anaerobic blood cultures. In this study, we extracted baseline aerobic and anaerobic blood culture rates over the past 10 years (2001–2010) from our pediatric wards. A questionnaire survey of doctors was conducted to gather their views regarding anaerobic blood cultures. Interventions such as physician education were introduced over 6 months to reduce unindicated anaerobic blood cultures. Furthermore, the rates of blood cultures were tracked over time after intervention. Before intervention, 85% of doctors surveyed routinely ordered anaerobic blood cultures, 90% were unaware of any guidelines for anaerobic blood cultures, and 100% were unaware of the costs. The combination of physician education and restrictive interventions resulted in an 80% reduction in the number of anaerobic blood cultures performed and processed, which translated into savings of USD $2,883 per week, with projected savings of USD $145,560 annually.

Background

Recent studies have shown that the incidence of bloodstream infections caused by obligate anaerobic bacteria is low in the general pediatric population (Brook, 2002; Grohs et al., 2007). From 1974 to 1988, the incidence of anaerobic bacteremia at the Mayo Clinic (Rochester, MN) fell by 45% (Dosher et al., 1991). Lazarovitch and colleagues (2010), concluded that there was a slight drop in the incidence of anaerobic-related bacteremia from 0.84% in 1998 to 2002 to 0.74% in 2003 to 2007 (p = .03). These reports are compounded by the finding that young children have a lowest risk of developing anaerobic bacteremia compared with adults (Goldstein, 1996). Subsequently, some investigators (Cockerill et al., 1997; Rosenblatt, 1997) proposed selective rather than routine use of anaerobic blood cultures. Others (Iwata and Takahashi, 2008; Morris et al., 1993) recommended that anaerobic blood cultures only be performed for patients who are immunocompromised or suspected to be suffering from intra-abdominal sepsis or head and neck infections. Despite these developments, the practice of ordering paired blood cultures (aerobic and anaerobic) is still prevalent in pediatric wards.

A 10-year review (2001–2010) of blood cultures (aerobic and anaerobic) from pediatric patients in our hospital showed that only 4% of all blood cultures yielded positive results. Most positive results were obtained from aerobic cultures, whereas anaerobic cultures only grew facultative anaerobes. There has been no positive yield of obligate anaerobic organisms from pediatric patients in the past 10 years, despite an increase in the number of pediatric admissions with a simultaneous increase in the number of blood cultures performed. This is consistent with research done by James and al-Shafi, 2000, who found that "significantly more isolates were obtained from standard aerobic bottles than from standard anaerobic bottles ($p < .001$)."

Rising healthcare costs have resulted in increased financial burdens on patients and hospitals. The overutilization of laboratory tests has contributed to the huge healthcare costs (Stratton, 2000). At our hospital, a fee of USD $29 is charged for one Bactec Bottle and for processing. In addition, an estimated USD $21 is charged

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for manpower, use of treatment room, and consumables when performing blood cultures. Therefore, the total cumulative cost for one anaerobic blood culture, taking into consideration the previously mentioned charges, is USD $50. For paired (aerobic and anaerobic) blood cultures, the total cumulative cost is USD $101. In the year 2010 alone, a total of 8,938 blood cultures were performed: 4,473 (50.1%) aerobic and 4,465 (49.9%) anaerobic. The expenditure alone for blood cultures was almost half a million dollars (USD $447,947), of which USD$ 224,174 were for anaerobic blood cultures alone.

Anaerobic blood culture bottle (Bactec Paed/plus) currently used is validated for a minimum of 2–3 mL of blood as a sample (Becton, Dickinson and Company, 2012). The amount taken from children is limited due to difficulties in obtaining blood (Freedman and Roosevelt, 2004). This limits the positive detection of bacterial isolates from blood cultures as bacteremia rates improve significantly when the volume of blood tested increases (Freedman and Roosevelt, 2004). This is further compounded by various studies that have shown that the most important factor for positive yield in either aerobic or anaerobic culture bottle is the quantity of blood inoculated (Morris et al., 1993; Murray et al., 1992). Despite the established guidelines on the indications of anaerobic blood cultures, the practice of ordering paired blood cultures is still prevalent in our pediatric wards and is increasing yearly.

In addition to rising costs, unindicated anaerobic blood cultures result in increased workload for healthcare staff. At our hospital, anaerobic blood cultures consist of 2% of the workload for junior doctors and 6% of the workload for microbiology laboratory staff.

Aim

As a result of the concerns previously mentioned, we proposed a healthcare quality improvement project to reduce the number of unindicated anaerobic blood cultures. The purpose of this study was to reduce the median usage of unindicated anaerobic blood cultures by 50% within 6 months in the pediatric wards. If successful, this study will result in savings in terms of money and resources while still maintaining the quality of healthcare services provided.

Methods

Inclusion criteria for the project were all pediatric patients younger than 16 years who were admitted to the pediatric medical wards. Exclusion criteria were patients who were immunocompromised, had head and neck infections, and patients with intra-abdominal infections. These criteria are further supported by recommendations that anaerobic blood cultures should only be performed for patients who are immunocompromised or suspected to be suffering from intra-abdominal sepsis or head and neck infections (Iwata and Takahashi, 2008; Morris et al., 1993). This study was conducted over 6 months and included 6 pediatric wards, excluding all high-risk wards such as the children's intensive care unit, surgical wards, hematology–oncology wards, and the high dependency unit.

Change was effected through the rapid cycle change methods, involving a series of Plan-Do-Study-Act (PDSA) cycles. A question and answer survey was disseminated to doctors to understand the current variations in blood culture practices in pediatric wards. Staff members were then taught using strategic and opportunistic educational sessions. Various interventions were put in place and piloted in a single pediatric ward for 1 week. These included limiting the number of anaerobic blood culture bottles available in each ward, putting up wall-mounted reminders, bottle tags and indication forms, and educational lectures, and brochures were provided for staff members. After a successful pilot run, the interventions were rolled out to the rest of the general pediatric wards.

The primary outcome measure was the number of unindicated anaerobic blood cultures performed and the countermeasure of the number of replenished anaerobic blood culture bottles at the ward level. Similarly, the number of aerobic blood cultures performed and the number of blood culture bottles replenished at the ward level were also monitored. Monitoring of outcome measures was done on a weekly basis. These parameters were then plotted onto run charts, and the medians were calculated. This temporal view displays process performance and allows us to determine the changes that resulted in improvement. A before–after study chart was chosen to compare the effectiveness of the interventions. The *t* test was used to determine the significance of results.

Results

Data from the microbiology laboratory suggested that an average of 75 bottles each of anaerobic and aerobic blood cultures were received and processed weekly. This translated to a total of 150 bottles received and processed weekly. The countermeasure confirmed this finding because an equal number of bottles were replenished at the ward level weekly.

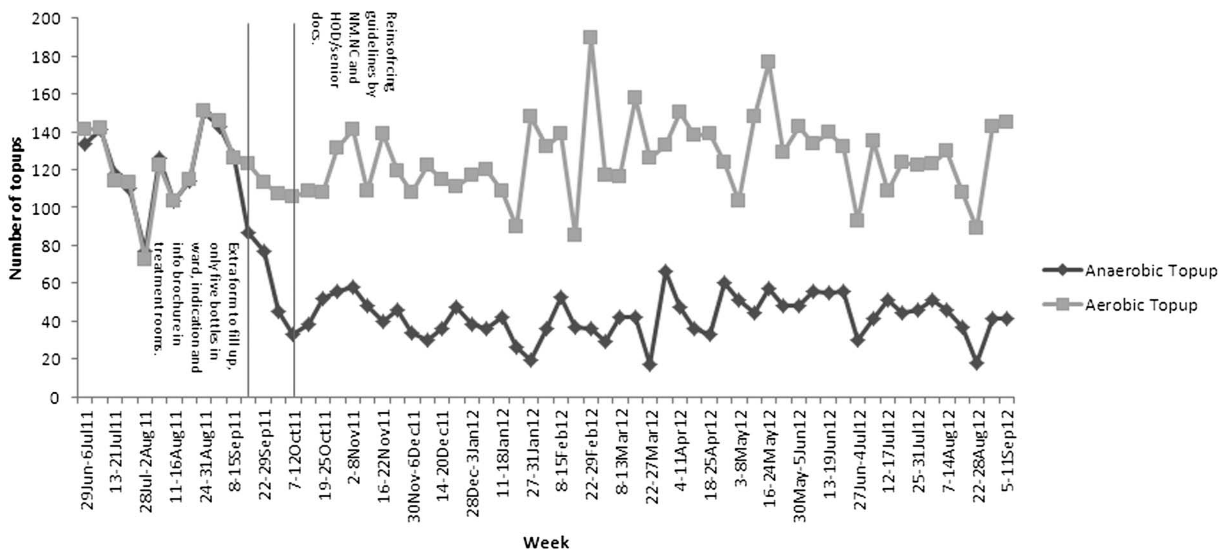
A total of 63 doctors responded to the survey, and the results showed that 85% of the medical staff routinely performed both anaerobic and aerobic blood cultures (paired blood cultures) as part of the septic workup. Ninety percent of the medical staff surveyed were unaware of any clinical guidelines regarding anaerobic blood cultures. In addition, 100% of the medical staff surveyed were completely unaware of the costs involved in processing anaerobic blood cultures.

These became the baseline references for the next interventions. With these results, the next intervention was designed to educate all staff involved, that is, medical doctors, nurses, and microbiology laboratory staff. A series of educational lectures and visual materials were designed and distributed. Special information brochures were also circulated through e-mail and placed in strategic locations as a general reminder to all. Short presentations were shown during meetings/handover sessions to remind doctors and nurses about the clinical indications for performing anaerobic cultures. In addition, reminder posters and bottle tags were displayed to help aid health practitioners in their decision. Health practitioners were also reminded about the information sources available (e.g., handbooks, intraweb) that state the clinical indications for anaerobic cultures.

After the first week of the project, various interventional measures were implemented: reducing the number of anaerobic blood culture bottles available to five per ward and introducing standardized clinical indication forms that the clinician needed to complete before performing an anaerobic blood culture. This served a dual purpose of providing information and being part of clinical surveillance. By restricting the number of bottles per ward, doctors were more likely to reserve these bottles for conditions with clinical indications requiring anaerobic cultures as part of all septic workups. Reminder tags with indications of anaerobic blood cultures were also placed on all anaerobic blood culture bottles. Finally, there were regular updates and reinforcement from higher management including the infectious disease service, head of the department of pediatrics, director of nursing, and senior doctors and nurses. Reinforcement by the higher management involved timely reminders that helped to reinforce the true clinical indications for performing anaerobic blood cultures.

Since the start of the project, there has been a steady decline in the number of anaerobic blood cultures processed and replaced. In the first week of this study alone, there was a decline of 50%. This continued to reduce in subsequent months after further intervention. The median number of anaerobic blood cultures declined from 75 to a nadir of 17.5 per week (Fig. 1) by week 4 of the project. Concomitantly, the number of aerobic blood cultures showed no significant differences over the study weeks with the median number still maintaining at 75 bottles.

Figure 1. Number of blood cultures performed before and after interventions.



In parallel, we monitored the number of aerobic and anaerobic blood culture bottles replenished at the ward level, which confirmed the observations as there was also a reduction in the number of anaerobic bottles being replenished while the number for aerobic bottles remained static.

By the end of the project, there was an 80% reduction in the number of anaerobic blood cultures performed and processed. Since the concurrent median for aerobic blood cultures remained the same at 75 per week, it implies that the significant reduction in anaerobic blood cultures was not due to an overall reduction in blood cultures (Fig. 1).

A *t* test showed that there was a significant reduction in anaerobic blood cultures (t test = -7.37, $p < .0001$). This significant reduction in anaerobic blood cultures translates to cost savings of USD $2,883 per week, with projected savings of USD $145,560 annually. The workload on the microbiology laboratory staff was also significantly reduced. We continued to monitor the numbers of aerobic and anaerobic blood cultures for more than a year after the project started. Results show that with constant updates and positive reinforcements, the number of anaerobic blood cultures being performed and the number of anaerobic blood culture replenishments remained low more than a year after the study started (Fig. 1).

Discussion

From the start of this project, the most obvious reason for the overuse of anaerobic blood cultures was the fact that physicians simply forgot the true indications of anaerobic blood cultures. Educating staff about the true indications and the costs of anaerobic blood cultures helped to manage this. Persuasive interventions in the form of education, brochures, and wall-mounted reminders in conjunction with restrictive measures reduced the number of unindicated anaerobic blood cultures successfully. Therefore, it can be seen that the general change principle underlying this significant improvement initiative relates to changing physicians' behavior through education and restriction of the availability of the anaerobic blood cultures. We reached out to all healthcare professionals involved through regular teaching sessions in doctors' and nurses' meetings, orientation lectures, and opportunistic teaching sessions, for example, handover sessions and increasing their awareness on the true indications of performing anaerobic blood cultures in the pediatric population. In addition, with restrictive measures and various reminders put in place in wards, the weekly number of anaerobic blood cultures remained low. As the number of anaerobic cultures began to decline, timely positive reinforcement from the heads of departments and the head of infectious disease service helped to maintain the ongoing improvement.

The number of unindicated anaerobic blood cultures was sharply reduced successfully over 4 weeks to a nadir of 17.5 per week, which was an 80% reduction. After completion of the 6-month project in December 2011, the number of anaerobic cultures performed remained low and the effect was sustained for at least 1 year thereafter. This translates to cost savings of USD $145,560 per annum.

Infectious disease referrals were usually made if the patients were not responding to standard first-line therapy or if they were suffering from a prolonged fever. Infectious disease referrals to the Infectious Disease team during this study were observed, and according to the Infectious Disease team's electronic data records, there were no cases of missed infections attributed to anaerobic organisms. The findings from this study have significant implications for improving workflow, resource utilization, and reducing healthcare costs.

Conclusion

This project has helped to identify the shortcomings of routine anaerobic blood cultures for septic workups in the pediatric population and implement measures to rectify the situation. With continued compliance monitoring from the laboratory and timely positive feedback to support collation, these numbers remain low. As such, what this quality improvement project translates to is improved clinical practice with increased awareness amongst staff members, reduction in unindicated blood cultures, reduction in workload of microbiology laboratory staff, and significant projected cost savings for both patients and the hospital. Positive reinforcement from higher management and senior staff has led to a sustained improvement. From the positive results, we strongly recommend the incorporation of indications for anaerobic blood cultures into orientation lectures, guidelines, medical handbooks, and local healthcare Web sites to maintain awareness amongst hospital staff.

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Core CPHQ Examination Content Area

III. Performance Improvement
Anaerobic blood cultures.

Learning Objectives

1. Describe the indications of anaerobic blood culture in pediatric population.
2. Understand the importance of various steps of the improvement process such as a baseline survey and planning interventions based on results.
3. Design effective interventions to create the maximum change and improvements.

Questions

1. Describe the indications for doing anaerobic blood culture
   a. Community acquired pneumonia, urinary tract infection, septic arthritis
   b. Suspected intraabdominal sepsis, head-neck infection and fever in immunocompromised patients
   c. Fever in neonates and infants without source, pyrexia of unknown origin
   d. Wound infection for clean-contaminated surgical wounds.
2. What is the main objective of doing a structured survey before a quality improvement project?
   a. To ask patients and/or staff about the need for quality improvement initiative
   b. To inform staff so as to improve participation and cooperation.
   c. To assess the baseline understanding, identify areas of improvement and plan interventions
   d. To determine the timeline and tracking mechanism for interventions
3. What did the initial survey results reveal in this project
   a. High cost of anaerobic blood cultures and the process of blood culture in laboratory
   b. Knowledge gaps in healthcare workers regarding the indications for anaerobic blood cultures
   c. Workload of healthcare workers and laboratory staff from anaerobic blood cultures
   d. Costs to patients from anaerobic blood cultures

4. The most common reason for performing anaerobic blood cultures in pediatric wards in this study was
   a. Healthcare staff were unaware of guidelines for anaerobic blood culture
   b. High incidence of culture-positive anaerobic infections in pediatric patients
   c. Anaerobic blood cultures improve the yield of bacterial growth as compared to aerobic blood culture
   d. Easy access to blood for anaerobic blood cultures

5. Which of the following variables reflected the improvement in utilization of anaerobic blood cultures?
   a. Workload reporting by participating health care workers (doctors, nurses, laboratory staff)
   b. Number of anaerobic blood culture bottles processed per week in the laboratory and number of bottles replenished in ward
   c. Number of septic workup per week per ward and total number of admissions
   d. Positive isolation rates from anaerobic blood cultures

6. Which one of following is the most suitable method to represent the data showing the changes in this type of quality improvement projects?
   a. Runcharts with gridlines
   b. Data table for study period
   c. Differential bar graph of each week
   d. Pie chart with proportion labels

7. In graphical representation of data in quality improvement projects, the trend towards the pre-determined benchmark represents
   a. Change is due to intervention and it is a worsening of process
   b. There is natural progression and hence the change is not because of intervention
   c. Change is due to intervention and it is an improvement
   d. Change is not significant and more data needed

8. Based on findings from the initial survey, which one of the following would have made maximum impact in this quality improvement project
   a. Education of healthcare workers (Doctors and nurses)
   b. Reducing supply of anaerobic blood culture bottles
   c. Reminders in form of tags, posters, emails, reinforcements
   d. Monitoring and feedback

9. What is the importance of long-term surveillance in a quality improvement project that involves a short duration?
   a. To highlight the importance of quality improvement project amongst the staff so that more projects can be done
   b. To maintain the key performance indicator for the department.
   c. To monitor and establish that the improvement changes are long-lasting or permanent
   d. To ensure that healthcare costs do not escalate beyond what the health insurance allow in claims

10. What is the importance of monitoring multiple variables/paramenters (countermeasures) in quality improvement project?
    a. To justify the need for quality improvement projects
    b. To confirm the change is due to intervention and it is an improvement
    c. For data monitoring and patient safety
    d. To improve significance and precision of results and add more data points to graphs