# Trends in Blood Culture Contamination

## A College of American Pathologists Q-Tracks Study of 356 Institutions

*Leonas G. Bekeris, MD; Joseph A. Tworek, MD; Molly K. Walsh, PhD; Paul N. Valenstein, MD*

• ***Context.*—Blood culture contamination extends hospital stays and increases the cost of care.**

***Objectives.*—To measure blood culture contamination rates in a large number of institutions over time and to elucidate practice patterns and demographic factors associated with sustained reduction in contamination rates.**

***Design.*—Longitudinal cohort study of 356 clinical laboratories that provided quarterly data about blood culture results, using a uniform definition of contamination. Mixed linear model analysis of the 1999 through 2003 data set.**

***Results.*—Blood culture contamination was significantly higher in institutions that used nonlaboratory personnel to collect blood ($P = .03$) and significantly lower in facilities that used a dedicated phlebotomy team ($P < .001$). Higher volume of blood collection was significantly associated with lower contamination rates ($P < .001$). Continued participation in the Q-Tracks monitoring program was associated with significant and progressive reduction in contamination rates. By the fifth year of participation, the median institution had reduced its blood culture contamination rate by 0.67% ($P < .001$).**

***Conclusions.*—Institutions that use decentralized patient-centered personnel rather than dedicated phlebotomy teams to collect blood cultures experience significantly higher contamination rates. Long-term monitoring of contamination is associated with sustained improvement in performance.**

**(*Arch Pathol Lab Med.* 2005;129:1222–1225)**

Blood cultures are vital for identifying pathogens causing serious infections and in directing appropriate antibiotic therapy. Unfortunately, blood culture contamination is a common occurrence and may lead to confusion regarding the significance of a ''positive'' blood culture.[1,2] The most common contaminants are coagulase-negative *Staphylococcus* species, which are also becoming more prevalent as a primary pathogen in immunocompromised patients and in patients with indwelling intravascular devices.

The uncertain clinical significance of potential contaminants leads to longer hospital stays, unnecessary antibiotic therapy, and additional laboratory testing.[3] As a result, the cost of blood culture contamination incurred by a hospital is many times that incurred by the laboratory.[3,4]

Although it is not currently possible to eliminate blood culture contamination, many interventions have been shown to reduce contamination rates. These include collection from separate venipuncture sites rather than indwelling intravenous catheters,[5] use of specific antiseptic preparations,[6,7] use of a double-needle technique,[8] reliance on specially trained or dedicated phlebotomists,[9–11] and feedback about contamination rates to individual phlebotomists and nursing units.[12] Some approaches, such as the double-needle technique, are now discouraged to reduce the risks of transmission of human immunodeficiency virus through needlesticks. Other interventions are variably applied in practice. As a result, blood culture contamination rates vary widely from institution to institution.[13]

In addition to variation in the blood culture contamination rate found among laboratories at any one point in time, several institutions have reported that their proportion of contaminates has been increasing.[14,15] This trend has been attributed to the use of new blood culture detection systems that more sensitively detect staphylococci[16] and to an increased propensity to draw cultures from indwelling intravenous catheters, a practice associated with a higher contamination rate.[17]

The multiplicity of factors that impact blood culture contamination rates and the trend toward higher rates make it difficult for laboratory managers to benchmark their local contamination rates against industry standards or to design programs for improving performance. We examined a large group of laboratories that were enrolled in a College of American Pathologists (CAP) Q-Tracks program and regularly submitted data on blood culture contamination to the CAP, using a uniform definition of culture contamination. The specific purposes of this study were to (1) provide contemporary benchmark data about blood culture contamination rates in a large number of clinical laboratories and (2) use the longitudinal Q-Tracks data set to elucidate factors associated with sustained improvement in performance.

Accepted for publication June 1, 2005.

From Phoenixville Hospital Laboratory, Phoenixville, Pa (Dr Bekeris); Pathology and Laboratory Management Associates, Ann Arbor, Mich (Drs Tworek and Valenstein); and College of American Pathologists, Northfield, Ill (Dr Walsh).

The authors have no relevant financial interest in the products or companies described in this article.

Some of the material in this article was distributed to Q-Tracks study subscribers by the College of American Pathologists in the form of an annual data commentary. Most of the trend analysis presented in the article represents new, unpublished information.

Reprints: Leonas G. Bekeris, MD, Phoenixville Hospital Laboratory, 140 Nutt Rd, Phoenixville, PA 19460 (e-mail: leonas.bekeris@uphs.upenn.edu).

**Table 1. Characteristics of 356 Study Laboratories During Their First Year of Program Enrollment**

| Characteristic* | No. (%) of Laboratories |
|---|---|
| Teaching hospital | 115 (32.3) |
| Nonteaching hospital | 209 (58.7) |
| Unknown | 32 (9.0) |
| **Total** | **356 (100)** |

* Characteristic shown is for participant's year of program enrollment, unless otherwise indicated.

## MATERIALS AND METHODS

### Study Population and Data Collection

Data were collected from 1999 through 2003 (inclusive). The number of contaminated blood cultures and the total number of blood cultures from 356 institutions participating in Q-Tracks program QT-02 (Blood Culture Contamination) were reported quarterly to the CAP. Program participants that did not submit data for at least 2 quarters during the study period were excluded from the analysis. Some study laboratories submitted data for as few as 2 quarters (<1 year), while others submitted data for up to 20 quarters (5 years). Data were tabulated separately for neonatal and nonneonatal patients. In addition to the contamination rate, participants provided the total number of blood cultures processed during the quarter and also completed a questionnaire that described their blood culture practices and procedures, and provided specific demographic information. If an institution's practice patterns or demographic information changed during the course of the study, the institution had the opportunity to submit updated questionnaires. Characteristics of study institutions are shown in Table 1.

### Definition of Contamination

A blood culture was considered to be contaminated if 1 or more of the following organisms were identified in only 1 of a series of blood culture specimens: coagulase-negative *Staphylococcus* species, *Propionibacterium acnes*, *Micrococcus* species, ''viridans''-group streptococci, *Corynebacterium* species, or *Bacillus* species. A blood culture series was defined as 1 or more specimens collected serially within a 24-hour period to detect a bacteremic episode. Blood cultures were processed by a variety of automated and manual methods, and isolates were identified by procedures routinely used by the participant. The definition of contamination used in this study is appropriate for calculating institutional blood culture contamination rates, but is not appropriate for clinical decision making, as rare isolates classified as contaminates using the study definition may be associated with clinical infection.[18] Institutional contamination rates were defined as the number of contaminated cultures processed during a quarter divided by the total number of cultures performed during the quarter.

### Statistical Analysis

The data set available for analysis consisted of a series of quarterly contamination rates from individual institutions. Because the Q-Tracks program is offered as a yearly subscription service, some laboratories were added to the program or dropped out of the program during the 5-year study period. For each datum value (quarterly contamination rate), the number of quarters the institution had previously participated in the study was determined. This value was introduced into the modeling to determine whether continued program participation was associated with improved performance, and also to determine whether program dropouts had been experiencing better or worse performance than laboratories that chose to remain in the program. Each datum point was also associated with institutional practice characteristics and demographic information from the institution's most recently completed questionnaire; for some institutions, this information changed during the course of their participation in the study.

**Table 2. Variables Analyzed in Mixed Linear Model**

| |
|---|
| No. of quarters since first participation |
| Quarter of participation (99A, 99B, etc) |
| Percentage of routine blood cultures collected by a dedicated phlebotomy team |
| Percentage of routine blood cultures collected by medical technologists/technicians |
| Percentage of routine blood cultures collected by physicians/residents/medical students |
| Percentage of routine blood cultures collected by nurses |
| Percentage of routine blood cultures collected by an intravenous team |
| Percentage of routine blood cultures collected by others |
| Antiseptic preparations (iodophor/tincture of iodine/chlorhexidine/other) |
| Aseptic solution applied to top of broth bottle/tube before collection |
| Double-needle collection method routinely used for blood cultures |
| Total blood volume per adult venipuncture collected for routine blood culturing |
| Total blood volume per neonate venipuncture collected for routine blood culturing |
| Teaching hospital versus nonteaching hospital status |

The hypothesis that longer program participation would result in reduced blood culture contamination rates was formally tested using the PROC MIXED procedure in SAS (Cary, NC). Since the rate of blood culture contamination was highly correlated with earlier and subsequent time-adjacent rates from the same institution, a mixed linear model was used. This model accounted for repeated measures taken from the same experimental units that were correlated. An underlying assumption for use of this technique is that the data are normally distributed (Gaussian); since the original rate data were slightly skewed, a natural log transformation applied to the rates made their distribution approximately Gaussian. Table 2 lists the variables analyzed in the mixed model. The same approach was used to determine whether other variables were associated with a reduction in contamination rates. First, univariate associations were tested, followed by a single multivariate model that was used to determine if independent associations existed for ones in which $P < .05$.

## RESULTS

### Blood Culture Contamination Rates

The distribution of cumulative blood culture contamination rates for 356 laboratories during the first year of participation is shown in Table 3. The median laboratory had a contamination rate of 2.89% for all cultures, 2.08% for neonates, and 2.92% for nonneonates. There was a wide spread among institutions, with an interquartile range of 2.15% to 3.67% for all patient types. There was a greater interinstitutional spread in contamination rates of cultures drawn from neonates than in those drawn from adults. Because most institutions received relatively few cultures from neonates, some of this variation was likely to be due to smaller sample sizes. The remaining variation was presumably due to differences in blood culture collection practices.

### Factors Associated With Improved Performance

Longer participation in the Q-Tracks monitoring program was associated with progressive reduction in an institution's blood culture contamination rate ($P < .001$; Table 4). Institutions with 4 or 5 years of participation had average reductions in contamination of 0.4% and 0.7%, respectively, compared with their first-year values. We investigated whether this association might be the result of

**Table 3. Blood Culture Contamination Rates**

| Population | No. of Laboratories | Contamination Rate, %* | | |
|---|---|---|---|---|
| | | 25th Percentile | 50th (Median) Percentile | 75th Percentile |
| Adult | 326 | 2.23 | 2.92 | 3.80 |
| Neonates | 254 | 0.75 | 2.08 | 4.27 |
| All patients | 356 | 2.15 | 2.89 | 3.67 |

* Contamination rates grouped by institution percentiles.

**Table 4. Association Between Length of Monitoring and Blood Culture Contamination Rate**

| No. of Years Enrolled in Q-Tracks Monitoring Program | No. of Laboratories | Average Reduction in Blood Culture Contamination Rate, %* |
|---|---|---|
| 1 | 167 | 0.03 |
| 2 | 54 | 0.07 |
| 3 | 52 | 0.09 |
| 4 | 39 | 0.41 |
| 5 | 44 | 0.67 |

* Average reduction in contamination rate at end of year compared with the institution's first submitted quarterly contamination rate.

**Table 5. Association Between Blood Culture Collection Staff and Contamination Rate**

| Blood Cultures Collected by Indicated Staff Type, % | No. of Laboratories | Mean Blood Culture Contamination Rate, % |
|---|---|---|
| Dedicated phlebotomy staff | | |
| 0–25 | 94 | 3.27 |
| 26–75 | 127 | 3.02 |
| 76–100 | 120 | 2.84 |
| Medical technologists or technicians | | |
| 0 | 165 | 3.25 |
| 1–10 | 113 | 2.95 |
| 11–100 | 60 | 2.69 |
| Nonlaboratory staff | | |
| 0 | 36 | 2.17 |
| 1–50 | 253 | 3.00 |
| 51–90 | 36 | 3.40 |
| 91–100 | 17 | 4.21 |

poorly performing laboratories electing to discontinue program participation at a higher rate than typical laboratories. However, laboratories in their last year of program participation were no more likely to have high contamination rates than laboratories that had been in the program for the same length of time, but elected to continue with the study for a subsequent year.

Blood culture contamination rates were lower in institutions that employed dedicated personnel for the collection of blood cultures (Table 5). Specifically, rates were lower in institutions with a dedicated phlebotomy team or that used medical technologists or technicians to collect blood cultures, as opposed to nursing and ward-based staff ($P < .001$ for dedicated phlebotomy team vs other, and $P = .03$ for nursing staff vs other). Institutions that did not use nursing staff to collect routine blood cultures had an average contamination rate of 2.17%, whereas institutions in which virtually all blood cultures were collected by nursing personnel had an average contamination rate of 4.21%.

**Table 6. Association Between Blood Culture Volume and Contamination Rate**

| Blood Culture Volume (Adults), mL | No. of Laboratories | Mean Blood Culture Contamination Rate, % |
|---|---|---|
| 0–10 | 162 | 3.11 |
| 11–19 | 110 | 3.00 |
| ≥20 | 69 | 2.87 |

The overall blood culture contamination rate was inversely correlated with the volume of blood collected for culture; the larger the volume, the lower the rate ($P < .001$; Table 6). The contamination rate was not correlated with type of antiseptic preparation, the application of antiseptic solution to the top of collection bottles before inoculation, the use of a double-needle collection method, or the calendar year. Because almost all of the laboratories in the study used tincture of iodine as a disinfectant, the statistical power of the study to detect the superiority of one disinfectant over another was limited, and no conclusions could be reached.

## COMMENT

Bates et al[3] reported in 1991 that the average inpatient with a contaminated blood culture accumulated $4385 in excess charges and stayed in the hospital 4.5 additional days, compared to an otherwise similar patient without a contaminated blood culture. Assuming a charge-to-cost ratio of 1.5:1 and correcting for inflation since the Bates study was conducted (medical care series CUUR0000SAM, US Bureau of Labor Statistics), the incremental expense per patient with a contaminated blood culture in 2004 was $5506. Thus, an institution that processes blood cultures from 10 new patients per day will free up 82 bed-days and reduce expense by $100 500 during the course of a year if the local blood culture contamination rate could be reduced by 0.5%.

What can be done to reduce blood culture contamination? This study applied a repeated-measures analysis to a unique multi-institutional longitudinal data set to evaluate options that managers might consider for reducing blood culture contamination. Our findings reinforce several previously published observations and provide new insights.

We found that participants that used dedicated phlebotomists or medical technologists to collect cultures had a significantly lower rate of blood culture contamination than participants that used nursing or ward-based staff. Other researchers have noted similar results.[9–11] This relationship may reflect the special training dedicated phlebotomy staff receive, skill acquired with repeated practice,

nurses' increased propensity to draw blood from intravenous catheters, the distractions and clinical pressures ward-based staff experience, or some combination of these factors. The magnitude of contamination attributable to phlebotomy by ward-based staff deserves comment. Average contamination rates in institutions that used nurses to draw the majority of blood cultures were more than 1% higher than at sites that used laboratory staff to draw the majority of cultures. The financial impact of this difference is not trivial and for many institutions is likely to offset any savings that might be achieved by switching from laboratory-based phlebotomists to so-called patient-centered care technicians who perform multiple tasks in addition to phlebotomy.

We found that institutions that routinely processed larger blood culture volumes enjoyed lower contamination rates. To our knowledge, this relationship has not been previously reported and does not have an obvious explanation. Larger blood culture volumes have been associated with more frequent recovery of pathogenic organisms in a number of studies,[19,20] and it has been postulated that the drawing of larger volumes of blood increases the likelihood that bloodborne bacteria in very low concentrations will find their way into the blood culture bottle and thereby be detected. In contrast, we hypothesize that the likelihood of acquiring contaminating skin microflora during venipuncture is independent of the volume of blood collected and that larger collection volumes simply dilute any contaminates in the culture bottle, making them less likely to be detected during the 5 to 7 days when culture bottles are incubating. Blind subculture of bottles after incubation represents one approach that could be used to test our hypothesis.

We were not able to demonstrate an association between blood culture contamination and the type of skin disinfectant used for phlebotomy. This investigation lacked the statistical power to reliably demonstrate any effect, because most of the study laboratories had already adopted the use of preferred disinfectants; therefore, our results do not bring into question previous work that has associated disinfectant type with contamination rates.[6,7] For similar reasons, this study did not demonstrate any association between contamination rates and the practice of disinfecting the tops of blood culture bottles prior to inoculation. Because study laboratories could not obtain reliable data about the source of blood cultures, we did not compare the practice of obtaining blood by dedicated venipuncture rather than from an existing indwelling intravenous catheter. We found no evidence that contamination rates were rising during the study period, despite isolated reports in the literature that contamination rates at individual institutions have been increasing.[2]

One of the more encouraging findings of our investigation was that continued participation in the Q-Tracks monitoring program was associated with progressive decline in blood culture contamination. In point-in-time studies, the presence of a monitoring program has been associated with lower contamination rates.[13] We found that institutions that had longer lengths of participation in the Q-Tracks program had progressively lower rates of contamination; in fact, the largest decreases were observed in the fourth and fifth year of participation. This observation suggests that the act of monitoring produces benefits beyond the so-called Hawthorne effect, in which subjects under observation perform better than unobserved subjects. We do not know whether monitoring over time increases compliance with practices known to reduce contamination, promotes acquisition of phlebotomy skills, encourages the adoption of unmeasured practices that reduce contamination, or works through some other mechanism. Whatever the reason, the benefits we observed from continuous monitoring of blood culture contamination have been reported for other quality indicators in the laboratory, such as correct patient identification and receipt of specimens meeting criteria for acceptability.[21]

The mixed linear model we used to analyze the Q-Tracks longitudinal data set provides for more robust conclusions about factors that influence contamination rates than point-in-time comparisons, since each study participant serves as its own control. The fact that continuous monitoring of blood culture contamination is associated with progressive performance improvement should stimulate laboratory managers to regularly monitor blood culture contamination in their own institutions, as well as other key quality indicators.



**References**


1. Mirrett S, Weinstein MP, Reimer LG, Wilson ML, Reller LB. Relevance of the number of positive bottles in determining clinical significance of coagulase-negative staphylococci in blood cultures. *J Clin Microbiol.* 2001;39:3279–3281.
2. Weinstein ML. Blood culture contamination: persisting problems and partial progress. *J Clin Microbiol.* 2003;41:2275–2278.
3. Bates DW, Goldman L, Lee TH. Contaminant blood cultures and resource utilization: the true consequences of false-positive results. *JAMA.* 1991;265:365–369.
4. Souvenir D, Anderson D, Palpant S, et al. Blood cultures positive for coagulase-negative staphylococci: antisepsis, pseudobacteremia, and therapy of patients. *J Clin Microbiol.* 1998;36:1923–1926.
5. Nordberg A, Christopher NC, Ramundo ML, Bower JR, Berman SA. Contamination rates of blood cultures obtained by dedicated phlebotomy vs intravenous catheter. *JAMA.* 2003;289:726–729.
6. Strand CL, Wajsbort RR, Sturmann K. Effect of iodophor vs iodine tincture skin preparation on blood culture contamination rate. *JAMA.* 1993;269:1004–1006.
7. Mimoz O, Karim A, Mercat A, et al. Chlorhexidine compared with povidone-iodine as skin preparation before blood culture: a randomized, controlled trial. *Ann Intern Med.* 1999;131:843–837.
8. Spitalnic SJ, Woolard RH, Mermel LA. The significance of changing needles when inoculating blood cultures: a meta-analysis. *Clin Infect Dis.* 1995;21:1003–1006.
9. Schifman RB, Pindur A. The effect of skin disinfection materials on reducing blood culture contamination. *Am J Clin Pathol.* 1993;99:536–538.
10. Surdulescu S, Utamsingh D, Shekar R. Phlebotomy teams reduce blood culture contamination rate and save money. *Clin Perform Qual Health Care.* 1998;6:60–62.
11. Weinbaum FI, Lavie S, Danek M, Sixsmith D, Heinrich GF, Mills SS. Doing it right the first time: quality improvement and the contaminant blood culture. *J Clin Microbiol.* 1997;35:563–565.
12. Gibb AP, Hill B, Chorel B, Rollin B. Reduction in blood culture contamination rate by feedback to phlebotomists. *Arch Pathol Lab Med.* 1997;121:503–507.
13. Schifman RB, Strand CL, Meier FA, Howanitz PJ. Blood culture contamination: a College of American Pathologists Q-Probes study involving 640 institutions and 497 134 specimens from adult patients. *Arch Pathol Lab Med.* 1998; 122:216–221.
14. Weinstein MP. Blood culture contamination: persisting problems and partial progress. *J Clin Microbiol.* 2003;41:2275–2278.
15. Weinstein MP, Towns ML, Quartey SM, et al. The clinical significance of positive blood cultures in the 1990s: a prospective comprehensive evaluation of the microbiology, epidemiology, and outcome of bacteremia and fungemia in adults. *Clin Infect Dis.* 1997;24:584–602.
16. Smith JA, Bryce EA, Ngui-yen JH, Roberts FJ. Comparison of BACTEC 9240 and BacT/Alert blood culture systems in an adult hospital. *J Clin Microbiol.* 1995; 33:1905–1908.
17. Bryant JK, Strand CL. Reliability of blood cultures collected from intravascular catheter versus venipuncture. *Am J Clin Pathol.* 1987;88:113–116.
18. Valenstein P. *Blood CultureContamination: 2003 Q-Tracks Annual Summary Report.* QT-2. Northfield, Ill: College of American Pathologists; 2004.
19. Aronson M, Bor D. Blood cultures. *Ann Intern Med.* 1987;106:246–253.
20. Reimer LG, Weinstein MP, Wilson ML. Update on the detection of bacteremia and fungemia. *Clin Microbiol Rev.* 1997;10:444–465.
21. Zarbo RJ, Jones BA, Friedberg RC, et al. Q-Tracks: a College of American Pathologists program of continuous laboratory monitoring and longitudinal performance tracking. *Arch Pathol Lab Med.* 2002;126:1036–1044.