DIAGN MICROBIOL INFECT DIS
1992;15:575–578

MYCOLOGY

Catheter-Related Bacteremia and Fungemia

Reliability of Two Methods For Catheter Culture

José Gutiérrez, Cristobal Leon,
Rigoberto Matamoros, Carmen Nogales,
and Estrella Martín

The purpose of this study was to analyze 98 febrile patients with suspected catheter-related bacteremia (CRB) or fungemia (CRF) and compare two different methods, one semiquantitative (SQ) (Maki's method) and the other quantitative (Q) (modification of Brun-Buisson method) to determine each ability for diagnosing CRB. Twelve patients had CRB or CRF. The sensitivity, specificity, positive, and negative predictive values, and efficiency using the Maki method were 83%, 84%, 42%, 97%, and 83%, respectively. The same parameters using the other method were as follows: 92%, 84%, 44%, 99%, and 84%, respectively. Although the diagnostic reliability in each method was similar, the Maki method was quicker and easier to perform in clinical microbiology laboratories.

INTRODUCTION

Catheter-related bacteremia (CRB) continues to be a major problem in hospitalized patients (Maki, 1977 and 1981; Stamm, 1978; Hamory, 1987). In recent studies, the incidence of CRB ranges were from 7% to 42% (Liñares et al; 1985). The diagnosis of this infection remains an unresolved problem.

In 1977, Maki et al. described a technique that enabled one to differentiate colonization and infection of intravascular catheters (IVC). Maki continues to be a widely used reference method. More recently, other methods of evaluating IVC inserts as potential sources of bacteremia have been proposed (Brun-Buisson et al., 1987).

In this study, we compared two different methods, one semiquantitative (SQ) and the other quantitative (Q), and examined the ability of these methods to predict CRB or catheter-related fungemia (CRF).

MATERIALS AND METHODS

During a 6-month period (March–August 1990), 98 intravascular (tip) 3-cm-long catheter segments were prospectively studied. Of them, 59 were from septic patients hospitalized in intensive care and internal medicine, and the other 39 were from septic patients hospitalized on other floors in the Universitary Hospital Virgen of Valme. The patients were included in the protocol. All catheters were removed under strict sterile conditions and were immediately sent in sterile containers to the laboratory for culture. Prior to removing the catheter we obtained three sets of blood cultures from peripheral veins of all these patients.

From the Microbiology Laboratory, Intensive Care Unit (C.L., R.M.), University Hospital Virgen of Valme, Sevilla, Spain.

Address reprint requests to Dr. J. Gutiérrez, c/Camino Bajo De Huetor 84, 1°A, 18008 Granada, Spain.

Received 26 July 1991; revised and accepted 27 December 1991.

0732-8893/92/$5.00

Microbiologic Studies

Blood cultures were performed by conventional methods (three bottles of BACTEC NR 16A, and three bottles of BACTEC NR 17A; Becton-Dickinson Microbiology Systems, Cockeysville, MD). Catheter cultures were carried out by using both the semiquantitative method proposed by Maki et al. in 1977, and a modified form of the quantitative method described by Brun-Buisson et al. in 1987 (the tip is introduced in a tube with water and agitated). In the first method, each catheter segment was transferred to the surface of a 90-mm blood-agar plate and rolled back and forth across the surface at least four times. After this, the Q method was carried out by flushing the catheter lumen with 1 ml of distilled water, which was verted in a sterile tube. After agitation for 1 min in a vortex, 0.1 ml was taken and streaked onto a sheep blood-agar plate. Colonies were counted between 48 hr and 5 days during incubation; bacterial and fungal isolates were identified by conventional methods and the Automated Vitek System (Vitek System, Hazelwood, MO). Antibiotic susceptibility studies were performed by disk diffusion and the Automated Vitek System. The criteria for positivity in the SQ method was $\geq$15 colony-forming units (CFU) per plate (Maki et al., 1977) and, for the Q method, it was $\geq 10^3$ CFU/ml (Liñares et al. 1985).

Catheter-Related Bacteria or Fungemia

The catheter was considered the source of bacteremia or fungemia when the same organism (identical biotype and susceptibility pattern) was isolated from the catheter segment and blood (three positive bottles) and without another infection focus; also, after removing the catheter the febrile process ceased. In all cases of CRB or CRF, tip culture should yield $\geq$15 CFU/plate or $\geq 10^3$ CFU/ml with the SQ and Q methods, respectively.

The statistical method used was χ^2 test for comparing qualitative variables and Pearson's test for comparing quantitative variables.

RESULTS

Of the 98 catheters studied, 24 (24.5%) of them had a significant number of CFU by the SQ method, and 25 (25.5%) in Q method (Table 1). There was a lineal correlation between both methods ($p>0.001$). There was no significant number of CFU, CRB, or CRF in 72 catheters (72.4%) by Q and SQ methods. There was a significant number of CFU, but not CRB or CRF in 14 cases (Table 1), which performed favorably without bacteremia. In this case, the microorganisms isolated from the catheter were five *Staphylococcus hominis* and nine *S. epidermidis*. The number of colonies were variable by either the SQ or the Q method.

TABLE 1 Relation Between Catheter-Related Bacteremia (CRB) or Fungemia (CRF) and the Different Methods of Catheter Culture

Methods		CRB/CRF Yes	CRB/CRF No
Semiquantitative	$\geq$15 CFU/plate	10	14
	<15 CFU/plate	2	72
Quantitative	$\geq 10^3$ CFU/ml	11	14
	$<10^3$ CFU/ml	1	72

Of the 25 culture-positive catheters by one or the other method, 12 had organisms isolated that also were isolated from blood cultures (Table 2): three *S. epidermidis*, two *S. hominis*, two *Enterococcus faecalis*, two *Proteus mirabilis*, one *Enterobacter cloacae*, one *Xantomonas maltophilia*, and one *Candida albicans*. Of these 12 microorganisms, eight were isolated in significant quantities by both methods (Q and SQ), two by Q alone, and two by SQ. Although in some cases the culture of the catheter was significant using one of the methods, the same microorganisms were detected using the other method (organisms not yet in significant number).

The sensitivity, specificity, positive, and negative predictive values, and efficiency using the Maki method were 83%, 84%, 42%, 97%, and 83%, respectively. The same parameters using the other method were as follows: 90%, 84%, 44%, 98%, and 84%, respectively.

DISCUSSION

CRB is one of the infectious complications of intravenous therapy associated with the greatest morbidity and mortality (CDC, 1972–73; Stamm, 1978; Maki, 1981). The diagnosis of CRB is of much interest and is also the so-called entity of catheter infection because this infectious complication is diagnosed after catheter culture, and when using one or several methods, it demonstrates an arbitrary amount of bacterial growth. Some authors have studied the infection in the catheter tip (qualitative, SQ, and Q culture) (Maki et al., 1977; Cleri et al., 1980; Liñares et al., 1985; Brun-Buisson et al., 1987; Collignon and Munro, 1989; Nahass and Weinstein, 1990). Other authors confirm the presence or absence of bacteremia with qualitative and quantitative blood cul-

TABLE 2 Microorganisms Isolated from Semiquantitative and Quantitative Catheter Culture, in Catheter-Related Bacteremia or Fungemia

Case Number	Organisms	Number of Organisms	
		Semiquantitative[a]	Quantitative[a]
1	*St. epidermidis*	Uncountable	Uncountable
2	*Proteus mirabilis*	Uncountable	Uncountable
3	*Staphylococcus epidermidis*	15	160
4	*Staphylococcus epidermidis*	10^3	6×10^3
5	*Staphylococcus hominis*	7	10^3
6	*P. mirabilis*	28	10^2
7	*Enterobacter cloacae*	10^2	8×10^4
8	*Enterococcus faecalis*	Uncountable	Uncountable
9	*Enterococcus faecalis*	15	10^3
10	*Xanthomonas maltophilia*	6	10^4
11	*Staphylococcus hominis*	60	10^3
12	*Candida albicans*	10^2	Uncountable

[a]CFU per plate.

tures obtained through the catheter (Audremont et al., 1988; Benerza et al., 1988). Presently, there are other studies using superficial cultures that attempt to predict the amount of colonization without removing the catheter (Snydman et al., 1982). Nahass et al. (1990) demonstrated that qualitative catheter cultures were unable to differentiate between the colonized and infected catheter. Therefore, they cannot predict CRB.

The SQ reference method (Maki et al., 1977) has shown 100% of sensitivity and 76%–79% of specificity for CRB. However, this method has some problems and has been criticized (McGeer and Righter, 1987; Collignon and Munro, 1989).

The Q culture method of superficial and inner catheter has been reported by Cleri et al. in 1980 and Brun-Buisson et al. in 1987 with a sensitivity of 100% and 98% and a specificity of 92.5% and 88%, respectively. The use of the Cleri method has been limited because of its cumbersome and labor-intensive methodology, proving the Brun-Buisson method to be quicker and easier to use, although both had a similar reliability as Maki's reference method (Cercenado et al., 1990). We have compared a modification of the Brun-Buisson method with the Maki method. Our results show a similar correlation between CRB and catheter culture using both methods. The SQ and Q method had a high, sensitivity, specificity, and negative predictive value, which means that both methods are realiable in detecting the absence of CRB. The positive predictive value was low.

Statland et al. in 1984 believed that the perfect test would be that which had a sensitivity and specificity value equal to 200%, without a false-negative value. In our study, this value was 167% and 176% for SQ and Q methods, respectively.

We can conclude that the SQ and Q method used would be that with a high enough value to eliminate CRB because all catheter cultures with significant numbers of CFUs had a probability of 43% that is to be associated with CRB and a high sensitivity and specificity.

The diagnostic reliability of both methods was similar with the SQ method being the quicker and easier to be used as a routine method in a clinical microbiology laboratory.

The authors thank Manuel Correa for secretarial assistance.

REFERENCES

Audremont A, Paulet P, Nitemberg G, Hill C (1988) Value of semiquantitatives cultures drawn through catheter for estimating the risk of catheter tip colonization in cancer patients. *J Clin Microbiol* 26:2297–2299.

Benerza D, Kiehn T, Gold JWM, Brown AF, Turnbull ADM, Armstrong D (1988) Prospective study of infections in indwelling central venous catheters using quantitative blood cultures. *Am J Med* 85:495–498.

Brun-Buisson C, Abrouk F, Legrand P, Huet Y, Larabis S, Rapin M (1987) Diagnosis of central venous catheter-related sepsis: critical level of quantitative tip cultures. *Arch Intern Med* 147:873–877.

Centers for Disease Control (CDC) (Second Quarter 1972–1973) Definitions used by the National Nosocomial Infection Study. *Natl Nosocomial Infect Study Q Rep* 26.

Cercenado E, Ena J, Rodriguez-Creixems M, Romero I, Bouza E (1990) A conservative procedure for the diagnosis of catheter-related infections. *Arch Intern Med* 150:1417–1420.

Cleri DJ, Corrado ML, Deligman SJ (1980) Quantitative culture of intravenous catheter and other intravascular inserts. *J Infect Dis* 141:781–786.

Collignon PJ, Munro R (1989) Laboratory diagnosis of intravascular catheter associated sepsis. *Eur J Clin Microbiol Infect Dis* 8:807–814.

Hamory BH (1987) Nosocomial blood stream and intravascular device-related infections. In *Prevention and Control of Nosocomial Infections*. Ed, RP Wenzel. Baltimore: Williams and Wilkins, pp 283–319.

Liñares J, Sitges-Serra A, Garau J, Perez JL, Martín R (1985) Pathogenesis of catheter sepsis: a prospective study with quantitative and semiquantitative cultures of catheter hub and segments. *J Clin Microbiol* 21:357–360.

Maki DG (1981) Nosocomial bacteriemia: an epidemilogic overview. *Am J Med* 70:719–732.

Maki DG, Weise CE, Sarafin HW (1977) A semiquantitative culture method for identifying intravenous-catheter-related infection. *N Engl J Med* 296:1305–1309.

McGeer A, Righter J (1987) Improving our ability to diagnose infection associated with central venous catheter: value of gram staining and culture of entry site swabs. *Can Med Assoc J* 137:1009–1021

Nahass RG, Weinstein MP (1990) Qualitative intravascular catheter tip cultures do not predict catheter-related bacteriemia. *Diagn Microbiol Infect Dis* 13:223–226.

Snydman DR, Murray SA, Kornfeld SJ, Majks JA, Ellis CA (1982) Total parenteral nutrition-related infections: prospective epidemiologic study using semiquantitative methods. *Am J Med* 73:695–699.

Stamm II WE (1978) Prevention of infections: infections related to medical devices. *Ann Intern Med* 89:764–769.

Statland B, Winke P, Burke MD, Galen RS (1984) Métodos cuantitativos utilizados para evaluar las determinaciones de laboratorio y otros datos clínicos. In *Diagnósticos y tratamientos clínicos por el laboratorio*. Ed, J Bernard Henry. Barcelona: Salvat, pp 514–544.