Hospital Acquired Infection in the Pediatric Patient

EDITED BY

Leigh G. Donowitz

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In memory of my mother and father,
Sylvea and Morton C. Grossman,
my closest friends and
finest role models.

Preface

Hospitalized pediatric patients are at significant risk of developing hospital-acquired infection. The neonate in the newborn intensive care unit has a 15–25% risk, the child admitted to an intensive care unit has a 14% risk, and the ward patients have a 5% risk of developing hospital-acquired infection. In the pediatric patient, hospital-acquired infection carries the risk of significant additional morbidity, long-term physical, neurologic and developmental sequelae, and death.

Multiple texts review the infectious diseases of the newborn and child; other references describe nosocomial infections primarily as they occur in the adult surgical and medical patient. The goal of this book is to provide an informative, authoritative reference on the management of hospital-acquired infection in the pediatric patient.

The specific infections that are unique as infection control issues in the pediatric patient are divided into two sections: nosocomial infections by site (e.g., bacteremia, pneumonia, and diarrhea) and nosocomial infection by pathogen (e.g., varicella, tuberculosis, and cytomegalovirus).

A special section of the text has been devoted to the management of patients who have unique and high risks of hospital-acquired infections. This section includes a chapter on the neonate, the immunocompromised patient, and the critical care patient.

The Infection Control Personnel and Policy section of this text will become an important reference for medical personnel caring for infants and children. This section contains recommendations and guidelines on isolation; nursing policies; staff education; visitation policies for families, siblings and pets; toys as potential vectors for infectious pathogens; employee health; microbiologic infection control; and antibiotic restriction. The isolation guidelines are a unique highlighted section of this book, providing a ready reference for how to isolate an infant or child with a potentially transmissible infection.

Employee health issues are of particular importance as they pertain to pediatric patients. The immunity of staff members to rubella, chickenpox, mumps, and herpes simplex virus, and the prevalence of viral gastrointestinal and upper respiratory illness and staphylococcal dermatitis may be of lesser importance for personnel involved in adult care. When they occur in the pediatric inpatient setting, these infections can cause major epidemic disease in this nonimmune population and can result in significant morbidity, mortality, and expense in isolation, cohorting, passive immunization, personnel, and ancillary costs.

This book is written for physicians, nurses, medical laboratory personnel, and the many other people who care for hospitalized children. The book is designed to answer specific management questions on the prevention, isolation, and therapies of hospital-acquired infectious disease in the pediatric patient. The goals of the authors in the

writing of this informative and current reference text are the prevention of nosocomial infections and optimal management and containment of those infections that are not preventable.

I wish to thank Dick Wenzel, who as a colleague, teacher, and friend initiated my career in nosocomial infections, and John Nelson and Jerry Mandell, who personally encouraged and supported me in this project. I also would like to thank my secretary, Linda Bryant, who maintained a level of organization, editorial and secretarial skills, coupled with a sense of humor, which contributed to making this a far better book.

In conclusion, I wish to acknowledge the authors of this text who not only provided their expertise, time, and scholarship in writing this comprehensive and authoritative text, but who are the scientific investigators who have created the factual information upon which this book is based.

L.D.

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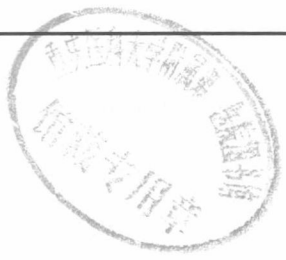

Contents

1

SITES

1

Bacteremia and Fungemia

Margaret A. Tipple, M.D., William R. Jarvis, M.D., and William J. Martone, M.D., M.Sc.

INTRODUCTION

Bloodstream infections among pediatric patients have long been recognized as an important problem. Pediatric training programs emphasize recognition of early signs and symptoms of sepsis. Blood cultures are drawn on febrile infants and children as part of "sepsis workups," and antibiotic combinations are chosen carefully for treatment of likely pathogens while culture results are pending.

Extensive literature exists on the problem of community-acquired bloodstream infections in otherwise healthy infants and children, and there is a reasonable understanding of neonatal sepsis (1–3). However, there is little information on the problem of nosocomial, or hospital-acquired bloodstream infections in pediatric patients. Any available information originates mainly from the National Nosocomial Infections Surveillance system (NNIS) and the medical literature. NNIS is a nationwide surveillance system organized by the Centers for Disease Control (CDC) in 1970, and is the only source of current national data on the incidence of nosocomial infections (4). NNIS hospitals are a geographically representative, nonrandom sample of U.S. hospitals; they comprise small hospitals, public hospitals, private hospitals, and teaching hospitals throughout the U.S. Prior to 1986, children's hospitals were underrepresented, and no data were available for pediatric or neonatal intensive care units. Most reports in the medical literature are analyses of nosocomial bloodstream infections among pediatric patients in single institutions.

DEFINITIONS

For this review we have adopted the NNIS system standard definitions (5).

Nosocomial Infection

A nosocomial infection is defined as a localized or systemic condition resulting from the adverse reaction to the presence of an infectious agent(s) or its toxin(s) with no evidence that the infection was present or incubating at the time of hospital admission. Reviews of bacteremia in the literature may use slightly different criteria for designation of nosocomial bacteremia. Usually, infection must have occurred 48 or 72 hours after admission for it to be considered as hospital-acquired. Organisms regarded as likely to have been of community origin (as *Hemophilus influenzae* or *Streptococcus pneumoniae*) may be excluded even if the time requirement has been met. Organisms which commonly occur as contaminants in blood cultures (as coagulase-negative staphylococci, alphahemolytic streptococci or *Bacillus* spp.) may be considered as causing infection only when multiple cultures are positive or only when associated with a vascular catheter. These differences in definitions, plus the possibility that different institutions will have patient populations with different underlying diseases and severity of illness, make it difficult to compare bloodstream infections between hospitals.

Neonatal Nosocomial Infection

When neonates are considered, it is often difficult to determine whether exposure to organisms causing infection occurred at the time of delivery or later. NNIS classifies all neonatal infections as nosocomial unless there is clear evidence of intrauterine infection (as might occur with cytomegalovirus or toxoplasmosis). Neonatal nosocomial infections are divided into two categories: maternal origin, if symptoms are recorded within 48 hours of admission, and hos-

pital-acquired, if the infant becomes symptomatic after 48 hours of age.

Primary versus Secondary Bloodstream Infection

Primary bacteremia is defined as a bloodstream infection occurring in a patient with no evidence of localized infection. However, bacteremia associated with a peripheral intravenous line, a central venous catheter, or an arterial line is regarded as primary even if there is evidence of local site infection. Secondary bacteremia is defined as bloodstream infection with clinical or microbiologic evidence of infection at another site, which is the source of the bloodstream infection. Fungemia refers to the presence of fungi in the bloodstream and generally does not distinguish between primary and secondary infection.

Endogenous versus Exogenous Infection

Endogenous infections result from invasion of the bloodstream by the patient's own flora, while exogenous infections result from invasion of the bloodstream by organisms from the hospital environment. The likely source of organisms may assist in determining if problems with environmental contamination or patient colonization need to be addressed. This may be difficult, however, in the patient with long or frequent hospitalization who may become colonized with hospital organisms and who later develops an endogenous infection with these organisms (6).

Endemic versus Epidemic Infection

Endemic infection refers to the occurrence of disease at a given baseline frequency over a prolonged period of time (7). One purpose of hospital infection control surveillance programs is to establish baseline rates of bacteremia and to determine whether significant changes in these rates have occurred.

Epidemic nosocomial infections, also referred to as outbreaks, are defined as unexpected increases in infection rates (7,8). For determining whether an outbreak exists, rates of infections for different time periods must be compared, making good surveillance data critical.

INCIDENCE OF NOSOCOMIAL BACTEREMIA

Nosocomial infections are estimated to have occurred in 3.4% of all patients hospitalized in the United States during 1984 (9). Data from NNIS suggest that, overall, pediatric patients are less likely to acquire infections than adults, possibly because of shorter average hospital stay. Overall nosocomial infection rates in 1984 were 14.4 per 1000 discharges (1.4%) for newborns and 13.3 per 1000 discharges (1.3%) for general pediatrics patients (Tables 1.1 and 1.2).

NNIS nosocomial infection and bacteremia rates for newborn and general pediatric services are consistent with those reported by various institutions in the United States and Western Europe (Tables 1.1 and 1.2).

Both overall nosocomial infection rates and bacteremia rates are lowest in well newborns. This may be related to their short hospital stay and lack of invasive interventions.

Rates are higher on pediatric services (Table 1.2) with wider variation, especially in overall infection rates, than those seen on newborn services. This wide variation may be explained by the type of surveillance employed (active or passive), inclusion of viral infections, proportion of surgical and medical patients, as well as age, type and severity of underlying disease, number of invasive procedures, length of hospitalization, and possibly other factors. Younger children have been shown to have higher nosocomial infection rates, especially when viral infections are included (14). Centers with a high proportion of oncology patients are also likely to have higher infection rates (15).

Not surprisingly, published studies from individual institutions have shown higher infection rates for pediatric intensive care (PICU) (Table 1.3) and neonatal intensive care (NICU) (Table 1.4) patients than for general pediatric and newborn patients. Nosocomial infection rates in the PICU have been reported to be approximately 4–20 times those for general pediatric patients (Table 1.3). From 5% to over 32% of these nosocomial infections are accounted for by nosocomial bacteremias. The reasons for this wide variability among institutions is unclear, but probably results from differences in study definitions, differences in ages, type and severity of illness, length of stay in the ICU, type and duration of IV therapy, and need for multiple invasive procedures.

As with PICUs, nosocomial infection rates in NICUs have been reported to be, on the average, 4–19 times higher than those in general newborn services (Table 1.4). A larger percentage (averaging about 20%) of nosocomial infections

Table 1.1
Nosocomial Infections in Newborns

Location	Year of Study	Ref. No.	Nosocomial Infection Rate[a]	Nosocomial Bacteremia Rate[b]	Bacteremia as Percent of all Nosocomial Inf.
University of Gottingen	1962–74	10		0.9	
West Germany	1975–82			2.0	
Yale University	1966–78	11		1.0–3.9[c]	
				0.9–2.5[d]	
Karolinska Institute	1969–73	12		1.4	
Sweden	1974–78			3.1	
University of Iowa	1976–77	13	6.0	0.2	3.3
University of South Carolina	1977–81	2		1.2	
Buffalo Children's Hospital	1980–81	14	17.0		
National Nosocomial	1984	9			
Infections Surveillance (NNIS) Study[b]					
Small Hospitals			8.6	0.6	7.0
Small Teaching Hospitals			14.7	2.0	13.6
Large Teaching Hospitals			17.3	3.6	20.7
Total (NNIS)			14.4		

[a]Number of infections per 1000 discharges.
[b]All newborn services—neonatal intensive care units and well-baby nurseries.
[c]Onset at or before 48 hours of age.
[d]Onset after 48 hours of age.

were attributed to bacteremias in NICUs than in any of the other pediatric care services. Risk factors for bacteremias have been shown to include birthweight, presence of infection elsewhere, type and duration of invasive procedures, duration of intravenous therapy, and use of total parenteral nutrition (TPN) (13,19,26,27). An additional risk factor is that neonates admitted to NICUs may not develop "normal" gastrointestinal flora, but instead are colonized with NICU environmental organisms, some of which may become invasive pathogens (28).

Table 1.2
Nosocomial Infection and Bacteremia in Pediatric Patients

Location	Year of Study	Ref. No.	Service	Nosocomial Infection Rate[a]	Nosocomial Bacteremia Rate	Bacteremia as Percent of all Nosocomial Inf.
Boston Children's Hospital	1970	15	AP[b]	46	6.2	14
University of South Carolina	1977–81	2	AP[b]		5.1	
Buffalo Children's Hospital	1980–81	14	AP[b]	32		
University of Virginia	1982–83	16	AP[b]	48	4	8
National Nosocomial Infection Surveillance Study	1984	17	All Pediatric Services			
			Small Hospitals	1.2	<.1	
			Small Teaching Hospitals	14.6	2.4	16.4
			Large Teaching Hospitals	16.6	2.1	12.7
			Total	13.3		

[a]Number of infections per 1000 discharges.
[b]AP—All pediatric medical and surgical patients.

Table 1.3
Nosocomial Infection and Bacteremia in Pediatric Intensive Care Patients

Location	Year of Study	Ref. No.	Service	Nosocomial Infection Rate[a]	Nosocomial Bacteremia Rate[a]	Bacteremia as Percent of all Nosocomial Inf.
Buffalo Children's Hospital	1980–81	14	PICU	110		
Tufts University	1981–83	17	PICU	62		
University of Virginia	1982–83	16	PICU	137	11	8
NNIS	1983–84	Jarvis	PICU	103	33.3	32
Georgia Hosp. A.	1981–82	18	PICU	216	12.2	7
Hosp. B.	1981–82	18	PICU	241	37.6	16

[a]Number of infections per 1000 discharges.

ETIOLOGY AND TRENDS OF NOSOCOMIAL BLOODSTREAM INFECTIONS

This decade has seen significant changes in the causes of nosocomial bloodstream infections. While Gram-positive cocci have continued to predominate as the most common category of pathogen, trends in the etiology of nosocomial bloodstream infection in the past 5–10 years reveal that coagulase-negative staphylococci have emerged as significant and frequently isolated pathogens. In 1984, analyses of the etiology of bloodstream infections on the pediatric and newborn services of NNIS hospitals revealed coagulase-negative staphylococci to be the most commonly isolated organisms. For newborn services, group B streptococcus, enterococci, *E. coli*, and *Klebsiella* spp. were the next most frequently isolated pathogens, while for the pediatric services they were *S. aureus*, *E. coli*, *Klebsiella* spp., and *Candida* sp. (Table 1.5).

Several studies suggest that the reasons for the recent emergence of coagulase-negative staphylococci have included the more frequent and prolonged use of indwelling intravenous catheters, improved survival resulting in prolonged hospitalization, increased use of parenteral nutrition, and the increased use of 2nd and 3rd generation cephalosporins which may select for increasingly antibiotic resistant strains of coagulase-negative staphylococci (27,29–34). In an investigation of increasing incidence of septicemia due to coagulase-negative staphylococci among infants in an institution in the Netherlands, Fleer and associates noted a 10-fold increase in infection among infants who had received contaminated total parenteral nutrition (TPN) solutions (32). Like others, their studies are confounded by an increased proportion of births being of low birthweight, an increased frequency of the use of intravenous cannulae, and frequent courses of antimicrobial agents.

Table 1.4
Nosocomial Bacteremia in Neonatal Intensive Care Patients

Location	Year of Study	Ref. No.	Nosocomial Infection Rate[a]	Nosocomial Bacteremia Rate[a]	Bacteremia as Percent of all Nosocomial Inf.
University of Utah	1970–74	19	246	34	14
University of Virginia	1973–77	20		40[b]	
University of Iowa	1976–77	13	169	27	16
Utrecht, Netherlands	1977–78	21	300	83	27
Buffalo Children's Hospital	1980–81	14	222[c]		
Virginia State Nosocomial Infection Registry	1980–82	22	80	15	19
Tufts University	1981–83	17	59	12	20
University of Liverpool	1981–82	23		51	
University of Pennsylvania	1982–84	24	72	22	31
Freiburg, W. Germany	1982–83	25	239	34	14

[a]Number of infections per 1000 discharges.
[b]Primary and secondary.
[c]Includes nosocomial viral infections.