

Original Articles

Nosocomial Infections in Intensive Care Wards: A Multicenter Prospective Study

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Abstract. In a three-year prospective investigation, a total of 6,952 patients were investigated prospectively in nine intensive care wards and their rate of nosocomial infections was analysed. The frequency of the nosocomial infections varied between 3% and 27%. The most frequent nosocomial infections were urinary tract infections, sepsis, infections of the skin and of the subcutaneous tissue, pneumonia and wound infections. The most frequent causes of sepsis were ventilation pneumonia, venous catheters, wound infections and urinary tract infections. The pathogen spectrum was analysed. By specific control of infection with employment of an infection control nurse, the frequency of nosocomial infections on intensive care wards was lowered from 17.2% to 14.3% within one year in one of the hospitals.

Key words: Intensive care units – Nosocomial infections – Prospective analysis – Causes – Control methods

Introduction

An average of 5%–6% of all patients given inpatient treatment acquire a nosocomial infection. The National Nosocomial Infections Study of the Center for Disease Control, Atlanta, Georgia, USA, reports for 1976 an average rate of nosocomial infections of 5.1% in university hospitals [4].

82 hospitals participated in this study. A total of 1,316,232 patients were examined prospectively by infection control nurses. The most frequent nosocomial infections were urinary tract infections, wound infections, respiratory tract infections, infections of the skin and sepsis. So far, there are very few specific prospective analyses of nosocomial infections in intensive care wards. The present paper reports on the results

of a three-year prospective study of nosocomial infections in intensive care wards of different departments of a university hospital in Germany and on a six-months prospective analysis of the intensive care wards of four hospitals in Switzerland.

Patients and Methods

Nosocomial infections were registered according to the criteria of the Center for Disease Control [3] by trained nurse epidemiologists (Freiburg) or by experienced nurses of the respective ward instructed by an infection control nurse (Switzerland). In Freiburg, the following wards were monitored from July 1976 until September 1979: intensive care wards of the University Department of Surgery, Neurosurgery, Pediatrics, Internal Medicine, Cardiac and Vascular Surgery. In Switzerland, all patients of the intensive care wards of the Geneva Cantonal Hospital (Departments of Medicine and Surgery), the Municipal Hospital Triemli, Zürich (Departments of Medicine, Surgery and Pediatrics), the Basel Cantonal Hospital (Department of Surgery) and the University Hospital Zürich (Department of Medicine).

The average period of stay in the intensive care units of Freiburg was 4.2 days for patients without nosocomial infections and 21 days for patients with nosocomial infections. The average age was 48 years, and the corresponding data for the Swiss clinics were 2.9 days, 14.0 days and 56 years. Routine bacteriological investigations were carried out at roughly the same frequency in the various hospitals: aerobic and anaerobic blood cultures were taken in every unelucidated fever. Tracheal secretions were examined bacteriologically twice a week in intubated patients, and urine was examined twice a week in catheterized patients. Discharge of pus from a surgical wound was examined bacteriologically in about 70% of the cases.

Table 3. Secondary septicemia in patients with nosocomial infections

Nosocomial infection	No. of patients	% Secondary septicemia
Pneumonia	47	36.2
Urinary tract infection	54	31.5
Wound infection	17	47
Venous catheter thrombophlebitis	40	77.5

fections were mostly tracheobronchitis in intubated and ventilated patients. Cases of infection of the skin and the subcutaneous tissue were mostly thrombophlebitis caused by venous catheters.

By retrospective analysis we attempted to analyse the risk for secondary septicemia in patients with nosocomial infections (Table 3). In 118 patients blood cultures have been taken not later than 5 days (mostly 1–2 days) after the infection occurred. Only blood cultures which grew bacterial species with antibiograms identical to those isolated from the infection (tracheobronchial aspirates, urine, pus from wounds, venous catheter tips) were considered as sign of secondary spread. A typing of the organism was not carried out. In this small group of patients, which was highly susceptible to infections, secondary septicemia was found in 31.5% to 77.5% of cases.

The spectrum of micro-organisms causing individual infections is shown in Tables 4a, 4b and 5. The most frequent gram-positive organism is *Staphylococcus aureus*, and the most frequent gram-negative bacteria are *Escherichia coli* and *Pseudomonas aeruginosa*, which chiefly cause pneumonia, urinary tract infections and wound infections. Enterococci are the

Table 4a. Bacteria and fungi causing nosocomial infections in ICU (Freiburg)

	UTI	Septicemia	Skin, subcut. tissue	Pneu- monia	Wound infections
Number of isolates	179	146	116	97	47
Gram-positive bacteria: (~50%)					
<i>Staph. aureus</i> %	6	48	64	21	40
<i>Staph. epidermidis</i> %	5	10	6	2	8
Enterococcus %	22	4	—	5	6
Streptococcus A %	—	3	1	1	—
Streptococcus B %	—	2	1	2	2
Pneumococcus %	—	1	—	—	—

Table 4b. Bacteria and fungi causing nosocomial infections in ICU (Freiburg)

	UTI	Septicemia	Skin, subcut. tissue	Pneu- monia	Wound infections
Number of isolates	179	146	116	97	47
Gram-negative bacteria: (~40%)					
<i>E. coli</i> %	28	9	4	12	16
<i>Pseudomonas aeruginosa</i> %	5	7	13	22	12
Enterobacter %	3	—	—	4	2
<i>Klebsiella pneumoniae</i> %	5	6	4	15	6
<i>Serratia marcescens</i> %	0.5	2	—	1	2
<i>Proteus mirabilis</i> %	8	3	1	5	4
Fungi: (~4%)					
<i>Candida albicans</i> %	6	1	3	7	2
other bacteria %	11.5	4	3	3	2

second most frequent causative organisms of urinary tract infections.

Staphylococcus epidermidis is the second most frequent causative organism of sepsis in Freiburg; the starting point was mostly thrombophlebitis caused by a venous catheter.

Together with anaerobes, fungi play a minor role. *Candida albicans* mainly causes urinary tract infections and pneumonia. Comparison of the pathogen spectra of the hospitals in Freiburg and in Switzerland reveals differences which are in some cases appreciable, although the total number of pathogens analyzed in the Swiss hospitals is still relatively small. In the Freiburg hospitals, Staphylococci are by far the most frequent causative organisms of sepsis, whereas *Serratia marcescens* was the most frequent causative or-

Table 5. Most common organisms causing nosocomial infections in ICU (%) (Zürich, Basel, Geneva)

Bacteria	UTI (n = 51)	Septicemia (n = 16)	Pneumonia (n = 30)
<i>S. aureus</i>	4	18	20
Enterococci	12	—	9
<i>E. coli</i>	20	12	20
<i>Ps. aeruginosa</i>	19	18	30
<i>Kl. pneumoniae</i>	9	—	17
<i>Cand. albicans</i>	12	—	6
<i>Serratia marc.</i>	7	25	6

Table 6. The role of fomites in transmission of nosocomial infections

<i>important:</i>	unsterile objects (e.g. instruments) or fluids coming in contact with wounds, urinary tract, respiratory tract, etc.
<i>less important:</i>	contaminated objects coming in contact with less susceptible body areas (bed pans, urine bottles, etc.)
<i>not important:</i>	fomites with almost no contact with patients (e.g. sinks, floors, furniture)

ganism of sepsis in the Swiss hospitals. The isolations of *Serratia marcescens* were essentially limited to one of the monitored intensive care wards.

Discussion

Nosocomial infections arise in two chief ways: endogenously from the flora of the patient's own body (e.g. urinary tract infections from the intestinal flora) or exogenously from bacteria in the patient's environment (e.g. contact infections by hands or instruments, droplet infections). It is assumed today that 30% – 50% of all hospital infections are endogenous in origin [8]. Most causative organisms of nosocomial infections are transmitted by direct contact, chiefly by the hands. Transmission by objects plays a comparatively small role (see Table 6).

The frequency of nosocomial infections in general wards averages 4% – 8% in various studies [1, 4, 13]. The most frequent infections are urinary tract infections, respiratory tract infections, wound infections, sepsis and infections of the skin or of the subcutis. Surgical departments (surgery, neurosurgery, gynecology) have a higher rate of nosocomial infections than medical, pediatric or obstetric departments [4]. The nature of the infections, their frequency and the spectrum of causative organisms depends on very diverse factors, e.g. types of patients, surgical interventions, age of the patients, application of antibiotics (especially antibiotic prophylaxis), training of the personnel etc.

Almost half of all the nosocomial infections are procedure-related, i.e. they arise in connection with urinary bladder catheters, venous catheters, infusion therapy, etc. Stamm estimates the number of patients with procedure-related infections in the United States as 850,000 patients per year [12]. 70% of these infections are caused by gram-negative bacteria. The risk of a urinary tract infection each day with an indwelling catheter is about 0.5% to 1% [10]. Aseptic operations lead to wound infections in 0.5% to 2% of patients [5]. The risk of a pneumonia during artificial

ventilation is specified by Wenzel and coworkers as 3.4%, in intermittent positive pressure breathing as 0.6% and in general anesthesia as 0.4% [13]. Nosocomial infections are more frequent in intensive care wards than in other wards, since almost all patients must be supplied with venous catheters or urinary bladder catheters or must be intubated. Patients from intensive care wards are, moreover frequently, subject to an extreme danger of infection due to their underlying disease (e.g. diabetes, shock, polytrauma, multiple operations, renal insufficiency, etc.). In polytraumatized patients of a surgical intensive care ward, e.g. the rate of nosocomial infections was 45.2% [6].

So far, there are only a few prospective studies on nosocomial infections in intensive care patients. In neonatal intensive care units, the rate has been reported identically as 24% in two studies in university hospitals [10] and 9.14% in a community hospital [12]. In adults, the frequency was 72% in a Swedish prevalence study in five hospitals. However, only 4,246 patients were evaluated on one day, of these 29 on the intensive care ward [2].

In our investigation, the frequency of nosocomial infections varied in the different wards between 3% and 27%. On average, it was higher in Freiburg than in the Swiss hospitals. This is probably connected with the overall shorter stay of patients in Swiss hospitals. The longer patients stay in hospital, the greater is the risk of acquiring an infection. Urinary tract infection is also the most frequent nosocomial infection on intensive care wards. This can be appreciably reduced by the use of suprapubic bladder drainage [7]. The second most frequent infection is *sepsis*, which on general wards only occurs as the fourth most frequent nosocomial infection [4].

The above-average frequency of sepsis in intensive care patients is connected with the large number of procedures which predispose to sepsis. In a prospective study of 4,716 surgical patients, the rate of sepsis in bladder catheters was specified as 2.46%, in venous catheters as 6.3% and in pneumonia as 2.02% [9]. The risk of secondary septicemia in our patients was much higher. Our data, however, were obtained by retrospective analysis of a group of highly susceptible patients. The true risk can only be evaluated by prospective studies on a larger number of patients with typing of the organisms isolated.

The most frequent causative organisms of urinary tract infections on intensive care wards are *E. coli* and enterococci, of sepsis and wound infections, Staphylococci and *E. coli*; gram-negative organisms are the most frequent cause of pneumonia. This is largely consistent with the spectrum of causative organisms in the National Nosocomial Infections Study [4]. Fungi and anaerobes play a subordinate role. Compa-

Table 7. Effect of infection control on hospital acquired infections (%) in ICU (Freiburg)

Ward	1978	1979
Neurosurgery	13	16
Surgery	35.3	26
Newborns	32	23
Medicine	3.6	3.8
Total	17.2	14.3
Number of discharges	1626	1234

risson of the pathogen spectrum of the individual intensive care wards however shows appreciable differences in some cases. *Serratia marcescens* was very rarely isolated in Freiburg, but in another intensive care ward it was one of the most frequently isolated organisms in sepsis, in urinary tract infections and in pneumonia. Every intensive care ward should classify the pathogen spectrum of the respective infections at least every six months, since the control measures in nosocomial infections also substantially depend on the respective pathogen spectrum.

Infections are one of the most frequent causes of death in intensive care wards. A specific control of infection is hence an indispensable component of intensive medicine. Measures must be chiefly directed against the five most important nosocomial infections on intensive care wards. In this way, a lowering of the rate of infections and at the same time of the mortality on intensive care wards can be attained.

By a specific program for the control of infection (employment of nurse epidemiologists, improvement of nursing techniques, etc.) the rate of nosocomial infections in Freiburg was reduced by an average of 17% within one year (see Table 7). The greatest reduction was in the surgical and neonatal intensive care wards. In the surgery patients, the lowering of the rate of infections was based, above all, on a reduction of urinary tract infections by the introduction of suprapubic bladder drainage [7].

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