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Interaction between the microbiology laboratory and clinician: what the microbiologist can provide

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Summary: The work of the clinical microbiologist comprises three major areas: diagnostic work in the laboratory, advice to clinicians about treatment of infected patients, and infection control. By clinical alertness, either from work in the laboratory or from clinical contacts, the microbiologist may contribute to the recognition of hospital outbreaks. The microbiologist plays a key role in implementing a restrictive antibiotic policy in hospital. Experience shows that a close personal contact with clinicians in the daily treatment of patients is the most efficient way to ensure a rational use of antibiotics and keep the consumption low. Other important measures include the elaboration of antibiotic guidelines and performance of audits. On basis of periodic summaries of laboratory data and data on antibiotic consumption, the microbiologist can keep the clinicians informed about antibiotic resistance and compliance with the antibiotic guidelines. In addition to informal contacts, the microbiologist also interacts with clinicians through participation in infection control and drug and therapeutic committees.

Keywords: Microbiology laboratory; microbiologist; clinician; infection control; antibiotic policy; audit.

Introduction

The increasing use of invasive technical equipment and immunosuppressive agents to treat hospitalized patients has widened the spectrum of nosocomial infections. New infections are emerging, and opportunistic pathogens play an increasing role. A characteristic feature of nosocomial organisms is their unpredictable susceptibility to antibiotics. As a consequence, there is a growing need for microbiological diagnostics, both for recognition of hospital-acquired infections and for characterization of identified organisms. The clinical microbiological laboratory plays a key role in this work. This paper describes how the microbiology laboratory is involved in infection control, and how the clinical microbiologist interacts with the clinicians.

The clinical microbiological laboratory

The microbiology laboratory is an important part of the local infection control network. Clinical microbiological departments should be present in all larger hospitals and be able to offer a 24 h service with a medically trained microbiologist on call outside ordinary working hours. In Denmark, the intention is to have

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Table I *Education of clinical microbiologists in Denmark (minimum requirements)*

Medical school	6 years
Clinical training (full registration)	1·5 years
Specialist in clinical microbiology:	
Clinical microbiology departments	2·5 years
Reference laboratories, State Serum Institute	2·0 years
Department for epidemic infectious diseases	0·5 years
Other relevant clinical departments	0·5 years
Total	5·5 years

Table II *Outbreaks of nosocomial infection recognized by clinical alertness in the clinical microbiological department at Hvidovre Hospital (HH) 1987–1997*

Department	Year	Type of infection	Micro-organism	Source of outbreak	Reference
Orthopaedic surgery	1989	Arthritis after arthroscopy	MRSA (imported strain)	Cross infection	3
Infectious diseases	1989	Gastro-enteritis	*Cryptosporidium parvum*	Ice machine	4
Orthopaedic surgery	1990–91	Surgical wound infection, septicaemia	*Streptococcus pyogenes*	Surgeon (throat carrier)	5
Infectious diseases	1991	Pseudo-outbreak	*Pseudomonas aeruginosa*	Bronchoscope	6
Several hospitals in Northern Europe	1991	Transfusion related septicaemia	*Serratia marcescens*	Commercial blood transfusion bags	7
ICU + burns unit	1991	Wound infection, septicaemia	*Pseudomonas aeruginosa*	Tap water used for irrigation of burns	8
Neonatal ICU	1992–93	Skin colonization, septicaemia	*Staph. epidermidis* (multi-resistant strain)	Lambskins	—
ICU + burns unit in HH + ICU in another Copenhagen hospital	1993	Ventilator-associated pneumonia	*Acinetobacter baumannii* (multi-resistant strain)	Cross infection	—
Neonatal ICUs in HH + two other Copenhagen hospitals	1996–97	Colonization of skin and intestinal tract, septicaemia	*Serratia marcescens*	Cross infection (?)	—

one clinical microbiological department in each county, situated in the main county hospital, and covering a population of 0·3–0·6 million inhabitants. These local microbiology laboratories have a close collaboration with reference laboratories, which are centralized at the State Serum Institute in Copenhagen.

The clinical microbiology laboratory receives a large number of clinical specimens for routine diagnostic purposes. Although the main object is to identify causative organisms in order to ensure a proper treatment of patients, the infection control aspect must always be kept in mind: an identified organism may require immediate isolation of the patient, and a cluster of identical organisms from a number of patients may indicate an outbreak. The laboratory also receives specimens taken specifically for infection control purposes, e.g. screening for methicillin-resistant *Staphylococcus aureus* (MRSA) and other multi-resistant organisms.

In order to play a role in infection control, the microbiology laboratory must have good diagnostic facilities, to enable rapid and accurate identification of all commonly occurring organisms to species level. Typing of species is

Table III *Effect of an audit on the consumption of antibiotics in Hvidovre Hospital 1995. Figures for consumption are given in Defined Daily Doses (DDD) per 1000 bed days*

	Orthopaedic surgery department		All other depts in Hvidovre Hospital	
	1994 (DDD/1000 bed days)	1995 (% of 1994)	1994 (DDD/1000 bed days)	1995 (% of 1994)
Beta-lactamase sensitive penicillins (J01C E)	90·5	105·4%	57·7	111·4%
Beta-lactamase resistant penicillins (J01C F)	226·9	94·0%	32·0	106·5%
Broad-spectrum penicillins (J01C A+R)	44·5	57·8%	91·4	102·8%
Cephalosporins (J01D A)	26·4	58·6%	18·0	87·8%
Aminoglycosides (J01G B)	5·8	51·3%	15·6	104·4%
Quinolones (J01M A)	14·9	106·0%	7·2	131·1%
Macrolides (J01F A)	9·1	133·7%	29·5	88·8%
Fusidic acid (J01X C)	23·0	32·1%	4·3	123·1%
Total	441·1	88·0%	255·7	103·8%

often relevant for epidemiological purposes. Resistance typing, i.e. typing on basis of antibiograms, is a rapid, simple and useful way to characterize strains of a given species, provided that they possess some acquired-resistance characteristics. This can be done in all local laboratories using routine susceptibility testing with a suitable selection of antibiotics. More complex typing methods (e.g. serotyping, phage-typing, and molecular typing methods) must usually be left to central reference laboratories.

The clinical microbiologist

Although microbiologists may have different educational backgrounds, in order to ensure good contacts with clinicians it is preferable that they are medical doctors with a basic clinical training. Clinicians tend to be more responsive to advice on controversial issues, like antibiotic policies, if it comes from a person with an educational background similar to their own. In Scandinavia and North West Europe, the microbiology laboratories are staffed with clinical microbiologists who have had a basic clinical training in addition to their education in laboratory medicine. The educational requirements for Danish clinical microbiologists are shown in Table I.

The working field of the clinical microbiologist comprises three major areas: microbiological diagnostic work in the laboratory, advice to clinicians about treatment of infected patients, and infection control. In the laboratory, the clinical microbiologist takes part in the daily diagnostic work, partly to be informed about patients and partly to supervise the work performed by technicians. On the basis of the bacteriological test results, the microbiologist will advise the clinicians how to treat patients with antibiotics. This may be done by telephone contact, by visits to the wards, or by participation in weekly clinical conferences. Clinical contacts will provide the microbiologist with important knowledge about the patients, from whom samples are being taken. This knowledge may be of great value for the laboratory, because many bacteriological test results require some information about the patient in order to be interpreted correctly.

Screening for multi-resistant organisms

In hospitals where the prevalence of MRSA and other multi-resistant organisms is low, it is

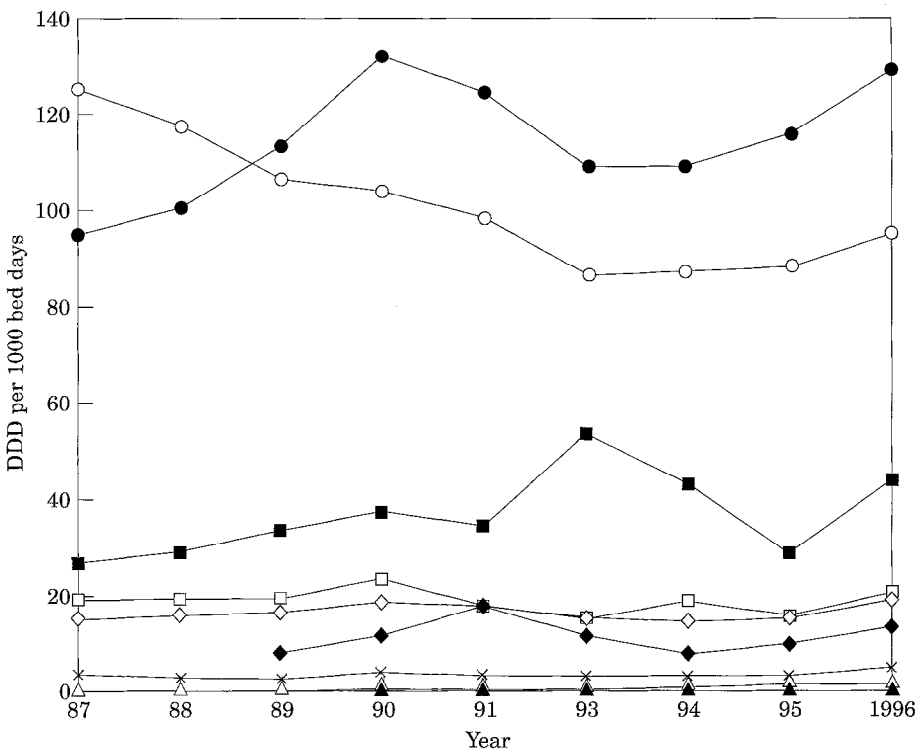

Figure 1 Consumption of antibiotics in Hvidovre Hospital 1987–1996, expressed in Defined Daily Doses (DDD) per 1000 bed days. Symbols: —●—, narrow-spectrum penicillins; —○—, broad-spectrum penicillins; —□—, cephalosporins; —▲—, carbapenems; —◇—, aminoglycosides; —◆—, fluoroquinolones; —■—, macrolides; —X—, tetracyclines; —△—, glycopeptides.

advantageous to isolate patients colonized or infected with such organisms in order to avoid transmission to other patients. In our hospital, the prevalence of resistant organisms is relatively low (see below), however, imported MRSA has previously given rise to great problems.[1] For nearly twenty years we have therefore isolated patients transferred to us from hospitals outside Scandinavia. On arrival, these patients are screened for MRSA and other multi-resistant organisms before being allowed to move freely in the hospital. Colonized patients will remain in isolation and be discharged as soon as possible. Isolation policies are the same for patients acquiring multi-resistant organisms while in our hospital. Originally this rather strict isolation policy was only practised with patients admitted to the burns unit with MRSA. However, gradually it has been extended to all patients, and the spectrum of organisms requiring isolation has also widened. Currently we isolate patients colonized or infected with: MRSA, vancomycin-resistant enterococci (VRE), gentamicin-resistant and extended spectrum beta-lactamase (ESBL)-producing *Enterobacteriaceae*, carbapenem- and gentamicin-resistant *Pseudomonas*, multi-resistant *Acinetobacter*, and penicillin-resistant pneumococci.

To implement and maintain such an isolation policy it is essential to have close contacts with the clinicians and keep them alert to current guidelines. Departments that seldom admit patients from abroad may be unaware of isolation policies, and even experienced departments may require daily consultations with the infection control team in order to maintain proper isolation regimens. The clinical units must have written guidelines on isolation practises at their disposal, which should be worked out in close collaboration with clinicians. This may be done in the infection control committee, where the clinical microbiologist meets together with the infection control nurse and relevant

Table IV *Frequency of acquired resistance characters in common pathogens isolated from all specimens of patients admitted to Hvidovre Hospital 1997*

Percentage resistance to:*	*Staphylococcus aureus*	*Streptococcus pneumoniae*	*Escherichia coli*	*Klebsiella*	*Pseudomonas aeruginosa*
Penicillin	87·3 (1120)	2·5† (400)	–	–	–
Methicillin/dicloxacillin	0·9 (1080)	–	–	–	–
Erthromycin	3·8 (1041)	1·5 (400)	–	–	–
Vancomycin	0·0 (1011)	–	–	–	–
Ampicillin	–	–	32·8 (2263)	–	–
Cefuroxime	–	0·3† (397)	1·7 (2078)	7·6 (551)	–
Ceftazidime	–	–	–	–	2·3 (217)
Gentamicin	0·7 (1086)	–	1·4 (2070)	3·6 (530)	3·2 (221)
Ciprofloxacin	–	–	1·3 (2001)	1·5 (532)	3·1 (225)

Each patient has only been included once. Numbers in brackets indicate the total number of patient-isolates examined.
* Susceptibility testing was performed with Rosco® tablets on Danish Blood Agar from Statens Serum Institut.
† Including intermediate sensitive strains.

clinicians, e.g. an infectious diseases physician and a surgeon.[2]

Detection of outbreaks

By clinical alertness, either from work in the laboratory or from contacts with clinicians, the microbiologist may contribute to the recognition of outbreaks of nosocomial infections. Clinical alertness in the laboratory is the most sensitive method for detection of outbreaks with unusual micro-organisms or micro-organisms with an unusual resistance pattern. A few cases is enough to recognize that something unusual is taking place. Table II lists outbreaks which were detected by clinical alertness in our laboratory and collaborating laboratories over the past ten years. Several of these have been described in detail elsewhere.[3–8]

Outbreaks due to commonly occurring micro-organisms may be difficult to detect by clinical alertness alone. A 10% increase in staphylococcal postoperative wound infections in an orthopaedic surgery department over a few months may easily go unnoticed, if the outbreak strain has no special phenotypic characteristics that makes it differ from the background population of staphylococci, e.g. a special resistance pattern ('you cannot see the wood for trees'). In such cases outbreak detection in the clinical microbiological laboratory will have to rely on periodic summaries of laboratory data. Tabulation of the frequency of isolation of particular hospital-acquired pathogens by anatomical site and hospital department may be very useful. Electronic laboratory systems have made it much easier to perform surveillance of nosocomial infections on the basis of microbiological test results. The main disadvantage of such surveillance programmes is that they are relatively slow to detect outbreaks. Due to the limited number of specimens received from individual departments, figures for different organisms can hardly be compared more frequently than at half-year intervals.[9]

Elucidation and containment of outbreaks requires close contact between the infection control team and the clinical departments involved. In collaboration with the clinical staff, plans must be made as to how to identify the source and the patients involved, and the efficacy of intervention has to be monitored.

Rational use of antibiotics in hospital

Misuse of antibiotics in hospitals is a major precipitating factor of nosocomial infections. Furthermore, a high consumption of antibiotics

may lead to selection and spread of multi-resistant organisms. A restrictive use of antibiotics is therefore an essential part of infection control in hospitals.

Experience shows that close personal contact between clinical microbiologists and clinicians in the daily treatment of patients with infections is the most efficient way to keep antibiotic consumption in hospitals at a low level. This close contact ensures a balanced prescription of antibiotics, taking into consideration both the patients' acute need for treatment and the long-term need for prevention of ecological side effects. Although clinical microbiologists only act as advisers to the clinicians, they may have great influence on prescribing decisions, partly because they are well known from their frequent visits to the wards, and partly because they have the same educational background as the clinicians (Table I).

Other important means to restrict antibiotic consumption are educational programmes, elaboration of guidelines, and audits. It is natural that the clinical microbiologist is in charge of this kind of work, which may be performed within the framework of the local hospital drug and therapeutics committee, where the clinical microbiologist should have seat. Audits may be a very useful tool for control of antibiotic consumption in hospital. This may be illustrated by the following example:

In 1995 we performed an audit of antibiotic prescribing in our hospital.[10] In brief it consisted of three elements:

(1) In close collaboration with our clinicians we worked out new guidelines in antibiotic prescribing covering the whole hospital. (The guidelines are available on the Internet at <http://www.hvidovre.hosp.dk/afdelinger.htm>)
(2) We held mini-courses in antibiotic prescribing for all newly appointed doctors and nurses once a month.
(3) We designed a special programme for the orthopaedic surgery department: on a given day every third month we registered all antibiotic prescriptions and compared them with the guidelines. All aberrant prescriptions were discussed with the clinicians at staff meetings held after each registration day.

The audit had significant impact on the consumption of antibiotics in the orthopaedic surgery department, as illustrated in Table III. Compared with the rest of the hospital, significant reductions were obtained for seven of the eight antibiotics listed. By contrast, we were unable to influence antibiotic consumption in the rest of the hospital, except for slight reductions in the consumption of cephalosporins and macrolides. The conclusion was that guidelines as such have little influence on antibiotic consumption. However, in combination with a periodic registration of prescriptions and feedback to the clinicians they may have significant effect. To be effective, education and audits must take place continuously, partly because young staff members often change positions and partly because good prescribing habits have a tendency to deteriorate over time.

The formulation and supervision of the antibiotic policy may take place in the hospital drug and therapeutics committee, of which the microbiologist is a member. In order to monitor compliance with recommended antibiotic guidelines it is essential for the drug and therapeutics committee to have access to data on antibiotic consumption for individual hospital departments. These data should be worked out yearly by the hospital pharmacy and be presented in defined daily doses (DDD) for each antimicrobial agent. On basis of these data and data on antimicrobial resistance, the clinical microbiologist may have discussions with the clinicians about their prescribing habits, and whether antibiotic recommendations need to be modified. Figure 1 shows the development in consumption of major groups of antibiotics in our hospital over the past ten years. Penicillins account for by far the greatest part of the consumption, whereas the consumption of cephalosporins and other newer broad-spectrum agents is still low. This consumption pattern has been stable for several years and mirrors the relatively low frequency of resistant organisms in our hospital, as illustrated in Table IV. The consumption of glycopeptides is very low, because there are very few MRSA, and the

consumption of carbapenems is negligible due to very few aminoglycoside-resistant or ESBL-producing Gram-negative rods. On the other hand, the frequency of ampicillin resistance in *E. coli* is high, probably because of the relatively high consumption of broad-spectrum penicillins.

Conclusion

The building up of local clinical microbiological laboratories has led to significant improvements in hospital infection control. The presence in hospitals of medically trained clinical microbiologists, who participate in patient treatment and work in close contact with clinicians, is probably one of the main reasons why many hospitals in Denmark have managed to keep the consumption of broad-spectrum antibiotics at a low level. Undoubtedly, this has prevented or delayed the spread of multi-resistant organisms and saved costs for treatment of hospital infections.

A drawback of many local microbiology laboratories is their relatively small size, which make them vulnerable to budget reductions in periods with shortage of resources for healthcare. After many years of decentralization there is now a trend in hospital management towards larger laboratory units. The main challenge for clinical microbiological departments in the coming years will be to meet the demands for efficiency engineering and the introduction of new expensive technology, without loosing their close clinical contact surface.

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