Microbial Surveillance in the Intensive Care Unit

S. Blot, P. Depuydt, K. Vandewoude

9.1 Introduction

Nosocomial infections occur approximately three to six times more frequently in patients admitted to ICUs than in patients residing in general wards [1]. The prevalence of nosocomial infection in critically ill patients is about 20%, depending on the type of admission diagnosis and underlying conditions predisposing to microbial colonization and infection [2]. Despite all the efforts taken in infection control, the incidence of nosocomial infection in ICUs has increased over the past 3 decades. There are several reasons for this trend. Together with the widespread use of invasive techniques disrupting the host’s anatomical barriers, more patients are receiving immunosuppressive therapy, decreasing humoral and cellular defense against microorganisms. And, thirdly, improved emergency and supportive care has resulted in better acute phase survival, but simultaneously has led to a growing number of long-term ICU residents. All these factors result in a pool of patients extremely vulnerable to nosocomial infection, grouped in units with a high workload and a degree of urgency which results in a suboptimal compliance with standard infection control measures.

Along with the threat of nosocomial infection goes the emergence of antimicrobial resistance [3]. Over time, for most bacterial species, sensitive strains have been replaced by resistant ones, and the patterns of resistance have increased in complexity, often with geographic variability [4]. The onward march of antimicrobial resistance is a major challenge to the adequate treatment of infections in the ICU. Both infections and antimicrobial resistance negatively impact outcome through increased morbidity and mortality. The higher mortality in antimicrobial-resistant infection appears to be mainly due to an increased risk of inappropriate initial antimicrobial therapy, which has been identified as an important predictor for an unfavorable outcome in numerous recent studies [5–7]. Apart from this human cost, resistance imposes an increased health-economic burden due to the additional hospital stay and the higher cost of broad-spectrum antibiotics [8–11]. Several mechanisms are involved in the appearance and spread of multi-drug-resistant (MDR) organisms in the hospital and community. These include: (1) acquisition of resistance by a sensitive strain due to de novo mutation, genetic transfer or overt expression of resistance already present in the population; (2) differential selection of a resistant subpopulation; (3) introduction of a resistant organism in a previously sensitive population; and (4) horizontal transmission of an MDR strain in the hospital. Whereas the first and second mechanisms essentially are driven by selection pressure due to antibiotic use, the last two phenomena can be contained by imposing barrier precautions or the identification of a possible point source of contamination. Timely control of an endemic spread of MDR strains requires early detection by an efficacious microbial surveillance program [12]. As such, microbial ecology data both on a health care facility level (hospital or ICU) and on a larger (community) scale by microbial surveillance have gained importance both for effective treatment of infection and to avoid the advance of antimicrobial resistance.

9.2 Type and Aim of Surveillance Systems

Microbial surveillance in the ICU can be defined as the continual, systematic collection, analysis, and interpretation of microbiological data essential for the planning, implementation, and evaluation of infection control practice either on an individual or a unit level. Site-specific infection density rates can be calculated by using the number of patients at risk, total patient days, days of indwelling urinary catheterization, central venous catheter days, or days on mechanical ventilation. Trends in infection rates are important indicators of quality control and are often used for benchmarking. Microbial surveillance, however, has a larger scope than the – often post hoc – registration of infection rates. While the diagnosis of infection is based on microbiological sampling of clinically relevant sites (e.g., sputum, urine, wounds), examination of the colonization status should take into account nose, mouth and
perineum as reservoirs of potentially MDR bacteria. For example, sampling of nose and perineum is rarely significant for diagnosis of infection, but may be of particular value to detect epidemiologically important microorganisms such as, respectively, methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant enterococci (VRE) or multiresistant gram-negative strains. A surveillance system that takes into consideration colonization as well as clinically indicated culture samples is a much more powerful tool for infection management and control. In addition to retrospective quality control, routine surveillance allows early detection of outbreaks with epidemiologically important microorganisms and provides data for the appropriate empirical antimicrobial therapy. Conceptually, this should contribute to better individual patient outcomes, as well as to a reduction in antimicrobial selection pressure by selection of agents with a judiciously targeted spectrum of activity. In this chapter the focus is on microbial surveillance and how it can benefit clinical practice, on top of the mere registration of infections.

Three major purposes can be recognized for microbial surveillance in the ICU. Firstly, surveillance is a cornerstone in infection control. Secondly, it can be used to control antimicrobial prescription patterns and therefore as a tool to limit the emergence of resistance. Finally, surveillance cultures can be used to guide empirical antimicrobial therapy. An up-to-date knowledge of locally prevailing antimicrobial drug resistance is an essential prerequisite for an appropriate initial antibiotic selection. Whether surveillance aiming at the colonization status of the individual patient can be used for the individual tailoring of the empirical therapy remains controversial. As the first two objectives are generally accepted and implemented, these are briefly discussed, while more attention is given to the value of surveillance cultures in optimizing empirical therapy.

9.2.1 Active Surveillance To Steer Infection Control

In the hospital, microbial surveillance is a potentially useful tool in tackling the problem of infection caused by MDR bacteria at different levels.

Firstly, microbial surveillance programs to detect contamination of hospital equipment, such as the presence of *Pseudomonas or Legionella* species in an aqueous environment (ventilator circuits, tap water, aerosols), should allow early control of this iatrogenic source of infection.

Secondly, microbial surveillance is helpful in the early detection of outbreaks of infection caused by MDR bacteria, after which barrier precautions can be rapidly implemented to limit further spread. The success of this strategy depends both on the quality of the surveillance (i.e., number and sensitivity of surveillance cultures) and on the mechanisms of dispersal of resistance. Thus, MDR pathogens, for which horizontal transmission is the main contributing factor of dissemination, are most likely to be controlled by this strategy. Examples of these are MRSA, *Candida* species and VRE. In contrast, multi-drug resistance acquired by expression of drug resistance coding genes widely dispersed within a microbial species is more likely to be contained by measures aimed to reduce selection pressure by antibiotic restriction. An example is carbapenem resistance in *Acinetobacter* species through expression of carbapenemases [13]. Control of MRSA serves as the best known example of the application of microbial surveillance guiding barrier precautions to dam dispersal [14–17]. It should be noted, however, that several authors reported failure of this strategy to control nosocomial spread of MRSA [18, 19], while others reported relapsing rates of spread after cessation of intensive surveillance [20], and only limited data exist on long-term control in endemic settings. A “search and destroy” strategy, consisting of searches for MRSA carriers coupled with attempts at decolonization, e.g., by applying nasal mupirocin, is the subject of ongoing controversy [21].

It has become apparent that endemicity for MDR strains such as MRSA in the hospital environment is maintained to a certain extent by a steady influx of colonized patients (the infection often previously acquired in health care related settings). In such endemic settings, screening at admission should be considered in patients referred from other hospitals or long-term care facilities, or after previous exposure to antibiotics in patients referred from other hospitals or long-term care facilities, or after previous exposure to antibiotics such as fluoroquinolones, which are known risk factors for harbouring MDR strains [22]. Early identification of colonization by MRSA could allow prevention of spread in the hospital by strict barrier precautions. On a larger scale, countries with a very low to sporadic prevalence of MRSA, such as the Netherlands and Denmark, so far seem to have effectively used screening of patients referred from abroad as a barrier to keep the MRSA problem outside their hospitals.

Similarly and more recently, VRE infection control has received considerable attention, with several studies highlighting the potential as well as the limitations of microbial surveillance guided barrier precautions in containing VRE dissemination. For example, a new occurrence of VRE in an Italian ICU invoked an active surveillance program directing the intensification of infection control measures with successful control of further dispersal [23]. Even when endemicity has been established, an active surveillance program combined with contact precautions has been shown to effectively limit spread of VRE [24]. It should be noticed that the great majority of patients colonized with VRE are detected by surveillance cultures and go undetected by