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Epidemiology and Control of Urinary Tract Infections in Intensive Care Patients

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1. Introduction

Healthcare-associated infections (HAIs) are one of the most common complications in hospitalized patients, leading to increased hospitalization, morbidity and mortality and associated with additional costs (Geffers and Gastmeier, 2011).

Urinary tract infection (UTI) is common in hospitalized patients. It has been reported that in U.S. hospitals, among adults and children outside of the intensive care units (ICUs), the urinary tract is the most common site of HAI, accounting for 36% of infections, followed by surgical site infections (20%), bloodstream infections and pneumonia (11%, each) and other infection types (all 22%) (Klevens et al., 2007).

Almost all healthcare-associated UTIs are caused by instrumental urinary tract procedures. In fact, the presence of a foreign body in the urinary tract predisposes the patient to UTI and alters the body's ability to eradicate bacteria (Gray et al., 2010). It has been estimated that more than 80% of UTIs are associated with an indwelling catheter (Anderson et al., 2007) and notably, catheter-associated UTI (CAUTI) has been related with such complications that prolonged hospital stay, and increased cost, morbidity and mortality (Gould et al., 2009).

Urologic patients should be considered at high risk for a healthcare-associated UTI, because they are usually exposed both to urethral catheterization and instrumentation of the urinary tract. In a surveillance study conducted in an urologic clinic of an Italian university hospital the incidence of symptomatic UTIs was 1.4 per 1000 patient-days (Agodi et al., 2007).

1.1 Epidemiology of UTI in intensive care units

Since of intrinsic (such as, severity of illness or impaired immunity) and extrinsic (such as, devise exposure: mechanical ventilation, urinary and central line catheterization) risk factors, patients admitted in ICUs are at high risk of HAIs (Lambert et al., 2011). Particularly, in Europe, the *Annual Epidemiological Report on Communicable Diseases in Europe* of the European Centre for Disease Prevention and Control (ECDC, 2009), show that 3% of patients staying more than two days in ICUs, acquire bloodstream infections, and 6.2% of patients acquire pneumonia.

UTI is one of the most common infection in ICU. The mean incidence density of UTI in patients admitted in European ICUs is 5.4 UTI episodes per 1000 patient-days. The majority of UTI (96.2%) are associated with the use of a urinary catheter (HELICS, 2005), that is the most important risk factor for development of UTI (Meddings et al., 2010). It has been reported that about 15% - 25% of patients may be exposed to short-term indwelling urinary catheters (Warren JW, 2001) and in several cases, catheters are placed for inappropriate indications. Urinary catheters are used frequently in ICUs for correct monitoring of urinary output, but, once inserted, catheters tend to remain in place until appropriate indications for their use end and thus CAUTI incidence increases as the duration of catheter use increases. Use of urinary catheters in the ICU causes breaches in the mucosa or may provide a surface for colonization, thus, increasing the incidence of CAUTI. The risk for infection is at least 5% per day of catheterization (Tissot et al., 2001; Elpern et al., 2009).

Other factors have been reported as potential risk factors for CAUTI including constitutional factors such as female gender, pregnancy and older age and potential modifiable factors such as poor nutrition, fecal incontinence, use of systemic antibiotics, severity of illness, impaired immune system function, and elevated creatinine level (Gray, 2010).

A recent multicenter study was conducted in a cohort of patients from 10 countries (Argentina, Brazil, Colombia, Greece, India, Lebanon, Mexico, Morocco, Peru, and Turkey) to estimate the excess length of stay (LOS) and mortality in ICU due to CAUTI. Results show that CAUTI lead to a small increase LOS in ICU, particularly, prolonging length of ICU stay by an average of 1.59 days, but CAUTI increase the risk of death by 15% (Rosenthal et al., 2011).

Thus, it is necessary to implement every possible preventive measure that have proven useful in the prevention of CAUTI.

Furthermore, UTIs are often underdiagnosed due the lack of physician requesting systematic laboratory tests and urine cultures (Agodi et al., 2007). Diagnosis, particularly in the ICU setting, is very difficult, as asymptomatic bacteriuria may be hard to be differentiated from symptomatic UTI (Shuman and Chenoweth, 2010).

The National Healthcare Safety Network (NHSN) is a system for the surveillance of HAI that aggregates data of surveillance, reported by hospitals participating in the network, into a single national database (Edwards et al., 2007). In the framework of the "Patient Safety component" of the NHSN, data are collected using standardized methods and definitions and are grouped into specific module protocols. Particularly, in the device-associated module infection control professionals collect data on CAUTIs that occur in patients staying in a patient care location such as an ICU, specialty care area, or ward. Indicators are calculated in terms of urinary catheter associated infection rate and urinary catheter utilization ratio (Table 1).

Indicator	
Urinary catheter associated infection rate	$\dfrac{\text{Number of urinary catheter-associated UTI}}{\text{Number of urinary catheter-days}} \times 1000$
Urinary catheter utilization ratio	$\dfrac{\text{Number of urinary catheter-days}}{\text{Number of patient-days}}$

Table 1. Calculation of urinary catheter-associated infection rate and urinary catheter utilization ratio.

The NHSN reports that in 2006 pooled mean urinary catheter utilization ratios in ICU and non-ICU wards ranged from 0.23 in inpatient medical/surgical ward to 0.91 in trauma ICU. The pooled mean of CAUTI rates ranged from 3.1 infections per 1000 catheter-days in medical/surgical ICU to 7.5 infections per 1000 catheter-days in burn ICUs.

In Europe, the German National Reference Centre for surveillance of nosocomial infections was started in 1997 creating a nationwide surveillance system: the Krankenhaus Infektions Surveillance System (KISS) (Gastmeier et al., 2008). The surveillance methods of the National Nosocomial Infections Surveillance (NNIS) System (Garner et al. 1988; Emori et al., 1991) were used and for diagnosing HAIs the definitions of the CDC were adopted. Surveillance data obtained from January 2005 to December 2009 in German ICUs, report an urinary catheter utilization ratio of 0.81 and a CAUTI rate of 1.97 per 1000 device-days (Geffers and Gastmeier, 2011).

1.2 Case definitions of UTI

Major challenges in appraising the quality of evidence in the CAUTI literature are represented by the limitations due to heterogeneity of definitions of UTI used in various published studies. Researchers have often used numerous different definitions for UTI, ranging from simple bacteriuria to symptomatic infection defined by combinations of bacteriuria and various signs and symptoms. Furthermore, the heterogeneity of definitions may reduce the quality of evidence for a given intervention and often precludes meta-analyses (Gould et al., 2009).

Case definition of UTI proposed by the Hospitals in Europe Link for Infection Control through Surveillance (HELICS) system is reported in Table 2 (HELICS-ICU, 2004). Particularly, in the HELICS protocol three different types of UTIs are identified and defined: microbiologically confirmed symptomatic UTI (UTI-A), not microbiologically confirmed symptomatic UTI (UTI-B) and asymptomatic bacteriuria (UTI-C) (HELICS-ICU, 2004). Of note is that UTIs may be added or not, optionally, in the HELICS protocol surveillance.

The case definitions of UTI by the HELICS are similar to the case definition by the Centers for Disease Control and Prevention/National Healthcare Safety Network (CDC/NHSN) (NHSN Manual; Horan et al., 2008), where CAUTIs are classified into two groups with specific sets of criteria for each: symptomatic urinary tract infections (SUTI) and asymptomatic bacteriuria (ASB). The only difference is that, in the HELICS, asymptomatic bacteriuria is defined as the subcategory UTI-C, and not as a separate category. Otherwise, the subcategories UTI-A and UTI-B are the same as respectively criterion 1 and 2 of the CDC/NHSN definition of symptomatic urinary tract infection. NHSN in January 2009 has revised the UTI definition criteria. Among the changes are removal of the ASB criterion and refinement of the criteria for defining symptomatic SUTI. The time period for follow-up surveillance after catheter removal also has been shortened from 7 days to 48 hours to align with other device-associated infections (NHSN Manual).

1.3 Pathogenesis of UTIs

Microorganisms causing CAUTI can be acquired by an endogenous source (such as, via meatal, rectal, or vaginal colonization) or an exogenous one (such as, via contaminated hands of healthcare personnel or devices).

UTI-A: **microbiologically confirmed symptomatic UTI**	Patient has at least one of the following signs of symptoms with no other recognized cause: - Fever (>38°C) - Urgency - Frequency - Dysuria - Suprapubic tenderness and Patient has a positive urine culture (≥ 10^5 microorganisms per ml of urine) with no more than two species of microorganisms
UTI-B: **not microbiologically confirmed symptomatic UTI**	Patient has at least two of the following with no other recognized cause: - Fever (>38°C) - Urgency - Frequency - Dysuria - Suprapubic tenderness and, at least one of the following: - Positive dipstick for leukocyte esterase and/or nitrate - Pyuria urine specimen with ≥10 WBC/ml or ≥ 3 WBC/high-power field of unspun urine - Organisms seen on Gram stain of unspun urine - At least two urine cultures with repeated isolation of the same uropathogen (gram-negative bacteria or *S. saprophyticus*) with ≥ 10^2 colonies/ml urine in nonvoided specimens ≤10^5 colonies/ml of a single uropathogen (gram-negative bacteria or *S. saprophyticus*) in a patient being treated with effective antimicrobial agent for a urinary infection - Physician diagnosis of a urinary tract infection - Physician institutes appropriate therapy for a urinary - infection
UTI-C: **asymptomatic bacteriuria**	Patient has no fever (>38°C), urgency, frequency, dysuria, or suprapubic tenderness and either of the following criteria: 1. Patient has had an indwelling urinary catheter within 7 days before urine is cultured and Patient has a urine culture, that is, ≥10^5 microorganisms per ml of urine with no more than two species of microorganisms. 2. Patient has not had an indwelling urinary catheter within 7 days before the first positive culture and Patient has had at least two positive urine cultures ≥10^5 microorganisms per mm^3 of urine with repeated isolation of the same microorganism and no more than two species of microorganisms

Table 2. Case definition of Urinary Tract Infection (HELICS-ICU, 2004).

The NHSN reported that between 2006-2007, the most frequent pathogens associated with CAUTI were *Escherichia coli* (21.4%) and *Candida* spp. (21.0%), followed by *Enterococcus* spp. (14.9%), *Pseudomonas aeruginosa* (10.0%), *Klebsiella pneumoniae* (7.7%), and *Enterobacter* spp. (4.1%). A smaller proportion of CAUTI was caused by other gram-negative bacteria or by *Staphylococcus* spp. (Hidron et al., 2008).

Finally, it is important to underline that bacteriuria associated to CAUTI commonly leads to antimicrobial use, that would have been avoidable, as well as to urinary drainage systems that are often reservoirs for multidrug-resistant bacteria and a potential source of transmission to other patients (Gould et al., 2009).

As reported in the *Annual Epidemiological Report on Communicable Diseases in Europe* (ECDC, 2010), the antimicrobial resistance of microorganisms is to be considered the most important disease threat. In 2008 a Europe-wide increase of resistance to all antibiotic classes under surveillance was observed for the most common Gram-negative bacteria – *E. coli* - responsible for bacteraemia and UTIs.

1.4 Prevention of CAUTI

CAUTIs are generally considered an avoidable complication. It has been estimated that between 17% and 69% of all observed CAUTIs may be prevented by implementation of an evidence based prevention program that is particularly important in the ICU setting with a high prevalence of urinary catheterization and a high percentage of patients with comorbidities (Gould et al., 2009).

The CDC/Healthcare Infection Control Practices Advisory Committee (HICPAC) published a specific document - *Guideline for Prevention of Catheter-associated Urinary Tract Infections* – that addresses the prevention of CAUTI for patients with short- or long-term urinary catheterization admitted in any type of healthcare facility and evaluates the evidence for several options of methods of urinary drainage, including intermittent catheterization, external catheters, and suprapubic catheters (Gould et al., 2009). The guideline is based on a specific systematic review of the best available evidence on CAUTI prevention; it uses the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach (Atkins et al., 2004; Guyatt et al., 2008a; Guyatt et al. 2008b) in order to provide clear links between the available evidence and the resulting recommendations.

Particularly, in this document, recommendations include: i) appropriate urinary catheter use; ii) proper techniques for urinary catheter insertion; iii) proper techniques for urinary catheter maintenance; iv) quality improvement programs; v) administrative infrastructure; and vi) surveillance.

As suggested by the Authors of this guideline further research in order to prevent CAUTIs should focus on catheter materials (antimicrobial and antiseptic-impregnated catheters and standard catheters), appropriate urinary catheter use (in incontinent patients and appropriate indications for continued use in postoperative patients), use of antiseptics (for periurethral cleaning prior to catheter insertion and to prevent CAUTI), alternatives to indwelling urethral catheters and bag drainage (suprapubic catheters, urethral catheters, use of catheter valves and other alternative methods of urinary drainage), optimal methods for preventing encrustation in long-term catheterized patients, other prevention measures and prevention of transmission of pathogens colonizing urinary drainage systems.

A specific recommendation for the appropriate urinary catheter use (category IB) is: "Minimize urinary catheter use and duration of use in all patients, particularly those at

higher risk for CAUTI or mortality from catheterization such as women, the elderly, and patients with impaired immunity" (Gould et al., 2009).

In this contest, a recent study (Elpern et al., 2009) has been conducted in a medical ICU in order to implement and evaluate the efficacy of an intervention, based on the decreasing use of urinary catheters, to reduce CAUTI. Results of this study report that the implementation of an intervention targeting the appropriate use of indwelling urinary catheters may result in a significant reduction in the duration of catheterization as well as in the occurrences of CAUTIs.

A systematic literature review and meta-analysis was performed to evaluate the effect of interventions that remind clinicians of the presence of urinary catheters to prompt the timely removal of catheters during hospitalization. Results of the meta-analysis report that the rate of CAUTI was significantly reduced by 52% with the use of a reminder or stop order. Furthermore, the mean duration of catheterization decreased by 37%. Thus, interventions to routinely prompt physicians or nurses to remove unnecessary urinary catheters appear to reduce the rate of CAUTI and should be strongly considered to enhance the safety of hospitalized patients (Medding et al., 2010).

The Institute for Health Care Improvement (IHI) developed the model of "bundles" to help health care workers more consistently deliver the best possible care for patients undergoing particular treatments (Institute for Health Care Improvement, 2006). "A bundle is a structured way of improving the processes of care and patient outcomes: a small, straightforward set of evidence-based practices — generally three to five — that, when performed collectively and reliably, have been proven to improve patient outcomes" (Resar et al., 2005).

A recent observational study (Venkatram et al., 2010) was conducted in order to study the effect of bundle strategies on the device use adjusted rate of HAI in adult medical ICU, to prevent HAIs associated with endovascular catheters, mechanical ventilation, and urinary tract catheters. Particularly, the UTI bundle regards the use of antimicrobial catheters, closed drainage systems, and daily assessment for removal. During the study period, HAIs declined from 47 in 2004 to 3 in 2007. Particularly, CAUTI decreased from 6.23 to 0.63 per 1000 device-days. However, the decline in infection rates cannot be accounted by the decline in device use by itself, in fact, when adjusted to device use, the decrease in HAI rates still showed statistical significance. Therefore, it is not easy to attribute this decline to any one component of the bundle. Results of this study demonstrate that best practices using a multidisciplinary bundle strategy including device use can lead to optimal outcomes with respect to HCAI rates.

2. Surveillance of urinary tract infections in ICUs

Epidemiologic surveillance of HAI in ICUs is an important tool of internal quality management in the hospital setting (Zuschneid et al., 2010), and together with appropriate infection control activities, can decrease infection rates significantly (Haley et al., 1985).

A specific recommendation, of category II, included in the CDC/HICPAC *Guideline for Prevention of Catheter-associated Urinary Tract Infections* is: "Consider surveillance for CAUTI when indicated by facility-based risk assessment". Particularly, it is recommended to identify the patient groups or units on which to conduct surveillance based on frequency of catheter use and potential risk of CAUTI and to use standardized methodology for

performing CAUTI surveillance (Category IB). Furthermore, providing regular feedback of CAUTI rates to the staff should be also considered (Gould et al., 2009).

In order to explore the epidemiologic *scenario* and control of UTIs in intensive care patients, surveillance of HAI was performed on three Sicilian ICUs participating in the first two edition of the SPIN-UTI (Sorveglianza Prospettica delle Infezioni Nosocomiali nelle Unità di Terapia Intensiva) project.

2.1 Methods of surveillance

The Italian Nosocomial Infections Surveillance in ICUs, SPIN-UTI project, established in Italy by the Italian Study Group of Hospital Hygiene (GISIO) of the Italian Society of Hygiene, Preventive Medicine and Public Health (SItI) (Agodi et al., 2010), started the first edition in 2006 - 2007, the second edition of the project was implemented in 2008 – 2009, and the third, in 2010 – 2011 is in progress.

The methodology of surveillance are describes in great details elsewhere (Agodi et al., 2010) and is based on the HELICS-ICU protocol, in order to participate in the European benchmark (HELICS-ICU, 2004; Suetens et al., 2007). The enrollment of patients was prospective, and data regarding ICU stay, patient's risk factors including exposure to invasive devices (such as intubation, central venous catheter and urinary catheter), were collected using a web-based data collection procedure for each patient staying longer than two days in the ICU (Figure 1).

The definitions of HAI used in the SPIN-UTI project are the same proposed by the HELICS-ICU protocol for pneumonia, bloodstream infections (BSIs), central venous catheter-related bloodstream infections (CRIs) and UTIs (HELICS-ICU, 2004; Suetens et al., 2007). UTI data collection was mandatory.

The indicators included cumulative incidence and, to adjust for length of stay, incidence density. Furthermore, device-associated infection rates and device utilization ratios were also calculated as the number of infections per 1000 device-days and the number of days with the device divided for the number of patient-days.

2.2 Web-based data collection and statistical analysis

Surveillance data collection was performed from all patients enrolled in the project using four electronic data forms – designed using SPSS "Data Entry Enterprise Server" - as instruments for data collection. Particularly, the following data forms were used: 1) 'Characteristics of hospital and of ICU', 2) 'Patient', 3) 'Infection' and 4) 'Microorganism' (Figure 1). The electronic forms were characterized by functional instruments. Using these electronic forms data are entered via Web and each record is sent to the server, where it is automatically routed to the appropriate database. Cleaning and analyses were performed using SPSS for Windows (version 14.0): univariate analyses and the above reported indicators were calculated. Furthermore, categorical variables were compared using the chi-square-test, and continuous variables by Student's t-test; $p < 0.05$ was considered statistical significant.

3. Results of surveillance

3.1 ICU setting

The study was conducted at three Sicilian ICUs participating in the first two edition of the SPIN-UTI Project. The ICU identified as ICU 1 is a 12-bed interdisciplinary ICU, from a 700-bed acute care hospital; the ICU identified as ICU 2 is a 7-bed interdisciplinary ICU, from a
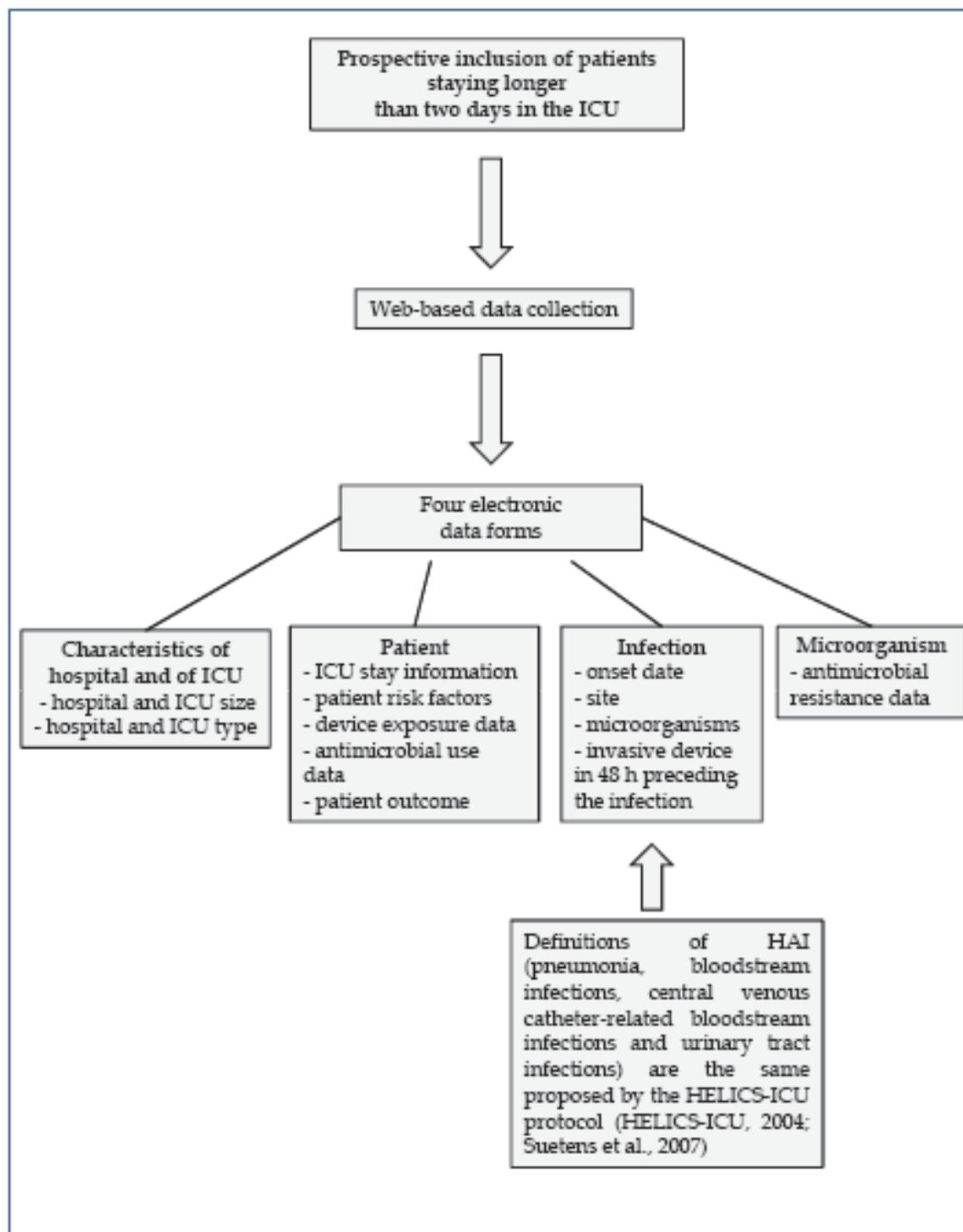
Fig. 1. Methods of Surveillance and web-based data collection.

830-bed tertiary care hospital; the ICU identified as ICU 3 is a 6-bed interdisciplinary ICU, from a 200-bed tertiary care hospital.

3.2 Patient's characteristics and device usage

A total of 501 patients with length of stay >2 days, for a total of 9681 patient-days, were admitted in the three ICUs during the two edition of the SPIN-UTI project and thus were enrolled in the study. A summary of patient characteristics and urinary catheter use is shown in Table 3.

Characteristic	ICU 1		ICU 2		ICU 3		Total	
	(2006-07)	(2008-09)	(2006-07)	(2008-09)	(2006-07)	(2008-09)	(2006-07)	(2008-09)
Number of patients	133	80	103	91	44	50	280	221
Mean age in years (range)	54.4 (5-94)	59,3 (22-92)	65.8 (2-94)	62,6 (1-97)	64.7 (19-87)	62,9 (13-87)	60.2 (2-94)	61.5 (1-97)
Male (%)	59.8	53,8	53.5	56	43.2	46	54.9	52.9
Mean SAPS II score (range)	41.85 (6-98)	51,58 (16-87)	31.38 (5-64)	27,41 (6-62)	34.06 (9-68)	43,80 (7-114)	37.37 (5-98)	40.84 (6-114)
Mean length of stay in days (range)	12.92 (3-65)	30,23 (6-106)	13.86 (3-79)	26,71 (3-120)	10.55 (3-57)	24,42 (3-84)	12.9 (3-79)	27.47 (3-120)
Total length of stay in ICU (in days)	1719	1598	1428	1335	464	736	3611	3669
Urinary catheter (%)	127 (95.5)	60 (75.0)	102 (99.0)	75 (82.4)	41 (93.2)	36 (72.0)	270 (96.4)	171 (77.4)
Total length of urinary catheterization (in days)	1576	1565	1269	1297	412	713	3257	3575
Mean length of urinary catheter in days (range)	12.5 (1-65)	19.8 (3-106)	12.6 (1-79)	14.3 (3-87)	10.1 (1-58)	14.9 (3-78)	12.2 (1-79)	16.4 (3-106)
Urinary catheter utilization ratios	0.92	0.97	0.89	0.97	0.89	0.97	0.90	0.97

Table 3. Main characteristics of patients included in the study.

Particularly, in the first edition of the project a total of 280 patients for a total of 3611 patient-days and a total of 221 patients for a total of 3669 patient-days in the second edition, were admitted. During the two edition of the project, a significant reduction of the proportion of patients with urinary catheter was observed (chi-square test, p <0.05). Particularly, in the first edition the overall proportion of patients with urinary catheter was 96.4% (range: 93.2%

- 99.0%) and in the second edition was 77.4% (range: 72.0 – 82.4%). Furthermore, in the first edition the total length of urinary catheterization was 3257 days (mean: 12.2 days; range: 1-79) and increased significantly (comparison between means, Student's t test, p <0.05), in the second edition where was 3575 days (mean 16.4 days; range: 3-106 days).

Considering all three ICUs, an increase of urinary catheter utilization ratio, from 0.90 to 0.97, was observed in the second edition of the project.

3.3 Infection's indicators

Table 4 reports infection's indicators. Considering all ICUs, in the first edition of the SPIN-UTI project, the most frequently reported ICU-acquired infection type was pneumonia (38.2%) followed by bloodstream infections (30.9%), urinary tract infections (20.9%) and central venous catheter-related bloodstream infections (10.0%). In the second edition, the most frequently reported ICU-acquired infection type was bloodstream infections (43.7%) followed by urinary tract infections (29.1%), pneumonia (23.2%) and central venous catheter-related bloodstream infections (4.0%). Thus, in the last edition of the SPIN-UTI project an increase of the proportion of infections due to bloodstream infections and to urinary tract infections were registered, both considering all ICUs and each ICU separately. Instead, a decrease of the proportion of infections due to pneumonia infections and to central venous catheter-related bloodstream infections were registered, both considering all ICUs and each ICU separately.

The risk of ICU-acquired infections for all sites was estimated by computing the cumulative incidence: 39.3 per 100 patients in the first edition and 68.3 per 100 patients in the second one; and the incidence density: 30.5 per 1000 patient-days in the first edition and 41.2 per 1000 patient-days in the second one. Particularly, the cumulative incidence and the incidence density of UTI were increased in the second edition compared with the first one (Table 4).

Notably, in the two edition of the project, all UTIs were related to the presence of urinary catheter.

Urinary catheter-associated UTI rates (i.e. the number of urinary catheter-associated UTI per 1000 urinary catheter-days) was 7.1 per 1000 urinary catheter-days in the first edition and 12.3 per 1000 urinary catheter-days in the second edition.

3.4 Microorganisms associated to HAI

Considering all infection sites, relative frequencies of the five most common isolated microorganisms in ICU-acquired infections are reported in Table 5.

Despite difference among ICUs (data not shown), in the first edition of the SPIN-UTI project, the most frequently reported microorganism associated with ICU-acquired infections overall was *P. aeruginosa* (18.1%), followed by *Acinetobacter baumannii* (15.5%), *S. epidermidis* (14.7%), *K. pneumoniae* (7.8%) and *E. coli* (6.9%). In the second edition *A. baumannii* became the most frequently reported microorganism (20.3%), followed by *K. pneumoniae* (15.8%), *P. aeruginosa* (12.4%), *S. epidermidis* (6.8%) and *E. coli* (4.5%).

Considering only UTIs, in the first edition of the SPIN-UTI project, the reported microorganism overall were *P. aeruginosa* (30.8%), followed by *A. baumannii* and *Escherichia coli* (15.4%, each), *K. pneumoniae* (11.5%), *Candida albicans, Candida tropicalis* and *Enterobacter cloacae* (11.5%, each) and *Enterococcus* spp. (3.8%). In the second edition *K. pneumoniae* became the most frequently reported microorganism (22.2%), followed by *E. coli* and *P. aeruginosa* (13.3%), *Enterococcus faecalis* (11.1%), *A. baumannii* and *Candida glabrata* (8.9%, each) and *C. albicans* (6.7%) (Table 6).

	ICU 1		ICU 2		ICU 3		Total	
	(2006-07)	(2008-09)	(2006-07)	(2008-09)	(2006-07)	(2008-09)	(2006-07)	(2008-09)
Total number of infections	54	86	52	52	4	13	110	151
Total number of UTI (%)	10 (18.5)	18 (20.9)	13 (25.0)	22 (42.3)	0	4 (30.8)	23 (20.9)	44 (29.1)
Total number of Pneumonia (%)	24 (44.4)	29 (33.7)	16 (30.8)	5 (9.6)	2 (50.0)	1 (7.7)	42 (38.2)	35 (23.2)
Total number of CRI (%)	11 (20.4)	6 (7.0)	0	0	0	0	11 (10.0)	6 (4.0)
Total number of BSI (%)	9 (16.7)	33 (38.4)	23 (44.2)	25 (48.1)	2 (50.0)	8 (61.5)	34 (30.9)	66 (43.7)
Total length of stay in ICU (in days)	1719	1598	1428	1335	464	736	3611	3669
Cumulative incidence of infection (all sites) (/100 patients)	40.6	107.5	50.5	57.1	9.1	26.0	39.3	68.3
Incidence density of infection (all sites) (/1000 patient-days)	31.4	53.8	36.4	39.0	8.6	17.7	30.5	41.2
Cumulative incidence of UTI (/100 patients)	7.5	22.5	12.6	24.2	0	8.0	8.2	19.9
Incidence density of UTI (/1000 patient-days)	5.8	11.3	9.1	16.5	0	5.4	6.4	12.0
Cumulative incidence of Pneumonia (/100 patients)	18.0	36.3	15.5	5.5	4.5	2	15.0	15.8
Incidence density of Pneumonia (/1000 patient-days)	14.0	18.1	11.2	3.7	4.3	1.4	11.6	9.5
Cumulative incidence of CRI (/100 patients)	8.3	7.5	0	0	0	0	3.9	2.7
Incidence density of CRI (/1000 patient-days)	6.4	3.8	0	0	0	0	3.0	1.6
Cumulative incidence of BSI (/100 patients)	6.8	41.2	22.3	27.5	4.5	16.0	12.1	29.9
Incidence density of BSI (/1000 patient-days)	5.2	20.7	16.1	18.7	4.3	10.9	9.4	18.0

Table 4. Infection's indicators in the three ICUs.

	All ICUs (all infection types)	
	(2006-07)	**(2008-09)**
1st microorganism (n; %)	*P. aeruginosa* (21; 18.1)	*A. baumannii* (36; 20.3)
2nd microorganism (n; %)	*A. baumannii* (18; 15.5)	*K. pneumoniae* (28; 15.8)
3rd microorganism (n; %)	*S. epidermidis* (17; 14.7)	*P. aeruginosa* (22; 12.4)
4th microorganism (n; %)	*K. pneumoniae* (9; 7.8)	*S. epidermidis* (12; 6.8)
5th microorganism (n; %)	*E. coli* (8; 6.9)	*E. coli* (8; 4.5)

Table 5. Relative frequencies of the five most common isolated microorganisms in ICU-acquired infections.

All ICUs (only UTIs: n; %)	
(2006-07)	**(2008-09)**
P. aeruginosa (8; 30.8)	*K. pneumoniae* (10; 22.2)
E. coli and *A. baumannii* (4; 15.4, each)	*E. coli* and *P. aeruginosa* (6; 13.3, each)
K. pneumoniae (3; 11.5)	*E. faecalis* (5; 11.1)
C. albicans, C. tropicalis, E. cloacae (2; 7.7, each)	*A. baumannii* and *C. glabrata* (4; 8.9, each)
Enterococcus spp. (1; 3.8)	*C. albicans* (8; 6.7)

Table 6. Relative frequencies of the isolated microorganisms in UTIs.

4. Discussion

In several high-income countries, device-associated HAI surveillance in the ICU plays a considerable role in hospital infection control and quality assurance (Edwards et al., 2009).

A recent study was performed in the framework of the German KISS with the aim of investigating whether surveillance of CAUTI in ICUs leads to reduced infection rates. When comparing the symptomatic CAUTI rates in the third and first years of the surveillance, a significant reduction in CAUTI was shown. However, before-and-after studies are limited by confounding variables such as the difficulties of ICU patients in recognizing and reporting UTI symptoms, that leads to the availability of microbiological reports as a major criterion for diagnosing symptomatic UTI. Thus, in the case of CAUTI diagnosis, microbiological reports may have decreased over time and have influenced reduction of CAUTI rates (Gastmeier et al., 2011).

In the same study, it has been reported that the overall surveillance effect was highest for ventilator-associated pneumonia and central venous catheter bloodstream infection. This could be explained by the perception of the clinicians that ventilator-associated pneumonia and central venous catheter bloodstream infection are more serious infections demanding more effective responses rather than CAUTI. However, CAUTI may also lead to sepsis, and changes in CAUTI rate over time, with consistent microbiology diagnostic procedures, may lead to the introduction of appropriate infection control measures (Gastmeier et al., 2011).

The SPIN-UTI project was implemented to create a HAI surveillance network of Italian ICUs (Agodi et al., 2010). The validation study of the SPIN-UTI project has showed a high sensitivity, specificity, and positive and negative predictive values of surveillance data (Masia et al., 2010).

Comparison of results of the two editions of the SPIN-UTI project revealed that, the risk of ICU-acquired infections for all sites, estimated by computing the cumulative incidence and the incidence density, increased in the second edition compared to the first one.

Differences were presented considering infection by site. In the second edition of the project a decrease of the proportion of infections due to pneumonia and to CRIs were registered. On the contrary, an increase of the proportion of infections due to BSIs and to UTIs were observed, either considering all ICUs or each ICU separately. Particularly, after comparing results of the two studies, in the second edition a higher proportion of the patients acquired a UTI in ICU than in the first edition. The cumulative incidence of UTI increased from 8.2 per 100 patients to 19.9 per 100 patients. The incidence density also increased from 6.4 per 1000 patient-days to 12.0 per 1000 patient-days.

Hospital wide prevalence rates for indwelling catheterization vary from 25% to 35% (Haley et al., 1981; Junkin & Selekof, 2007). Prevalence rates in ICU are substantially higher at 67% to 76% (Huang et al., 2004; Gray, 2010). In our study, a high proportion of patients were with urinary catheter (range: 72.0%- 99.0%), and although a significant reduction of the proportion of exposed patients was observed in the second edition of the project an increase of the mean length of urinary catheterization from 12.2 days to 16.4 days was observed. Furthermore, urinary catheter utilization ratio was significantly higher in the second edition compared with the first edition (from 0.90 to 0.97).

Notably, in the two edition of the project, all UTIs were related to the presence of urinary catheter. Urinary catheter-associated UTI rates increased from 7.1 per 1000 urinary catheter days in the first edition and 12.3 per 1000 urinary catheter days in the second edition.

It is advised that device-associated infection rates and device utilization ratios should be examined together so that preventive measures may be appropriately targeted. Since urinary catheter use is a significant risk factor for UTI, efforts must be redirected to reducing their use or limiting the duration with which they are used and to addressing the best consensus guidelines and recommendations in their insertion and maintenance (Edwards et al., 2007). In fact, it has been reported that targeted strategies for prevention of UTI include limiting the use and duration of urinary catheterization, using aseptic technique for catheter insertion, and adhering to proper catheter care (Shuman and Chenoweth, 2010).

The most frequently isolated microorganisms causing CAUTI in the ICU setting are enteric Gram-negative bacilli, enterococci, *Candida* species, and *P. aeruginosa* (Shuman and Chenoweth, 2010). Microorganisms are often multidrug resistant probably following the increasing use of broad-spectrum antibiotics in hospitals and this is a considerable problem in ICU.

In our surveillance survey, despite difference among ICUs, in the first edition of the project, the most frequently reported microorganism associated to UTI was *P. aeruginosa*, in the

second one, *K. pneumoniae* (22.2%) was the first species isolated. Notably, in the second edition an increase of *K. pneumoniae* isolation and a decrease of *P. aeruginosa* isolation were observed.

5. Conclusion

Our study represents a contribution to improve the quality of care in the ICU setting. A major item was identified for planning future intervention: focusing on the appropriate urinary catheter use. HAIs can be prevented by constant use of "bundles" of simple and effective measures, including the monitoring of device use, recommended by CDC and IHI (Institute for Health Care Improvement, 2006; Gould et al., 2009). To improve patient safety, an integrated, multimodal and comprehensive "bundles" approach is the means to reducing the impact of HAI.

6. Acknowledgements

7. References

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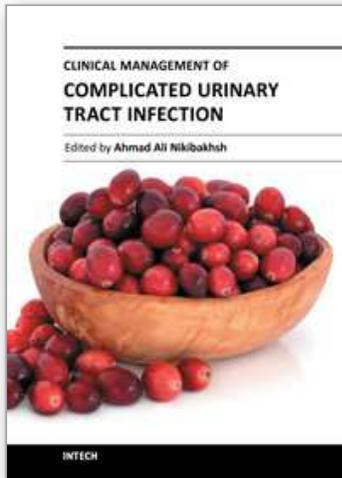
Clinical Management of Complicated Urinary Tract Infection

Edited by Dr. Ahmad Nikibakhsh

Complicated urinary tract infections (cUTIs) are a major cause of hospital admissions and are associated with significant morbidity and health care costs. Knowledge of baseline risk of urinary tract infection can help clinicians make informed diagnostic and therapeutic decisions. Prevalence rates of UTI vary by age, gender, race, and other predisposing risk factors. In this regard, this book provides comprehensive information on etiology, epidemiology, immunology, pathology, pathogenic mechanisms, symptomatology, investigation and management of urinary tract infection. Chapters cover common problems in urinary tract infection and put emphasis on the importance of making a correct clinical decision and choosing the appropriate therapeutic approach. Topics are organized to address all of the major complicated conditions frequently seen in urinary tract infection. The authors have paid particular attention to urological problems like the outcome of patients with vesicoureteric reflux, the factors affecting renal scarring, obstructive uropathy, voiding dysfunction and catheter associated problems. This book will be indispensable for all professionals involved in the medical care of patients with urinary tract infection.

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