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Adherence to European Association of Urology Guidelines on Prophylactic Antibiotics: An Important Step in Antimicrobial Stewardship

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Abstract

Background: The evolution of resistant pathogens is a worldwide health crisis and adherence to European Association of Urology (EAU) guidelines on antibiotic prophylaxis may be an important way to improve antibiotic stewardship and reduce patient harm and costs.

Objective: To evaluate the prevalence of antibiotic-resistant bacterial strains and health care costs during a period of adherence to EAU guidelines in a tertiary referral urologic institution.

Design, setting, and participants: A protocol for adherence to EAU guidelines for antibiotic prophylaxis for all urologic procedures was introduced in January 2011. Data for 3529 urologic procedures performed between January 2011 and December 2013 after protocol introduction were compared with data for 2619 procedures performed between January 2008 and December 2010 before protocol implementation. The prevalence of bacterial resistance and health care costs were compared between the two periods.

Outcome measurements and statistical analysis: The outcome measures were the proportion of resistant uropathogens and costs related to antibiotic consumption and symptomatic postoperative infection. We used χ^2 and Fisher's exact tests to test the significance of differences.

Results and limitations: The proportion of patients with symptomatic postoperative infection did not differ (180/3529 [5.1%] vs 117/2619 [4.5%]; $p = 0.27$). A total of 342 isolates from all patients with symptomatic postoperative infections were analysed. The rate of resistance of *Escherichia coli* to piperacillin/tazobactam (9.1% vs 5.4%; $p = 0.03$), gentamicin (18.3% vs 11.2%; $p = 0.02$), and ciprofloxacin (32.3% vs 19.1%; $p = 0.03$) decreased significantly after protocol introduction. The defined daily dose (DDD) use of ciprofloxacin fell from 4.2 to 0.2 DDD per 100 patient-days after implementation ($p < 0.001$). Antibiotic drug costs (€76 980 vs €36 700) and costs related to postoperative infections (€45 870 vs €29 560) decreased following introduction of the protocol ($p < 0.001$).

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Conclusions: Adherence to EAU guidelines on antibiotic prophylaxis reduced antibiotic usage without increasing post-operative infection rate and lowered the prevalence of resistant uropathogens.

Patient summary: We analysed the impact of adherence to European Association of Urology guidelines on antibiotic prophylaxis for all surgical urologic procedures on the prevalence of infections and resistant bacterial strains and on costs. We found that adherence to the guidelines reduced the rate of bacterial resistance, in particular against piperacillin/tazobactam, gentamicin, and ciprofloxacin, and reduced costs without increasing the risk of postoperative infection after urologic procedures. We recommend adherence to the guidelines as an important part of antibiotic stewardship programmes.

1. Introduction

Use of antibiotic prophylaxis before urologic surgical procedures is a recognised strategy to prevent postoperative infections [1]. However, prophylaxis use should be risk-adjusted according to the procedure to ensure that harms in terms of bacterial resistance in an individual and society do not outweigh the benefits [2,3]. The European Association of Urology (EAU) guidelines on urologic infections summarise evidence supporting the routine use of antibiotic prophylaxis for specific urologic procedures, and use the evidence to set out recommendations on whether or not to use preoperative prophylaxis for urologic procedures categorized according to risk categories for postoperative infection [2]. Adherence to the EAU guidelines is not universal, with considerable unwarranted variation among countries, regions, and types of hospital for preoperative prophylaxis and the agents used [3]. An additional problem is extended duration of antibiotic administration after a surgical procedure without any infective indication. This encourages the development of multidrug-resistant organisms, including strains resistant to newer agents [4], poorer clinical outcomes, and higher treatment costs [1,5]. A number of national and international governmental organizations have reported on the emerging threat of multiresistant bacteria, particularly for the main uropathogen, *Escherichia coli* [6]. To respond to this threat, a number of health care systems have instituted antibiotic stewardship programmes to promote appropriate use of antibiotics, improve patient outcomes, reduce microbial resistance, and decrease the spread of infections caused by multidrug-resistant organisms [7]. These programmes involve enforcement and monitoring of adherence to relevant evidence-based guidelines on antibiotic use, which can have patient benefits and can lead to significant cost reductions [8]. According to this evidence there is an urgent need for reappraisal of the use of antibiotic prophylaxis in each urology department. Against this background, with the hypothesis that introduction of an institutional policy of adherence to EAU guidelines would reduce the risk of emerging resistant bacteria and reduce costs without increasing the risk of postoperative infection, we investigated the following questions. Does adherence to EAU guidelines reduce antimicrobial resistance in uropathogens? Does adherence to EAU guidelines reduce costs related to antibiotic use and postoperative infection?

2. Patients and methods

2.1. Study design

In January 2011 a new departmental protocol for adherence to EAU guidelines on antibiotic prophylaxis was implemented in our institution. Before the protocol was initiated, an educational and training meeting for all urologists was held to demonstrate the protocol and ensure understanding regarding effective implementation. The EAU guideline used for this study was the version edited in 2010 [9]. An investigator (T.C.) performed monthly ward audits with a review of all patient charts to ensure adherence to the protocol among urologists. We prospectively collected all clinical and microbiological data including resistance patterns of implicated pathogens for all infectious complications in all patients undergoing surgical urologic procedures performed from January 2011 to December 2013. Similar data were retrospectively recorded from the clinical records for patients who underwent surgical urologic procedures between January 2008 and December 2010.

2.2. Study population and data collection

From January 2011 to December 2013, all patients attending our centre for surgical urologic procedures ($n = 3584$) were prospectively enrolled in the study. This cohort was compared with a cohort of patients treated ($n = 2698$) between January 2008 and December 2010, before the protocol was implemented.

2.3. Surgical antibiotic prophylaxis protocol

A midstream voided urine specimen was collected before hospital admission and a standard culture test was performed before starting prophylaxis. All patients with positive results for the urine culture were treated according to susceptibility testing and such patients were excluded from the analysis. After discharge all patients were monitored for 1 wk to evaluate all infectious complications related to the procedure after antibiotic prophylaxis. A 1-wk interval was chosen to increase the likelihood of capturing all infections only attributable to the surgical procedure, as events occurring later than 1 wk were deemed unlikely to be related to infection at the time of surgery [1]. All events were evaluated at the routine follow-up visit 30 d after discharge [1]. The resistance patterns of all isolated microorganisms were closely followed and empirical therapy was adjusted accordingly.

2.4. Study data collection

After implementation of the protocol, all data required were collected during the postoperative period by reviewing clinical records. Data items included date of birth, sex, history of urinary tract infections (UTIs), body mass index, American Society of Anesthesiologists score, surgical wound classification (Altemeier) [10], previous antibiotic use, reason for hospital admission, major concomitant diseases, and concomitant pharmacologic therapies. Perioperative microbiological data on urinary isolates, blood cultures, and wound swab cultures, including antibiotic resistance profiles, were recorded.

For the retrospective comparative cohort, all clinical and microbiological data were collected from a review of electronic and paper medical records or by recalling the patient. If preoperative urine had been obtained for this cohort, the results were collected. Additional data were retrieved by reviewing all electronic ambulatory medical charts from the hospital information system. All data were entered into a dedicated database. Patients with incomplete clinical or microbiological data regarding important information for the study aims were excluded from the analysis.

2.5. *Adherence to the protocol*

Adherence to the protocol was measured by comparing antibiotic consumption recorded by the hospital pharmacy to that recorded on the medical record. We compared the antibiotic agent prescribed for individual procedures with that recommended by the EAU guidelines [2]. We considered a prescription as adhering to the protocol when the antibiotic used was among those recommended in the EAU guideline [2]. Antibiotics were identified by generic name, drug classification, and the defined daily dose (DDD) of the anatomical therapeutic chemical classification index, in line with Sasse et al [1]. In particular, DDD was used as the measure of antibiotic consumption defined as the medium drug dose determined for an adult patient with reference to the main therapeutic function (or aim) [11,12]. The rate of antibiotic consumption was calculated as DDD per 100 patient-days [13]. To obtain comparable results, we analysed DDDs for 2009 for the period before and for 2012 for the period after protocol introduction.

2.6. *Microbiological techniques*

All isolates were identified using standard microbiological methods in accordance with Hooton et al [14]. Susceptibility testing was performed using a Vitek II semiautomated system for microbiology (BioMerieux, Marcy l'Etoile, France). The Kirby Bauer disc diffusion method was performed according to Clinical Laboratory Standards Institute recommendations [15]. The threshold for a significant bacterial concentration was $\geq 10^3$ colony-forming units/ml. Resistance patterns against fluoroquinolones (ciprofloxacin and levofloxacin), cephalosporins (ceftazidime, ceftriaxone, and cefepime), piperacillin/tazobactam, carbapenems (imipenem and meropenem), aminoglycosides (gentamicin), and vancomycin were tested for all isolated pathogens and expressed as percentage rates before and after protocol implementation.

2.7. *Definition of postoperative infection*

We defined an infection related to a procedure as either the presence of symptoms related to UTI and confirmed by microbiological analysis, or surgical site infection (SSI). Deep and superficial SSIs were defined according to the criteria of the Centres for Disease Control and Prevention/National Healthcare Safety Network [16]. The Clavien-Dindo classification was used for postoperative complications [17].

2.8. *Evaluation of health care costs*

The cost evaluation included the cost of antibiotic consumption and the cost of infections attributable to the surgical procedure. Antibiotic costs were calculated by summing the cost for each individual patient incurred by the hospital during the study period as provided by the Azienda Provinciale per i Servizi Sanitari della Provincia Autonoma di Trento billing office (Santa Chiara Regional Hospital, Trento, Italy) and using electronic ambulatory medical charts from the hospital information system. Postoperative infection costs were calculated by summing additional individual costs incurred by the hospital as a result of the patient suffering a postoperative infection and costs arising from infection occurring within 7 d of discharge that resulted in readmission to the hospital. We also recorded the length of hospital stay (LoS), defined as the number of days between hospital admission and discharge, as a proxy for both complexity and the cost of patient treatment [18]. For the purposes of this study we defined the minimum LoS as 1 d, because admission and discharge on the same day was considered outpatient care, in line with Spoorenberg et al [18]. We matched data for LoS with the causes of a longer hospital stay to exclude all increased LoS for other reasons. Moreover, indirect costs included all costs related to reintervention without increased LoS.

2.9. *Ethical considerations*

This was deemed a service evaluation by the local ethics committee and thus did not require approval. Informed consent was not required since all procedures were performed according to routine standards with no data collection additional to routine care. The study was registered as an audit within the institution.

2.10. *Statistical methods*

Results for categorical variables are presented as percentages and were compared using χ^2 analysis. Results for continuous variables are presented as the mean and standard deviation and were compared using Student's *t* test or the Mann-Whitney *U* test, as appropriate. The relationship between frequency of strains resistant to a particular antibiotic and antibiotic consumption was assessed by linear regression analysis. All *p* values reported are two-sided, with $p < 0.05$ taken as being significant. Statistical analyses were performed using SPSS 11.0 for Apple-Macintosh (SPSS, Chicago, IL, USA).

3. Results

A total of 2679 patients from before implementation and 3603 patients from after implementation were included in the study. Of these, 134 patients were excluded because of missing data ($n = 60$ before and $n = 74$ after protocol initiation). The final analysis thus included 2619 patients in the before group and 3529 patients in the after group. The two groups were comparable in terms of age, sex distribution, and type of procedure (Table 1). We observed that adherence to EAU guidelines concerning prophylactic antibiotics was high after protocol implementation (87%). Among all cases of noncompliance, adherence to EAU guidelines was far from optimal for cystoscopy and radical prostatectomy (rate of adherence 9% and 4%, respectively). The most common cause of noncompliance was continued administration of antibiotics after discharge.

The rate of postoperative UTIs and SSIs was similar between the two periods, with no statistically significant difference (117 [4.5%] before vs 180 [5.1%] after; $p = 0.27$). Table 2 shows the clinical and microbiological characteristics of all patients who suffered a postoperative infection. We also found a statistically significant reduction in the rate of antibiotic-related adverse events, with eight cases of *Clostridium difficile* infection before and one case after

Table 1 – Patient characteristics ($n = 6148$) and distribution according to enrolment period

	Before protocol implementation	After protocol implementation	*p* value
Patients (*n*)	2619	3529	
Age (years)			
Mean age, yr (SD)	70.7 (11.3)	70.2 (11.9)	0.09
Sex, *n* (%)			
Male	1907 (72.8)	2576 (72.9)	0.88
Female	712 (27.2)	953 (27.1)	
Charlson comorbidity index, *n* (%)			
<2	2095 (79.9)	2821 (79.8)	0.12
2	478 (18.3)	638 (18.3)	
≥3	46 (1.8)	70 (1.9)	
Mean body mass index, kg/m^2 (SD)	25.4 (10.2)	24.9 (9.8)	0.05
ASA score, *n* (%)			
1	2095	2827	0.92
2	426	598	
3	98	104	
Type of diagnostic procedure, *n* (%)	1378 (52.6)	1633 (46.4)	0.09
Cystoscopy	984	1,114	
URS	16	45	
Prostate biopsy	378	474	
Type of surgical procedure			
Endoscopic surgery, *n* (%)	878 (33.5)	1316 (37.3)	0.27
URS for uncomplicated stone treatment	94	236	
Transurethral resection of the prostate	100	128	
TURBT	678	916	
Percutaneous nephrolithotomy	6	36	
Open or laparoscopic urologic surgery, *n* (%)	363 (13.9)	580 (16.3)	0.18
Radical prostatectomy	188	229	
Nephrectomy	84	76	
Radical cystectomy	49	54	
Other surgical procedure	42	221	
Altemeier classification (*n*) [a]			0.06
Clean	126	297	
Clean-contaminated	1066	1545	
Contaminated	49	54	
Dirty	0	0	

ASA = American Society of Anesthesiologists; SD = standard deviation; URS = ureteroscopy; TURBT = transurethral resection of bladder tumour.
[a] Altemeier classification based on level of risk of infection [10].

protocol implementation ($p < 0.001$). These events mainly occurred following major open urologic surgery (radical cystectomy).

3.1. *Antibiotic consumption*

In the period after protocol implementation, consumption of many antibiotics fell (Table 3). In particular, the use of ciprofloxacin fell from 4.2 to 0.2 DDD per 100 patient-days ($p < 0.001$). Aminoglycoside consumption also fell significantly (gentamicin 1.5 vs 0.4 DDD per 100 patient-days; $p < 0.001$). By contrast, consumption of trimethoprim-sulfamethoxazole increased significantly (1.1 vs 5.8 DDD per 100 patient-days, $p < 0.001$; Table 3).

3.2. *Antibiotic resistance patterns*

A total of 342 isolates were analysed from patients with symptomatic postoperative infections before ($n = 117$) and after ($n = 180$) protocol implementation. Table 2 lists all the bacterial strains isolated. The most common bacteria isolated were Enterobacteriaceae. The susceptibility of all bacteria isolated in the two periods is also described in Table 2. The proportion of *E. coli* and *Klebsiella* spp. isolates resistant to piperacillin/tazobactam ($p = 0.03$), gentamicin ($p = 0.02$), and fluoroquinolones ($p = 0.03$) was lower after implementation of the new protocol. This was associated with decreases in consumption of piperacillin/tazobactam (Spearman rho 0.73, $p = 0.02$) and ciprofloxacin (Spearman rho 0.81, $p < 0.001$).

3.3. *Costs*

Antibiotic costs fell from €76 980 to €36 700 after protocol implementation ($p < 0.001$), and the length of stay for the reference procedure of radical cystectomy decreased from 18.3 ± 1.3 to 13.1 ± 1.1 d ($p = 0.006$). The cost of treating postoperative infections also decreased from €45 870 to €29 560 after protocol implementation ($p < 0.001$).

4. Discussion

4.1. *Main findings*

The continued misuse and overuse of antibiotics are paralleled by the growing frequency of multidrug-resistant

Table 2 – Clinical characteristics, bacterial spectrum, and resistance of bacterial isolates from patients with postoperative infectious complications against all antibiotics tested according to the study period

	Before protocol	After protocol	*p* value
Patients with infection, *n* (%)	117 (4.4)	180 (5.1)	0.27
Type of procedure, *n*/*N* (%) [a]			0.47
Diagnostic procedures			
Cystoscopy	20/984 (17.2)	34/1114 (18.8)	
Prostate biopsy	21/378 (17.8)	31/474 (17.3)	
Endoscopic surgery			
URS for uncomplicated stone treatment	12/94 (10.3)	19/236 (10.6)	
TURBT	41/678 (35.1)	50/916 (27.8)	
Percutaneous nephrolithotomy	–	3/36 (1.6)	
Open or laparoscopic urologic surgery			
Radical cystectomy	18/49 (15.3)	19/54 (10.6)	
Other surgical procedure	5/42 (4.3)	24/221 (13.3)	
Bacterial strains isolated, n (%)			0.96
Enterobacteriaceae			
Escherichia coli	63 (45.0)	95 (47.1)	
Klebsiella spp.	21 (15.0)	26 (12.8)	
Pseudomonas aeruginosa	14 (10.0)	20 (9.9)	
Serratia marcescens	3 (2.1)	4 (1.9)	
Proteus mirabilis	4 (2.9)	7 (3.6)	
Others			
Enterococcus spp.	32 (22.9)	45 (22.2)	
Citrobacter freundii	3 (2.1)	5 (2.5)	
Number of isolates (n)			
Enterococcus spp.	32	45	
P. aeruginosa	14	20	
Klebsiella spp.	21	26	
E. coli	63	95	
Resistant strains (%)			
Amikacin			
Enterococcus spp.	38.7	39.1	–
P. aeruginosa	18.3	18.2	–
Klebsiella spp.	4.9	4.7	–
E. coli	21.4	19.8	–
Ciprofloxacin			
Enterococcus spp.	23.8	22.9	–
P. aeruginosa	31.3	32.0	–
Klebsiella spp.	10.3	8.1	0.03
E. coli	32.3	19.1	0.03
Ceftriaxone			
Klebsiella spp.	3.9	3.5	–
E. coli	26.1	25.3	–
Levofloxacin			
Enterococcus spp.	18.3	18.0	–
P. aeruginosa	29.9	28.7	–
Klebsiella spp.	9.6	6.1	0.03
E. coli	29.9	25.6	0.03
Gentamicin			
Enterococcus spp.	41.5	43.1	–
P. aeruginosa	27.1	28.0	–
Klebsiella spp.	6.5	4.1	0.02
E. coli	18.3	11.2	0.02
Piperacillin/tazobactam			
P. aeruginosa	26.1	26.9	–
Klebsiella spp.	11.3	3.4	0.03
E. coli	9.1	5.4	0.03
Imipenem			
P. aeruginosa	19.3	18.9	–
Klebsiella spp.	0	0	–
E. coli	0.2	0	–
Cefotaxime			
Klebsiella spp.	8.3	8.8	–
E. coli	8.2	7.9	–
Vancomycin			
Enterococcus spp.	2.0	2.1	–

URS = ureteroscopy; TURBT = transurethral resection of bladder tumour.
[a] *N* is the total number of patients with postoperative infectious complications.

Table 3 – Defined daily dose per 100 patient-days (DDD) according to study period

Drug	DDD		*p* value
	Before protocol	After protocol	
Aminoglycosides			<0.001
Gentamicin	1.5	0.4	
Amikacin	0.9	0.7	
Fluoroquinolones			<0.001
Ciprofloxacin	4.2	0.2	
Levofloxacin	1.9	1.5	
Cephalosporins			0.38
Cefixime	3.9	2.9	
Cefotaxime	1.8	1.6	
Ceftriaxone	2.7	2.5	
Penicillins			0.41
Amoxicillin-clavulanic acid	1.8	2.1	
Piperacillin/tazobactam	2.1	1.4	
Carbapenems			0.82
Meropenem	0.58	0.47	
Others			
Trimethoprim-sulfamethoxazole	1.1	5.8	<0.001
Metronidazole	3.9	2.8	
Vancomycin	0.8	0.7	

pathogenic strains [19,20]. The evolution of resistant pathogens has developed into a worldwide health crisis [21], with elevated health costs and greater risk of poor patient outcomes. All clinicians have an imperative responsibility to contribute to antibiotic stewardship programmes. The results of this study show that implementation of a monitored policy of adherence to EAU guidelines on antibiotic prophylaxis for surgical urologic procedures results in lower total antibiotic consumption, reduced antibiotic resistance among uropathogens, and reduced costs without increasing the risk of postoperative infection.

4.2. *Strengths and limitations of the study*

The present study shows some strengths. First, before initiation, an educational and training meeting for all urologists was held to demonstrate the protocol and ensure understanding of the principles for effective implementation. Performing the study in a single tertiary urologic institution allowed us to accurately audit adherence to the protocol and to evaluate the effectiveness of its implementation. Furthermore, the use of regular and automatic uploading of electronic ambulatory medical charts available for both study periods reduced the risk of missing clinical or microbiological data.

Although our study is pragmatic and reflective of standard care, its main limitation is the use of a historical control group. We timed the control data to immediately precede protocol implementation and prospective data collection, but it is possible that other changes to service delivery such as enhanced recovery protocols may have contributed to the significant improvements in antibiotic usage. Our department also had a very thoughtful prophylaxis policy before protocol initiation. The single-centre nature of our study means the results may not be reproducible in other settings such as smaller general hospitals. We did not find any differences in the degree of missing data between the two periods but it is possible that there were systematic differences between the data given the closer observation and prospective data collection during the prospective phase after protocol implementation.

4.3. *Results in the context of previous work*

Our findings that adherence to antibiotic prophylaxis guidelines results in health care cost savings is in agreement with previous studies [22,23]. It has also been demonstrated that excess and/or inappropriate antimicrobial prophylaxis increases costs, which is reversed by measures to improve compliance with evidence-based recommendations [24,25]. For example, Sasse et al [1] calculated that savings of at least US$6.1 million could be made if international recommendations on antimicrobial prophylaxis were closely followed.

Switching from a broad range of agents to a restricted list as advised by the EAU guidelines resulted in a significant decrease in the proportion of pathogens subsequently causing postoperative infection that were resistant to these antibiotics. Avoidance of cephalosporins, for example, is likely to reduce the risk of development of extended beta-lactamase activity among uropathogenic Enterobacteriaceae, as reported by several authors [26]. Similarly, our observation that reduced overall use of gentamicin led to a lower risk of subsequent resistance among uropathogens echoes the findings of Kosmidis et al [27], who demonstrated that after a change in aminoglycoside use, gentamicin resistance rates decreased from 14.5% to 8.8%, whereas rates of resistance to other aminoglycosides remained unchanged. Moreover, they found that a reduction in gentamicin use might preserve the usefulness of this agent against severe infections by multiresistant bacteria such as carbapenemase-producing Enterobacteriaceae [27]. Fluoroquinolones are a particular example of overuse leading to the development of high rates of resistance [28–30]. This is evidenced by the link between antibiotic consumption and resistance rates of *E. coli* in reporting countries in Europe, with resistance ranging from 9.7% in Iceland to 42.0% in Cyprus and Italy [30]. Our results show that control of the use of this drug class can have an immediate effect in the hospital setting. The main changes with a high impact on resistance rates and cost savings are the cessation of prophylaxis for endoscopic procedures such as cystoscopy, transurethral resection of bladder tumor, and diagnostic ureteroscopy, and the cessation of antibiotic therapy after discharge.

It is important to highlight that postoperative infection rates were unchanged between the two periods. Our results suggest that this was mainly because of cessation of prophylaxis prescription for clean procedures such as cystoscopy for which there is no benefit [2]. However, in the early years of the GPIU study, the prevalence of hospital-acquired infections decreased in urology departments taking no other measures than highlighting the problem of hospital-acquired infections [31]. Adherence to guidelines usually entails lower use of broad-spectrum antibiotics, leading to a lower risk of selection of resistant strains [2]. In this sense, the decreasing use of broad spectrum antibiotics achieves another important goal, a reduction in antibiotic-related adverse events. In fact, we found a lower prevalence of antibiotic-related adverse events such as *Clostridium difficile* infection after protocol implementation. Moreover, we found that the length of stay for radical cystectomy was significantly reduced. However, this issue should be addressed in a future analysis with a greater number of patients. The reduction in LoS from 18 d to 13 d for patients who underwent radical cystectomy could also be due to improved postoperative management as a result of protocol implementation. Moreover, the lower cost of treating postoperative infections is probably due to the significant difference in length of stay between the two periods and to the limited use of broad-spectrum antibiotics after implementation.

Our study should encourage other institutions and perhaps national urological associations to undertake continuous surveillance studies to observe the full impact of adherence to EAU guidelines. The EAU-sponsored global prevalence study on infections in urology, which has been running for 12 consecutive years, already provides a tailored platform for this purpose [3,31]. Thus, we need to develop a clear strategy for implementation of and adherence to EAU guidelines to improve the quality and efficacy of antibiotic treatment.

5. Conclusions

The EAU guidelines on antibiotic prophylaxis for surgical urologic procedures reduce overall antibiotic consumption and the risk of resistance development among uropathogens without increasing the risk of postoperative infection and with reduced health care costs.

Author contributions: Tommaso Cai had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: Cai, Bartoletti.
Acquisition of data: Tiscione, Luciani, Eccher, Lanzafame, Malossini.
Analysis and interpretation of data: Cai, Brugnolli, Eccher.
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Critical revision of the manuscript for important intellectual content: Bjerklund Johansen, Pickard, Wagenlehner, Mirone, Bartoletti.
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