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TOPIC PAPER

Preoperative assessment of the patient and risk factors for infectious complications and tentative classification of surgical field contamination of urological procedures

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Abstract
Purpose To assess the patient and identify the risk factors for infectious complications in conjunction with urological procedures and suggest a model for classification of the procedures.
Method Review of literature, critical analysis of data and tentative model for reducing infectious complications.
Results Risk factors are bound to the patient and to the procedure itself and are associated with the environment where the healthcare is provided. Assuming a clean environment and sterile operation field, a five-level assessment ladder related to the patient and type of surgery is useful, considering: (1) the ASA score, (2) the general risk factors, (3) the individual endogenous and exogenous risk factors, (4) the class of surgery and the potential bacterial contamination burden and (5) the level of severity and difficulty of the surgical intervention. A cumulative approach will identify the level of risk for each patient and define preventive measures, such as the type of antibiotic prophylaxis or therapeutic measures before surgery. There are data suggesting that the higher the ASA score, the higher is the risk of infectious complication. Age, dysfunction of the immune system, hypo-albuminaemia/malnutrition and overweight, uncontrolled blood glucose level and smoking are independent general risk factors, whilst bacteriuria, indwelling catheter treatment, urinary tract stone disease, urinary tract obstruction and a history of urogenital infection are specific urological risk factors. There is inconclusive evidence for most other reported risk factors. The level of contamination of the surgical field is of utmost importance as are the procedure-related factors, and the sum of these have to be reflected on for the subsequent perioperative management of the patient.
Conclusions It is essential to identify and control risk factors to minimize infectious complications in conjunction with urological procedures. Our knowledge is limited and clinical research and quality registries analysing risk factors must be undertaken. We propose a working basis for assessment of patients' risk factors and classification of urological procedures.

Keywords Urologic surgery · Endourology · Risk factors · Infectious complications · Urinary tract infection · Surgical classes · Surgical field contamination

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Introduction

Preparing the patient for urologic instrumentation or surgery involves the assessment of the patient's vulnerability and risk factors for any complication, in particular urological infections. The objective of this work is to grade the patient's risk for infectious complication after urologic procedures, without, though, pretending to be complete as the independent contribution of the different risk factors has not been assessed after the control of confounding factors and only a few risk factors have been well defined. Controlling the risk factors (i.e. bacteriuria, blood glucose level) aim at minimising the complications.

Methods

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Risk factors in urological surgery have been reviewed previously [1]. An updated search on Medline from the year 2000 related to risk factors in urologic surgery by procedure was undertaken using the following keywords: *endourological surgery, endourology, genitourinary surgery, risk factors, infectious complications, urinary tract infection*. Only a limited number of articles were relevant for risk factor evaluation. All presumptive or generally accepted risk factors could not be reviewed, i.e. diabetes mellitus, smoking, overweight, individually or cumulatively, as each merits an independent systematic review. The list of references thus includes, whenever possible, review articles and studies on antibiotic prophylaxis where risk factors were taken into account. As there are no international standards for scoring risk factors, each of them were weighted and reported as *evidence for* if there was consistency in the findings or *inconclusive evidence for* if there were conflicting data on their role (Table 8). A tentative classification of the urological procedures in relation to the present accepted surgical classes is suggested. The studies were rated according to the level of evidence (LoE) and the grade of recommendation (GoR) [2, 3].

Risk factors for infectious complications

Defining a risk factor

There is a baseline risk of infection associated with each type of intervention. This level is not always known and can only be assumed studying the *natural history*—the expected natural development of a process after intervention—using cohorts or placebo controlled studies. A risk factor is a factor that further increases the risk of an infection, beyond the baseline level of a given procedure. To measure the relative role of a risk factor or its interactive cumulative impact in modifying the course of the *natural history* requires very large-sized studies.

Identifying the risk factor is defining the relative risk. Measuring the relative risk is assessing the independent value of different variables for the occurrence of a certain event. It is a ratio that assesses the strength of association between a variable and an event or disease. In the context of surgical site infection (SSI), for instance, a risk factor strictly refers to a variable that has a significant independent association with the development of SSI after a specific operation. The same is true for urinary tract infections (UTI).

Risk factors are identified by univariate or preferably by multivariate analysis to be considered as predictors for increased risk for infection in conjunction with healthcare [4, 5].

Risk factors are related to the patient, the environment and to the procedure itself.

Risk factors related to the host

Risk factors related to the patient can be built in a stepwise level. A key question is whether the source of bacteria in urological infections is *exogenous*, that is brought into the patient in conjunction with instrumentation, or whether the infection is *endogenous*, that is harboured, undetected by standard cultures, in the patient and exacerbated during the procedure. Figure 1 illustrates the different categories of risk factors.

General physical status

The **first** step in the assessment of a patient's risk is to determine the general health state of the patient as defined by associations of anaesthesiology such as the *American Society of Anaesthesiology*. The risk groups are given by the classes P1-P5 (Table 1) [6].

Opinions diverge on the relationship between the classes P1-P5 and SSI. There are, however, studies that identify an increased risk of infectious complications in patients with reduced general health status [7], especially P3 and above. Those patients are usually older with more advanced disease and co-morbidity [8].

General risk factors

The **second** step is to identify general risk factors for complications. These factors have principally been identified for the risk of a SSI [4]. Several of these remain controver-

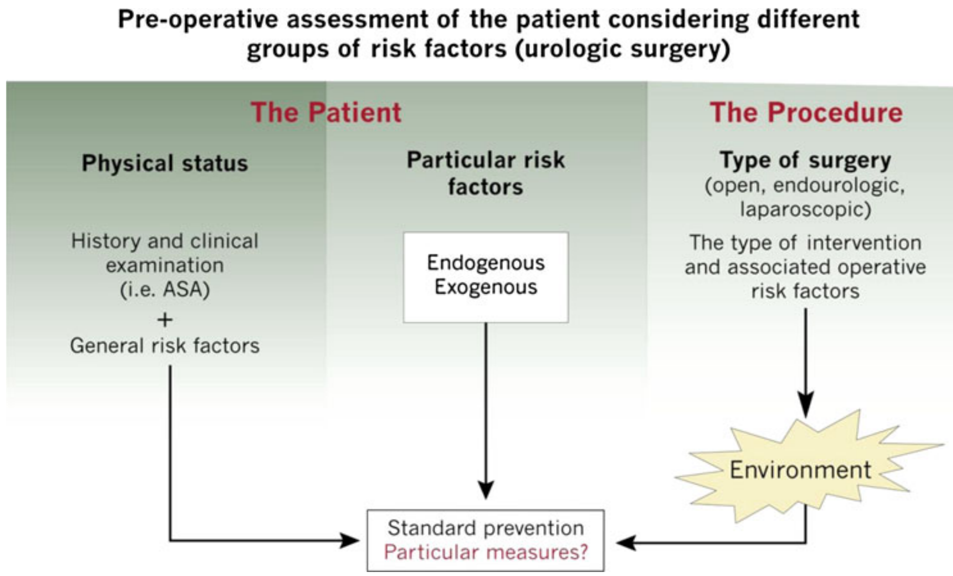

Fig. 1 Stepwise assessment of the patient's risk factors and procedure, given a fully controlled surgical environment (modified from [1])

Table 1 General physical status defined by the *American Society of Anaesthesiology* [6]

Category	Clinical evaluation
P1	A normal healthy patient
P2	A patient with a mild systemic disease
P3	A patient with a severe systemic disease
P4	A patient with a severe systemic disease that is a constant threat of life
P5	A moribund patient who is not expected to survive with or without the operation

Table 2 General patient-related risk factors that may influence the risk for SSI [4]

General risk factors
High age
Deficient nutritional status
Diabetes mellitus
Smoking
Extreme weight
Coexisting infection at a remote site
Colonization with micro-organisms
Altered immune response
Long preoperative hospital stay
Lack of elimination or control of risk factors

sial because the independent contribution has usually not been assessed after controls for confounding factors [4]. Very little work has been done so far as urological surgery is concerned. Most studies are related to cardiac and orthopaedic surgery. It is, however, assumed that the characteristics presented in Table 2 mean an increased risk for infectious complication follows a few examples:

Diabetes mellitus The independent role of diabetes for SSI is still controversial [4]. However, in a recent prospective study from Japan, poor postoperative blood glucose control was directly correlated to an increased rate of SSI [9]. A stable and correct blood sugar level is considered important before, during and after surgery [10, 11]. It is also recognised that bacteriuria is more often present in individuals with diabetes, is more severe and lasts longer [12, 13]. Bacteriuria being a well-defined risk factor for postoperative infectious complications, patients with diabetes must have a controlled blood glucose level and no bacteriuria prior to surgery. As diabetes mellitus is increasing in most societies, we can assume that there will be an increasing number of infectious complications (LoE 2a).

Other characteristics Age and deficiency of the immune system are associated with increased complication rates. Nicotine use delays primary healing and increase the risk of SSI [14] (LoE 2). The same is valid for steroid use. Malnutrition, measured by the nutritional risk index, was found to be an independent factor associated with nosocomial infections [15]. Low level of albumin is one marker of malnutrition. In a review of 10,253 general (non urological) surgical procedures, Haridas and Malangoni [8] found that 316 (3.1%) developed SSI, mainly superficial wound infections (84%) (LoE 2a). In a matched control study using multivariate analysis, they found that previous operation, hypo-albuminaemia and or low haemoglobin levels and a history of chronic obstructive lung disease were independent risk factors for SSI. Also excessive use of alcohol was deleterious and increased the risk of SSI. Only hypo-albuminaemia and previous surgery were associated with deep wound infections. It is, however, worth underlining that the benefits of preoperative nutritional repletion in reducing the SSI risk are unproven [4] (LoE 2a).

Table 3 List of the most important endogenous and exogenous risk factors (modified from [1])

Endogenous risk factors (3a)	Exogenous risk factors (3b)
High age	Introduction of micro-organisms
Colonization	Increased burden
Faecal–intestinal flora	Increased virulence factors
Periurethral	Susceptibility to antibiotics
Increased microbial burden	Instrumentation
Immunity (native or altered)	Endoscopic diagnosis
Age related	Surgical intervention
Compromised host defence mechanisms	Catheterization
HIV/AIDS	Indwelling catheter
Haematological	Nephrostomy tubes
Related to a concomitant disease	Stents (double-J stent)
Associated with burns	Metallic stents
Genetic determinants	Central vein catheters
Gender	Perfusion
Familial	
Genitourinary (GU) anatomical factors	Implantation of prosthetic devices
Prepuce	
Vesico-ureteral reflux	
Bladder dysfunction	
Residual urine	
Augmentation related	
Poor vascularisation	
Poor emptying of the GU system	
Hydronephrosis	
Urinary tract stones	
Inflammatory disease of the prostate	
Particular physiological status	
Pregnancy	Sexual activity
Postmenopausal hormonal deficiency	
Concomitant diseases	
Diabetes mellitus	
Renal insufficiency	
Cardiovascular diseases with poor circulation	
Obstructive pulmonary diseases	
Anatomic area subjected to radiotherapy	

Particular risk factors

The **third** step is the identification of particular risk factors. These can be divided into two major sub-groups, *endogenous* and *exogenous* risk factors (Table 3).

Endogenous risk factors

The endogenous risk factors are those prevailing in the individual patient. They are secondary to an anatomical abnormality, an organic dysfunction or one or several co-morbidity. The most frequently reported risk factors are listed in Table 3a. In urological prevalence studies, catheterisation, previous hospitalisation, antibiotic treatment and urinary tract stones were found to be the key risk factors for nosocomial UTI [16]. The fact that previous antibiotic treatment and hospitalisation go with increased risk is probably due to the fact that those patients have a known focus, have a more severe disease or have a weaker status.

Bacterial colonization The perineum and periurethral zones and the distal urethra are naturally colonized by both Gram-negative and Gram-positive bacteria [17] that can enter the bladder either by own migration, via an indwelling catheter or during instrumentation (LoE 3). Bacterial presence naturally increases with age, especially in women

[18] (LoE 3). Also in men subjected to TURP and having no indwelling catheter, preoperative bacteriuria is observed in more than 10% [19]. Bacteriuria at the time of TURP increases the risk of a febrile infection by 5–10 times [20] (LoE 2b). Regrettably, baseline data do not exist for most urological interventions but there are no reasons to believe the situation would be different for other urological procedures. Bacteria can be ‘hidden’ in the ducts of the prostatic gland [21], in the bladder, in dilated calices or diverticulae or other sites or adhere to biofilms of urinary tract stones or implanted devices, [22] causing also lesion of the protective mucosa layer. A standard urine culture will not necessarily detect the infectious focus.

Renal stones Urease-producing bacteria such as *Proteus spp* are well known in infectious calculi and staghorn stones. However, it has also been clearly shown by consecutive stone culture that pathogens adhere to stones in 30–70% of the stones [23]. Although a urine culture is recommended before an intervention, it is not necessarily a good predictor of a microbial presence [24]. Thus, all stone situations with a major kidney stones or stones of the proximal ureter, especially in the presence of an obstruction of the system, have a potentially increased microbial burden even in the absence of growth on a standard urine culture [24, 25] (LoE 2b).

Inflammatory disease of the prostate Little is known about the role of asymptomatic prostatitis and the risk of infectious complications at endoscopic surgery. However, a history of urogenital infection or prostatitis is shown to be a risk factor for infectious complication after core prostate biopsy [26], TURP [20, 27] and probably other surgery [16] which confirms the clinical empirical experience (LoE 3).

Exogenous risk factors

The exogenous risk factors are those introduced for one or another reason into the patient and that contribute directly to increase the risk of infection. The most frequently reported risk factors are given in Table 3b.

Table 4 A surgical wound classes (based on [4, 29]) and risk of wound infection [29] and suggested ESIU classification of urological instrumentation and procedures in the different classes. The risk expressed is that of classical wound infection or SSI and not of UTI

Category of intervention (risk of wound infection)	Description	Open or laparoscopic urological surgery (examples)	Endoscopic urological instrumentation and surgery (examples)
Clean (1–4%)	Urogenital tract not entered	Simple nephrectomy	Cystoscopy
	No evidence of inflammation	Planned scrotal surgery	Urodynamic study
	No break in technique	Vasectomy	TURB (minor, fulguration)*
	Blunt trauma	Varicocele surgery	ESWL*
Clean-contaminated (4–10%)	*Urogenital tract* entered with no or little (controlled) spillage	Pelvio-ureteric junction repair	TURB (major, necrotic)*
	No major break in technique	Nephron-sparing tumour resection	TURP*
		Total/radical prostatectomy	Diagnostic URS*
		Bladder surgery and partial cystectomy	Uncomplicated URS* and PCNL stone management
		Incl. Vaginal surgery	ESWL*
	Gastrointestinal tract entered with no or little (controlled) spillage	Urine diversion (orthotopic bladder replacement; ileal conduit)	
	No break in technique		
Contaminated (10–15%)	Spillage of gastrointestinal content	Urine deviation (colon) and small intestine/spillage	Core prostate biopsy*
	Inflammatory tissue	Trauma surgery	TURP*
	Major break in technique	Concomitant gastrointestinal disease	Impacted proximal stone management
	Open, fresh accidental wounds		Complicated PCNL
Dirty (15–40%)	Pre-existing infection	Drainage of abscess	Infectious stone surgery
	Perforated viscera at surgery	Large dirty trauma surgery	
	Old traumatic wound		

* Detailed description in Table 5

Indwelling catheter The urinary tract is the commonest source of HAI, particularly when the bladder is catheterised, representing some 40% of health-care-associated infections, originating from either urological manipulation (10–20%) or permanent urethral catheterisation (approx 80%) [28] (LoE 3). Most UTIs are derived from the patient's own colonic flora. All type of catheters, i.e. bladder catheter, nephrostomy tube or double-J stents, predispose to UTI. Duration of catheterisation is the most important risk factor. Most episodes of short-term catheter-associated bacteriuria are asymptomatic and caused by a single organism. When the catheterisation is long-lasting, there is a tendency for multiple strain colonisation (LoE 2a). Biofilms and encrustations are formed on the catheter creating a secondary limitation of the inner tube and finally obstruction. Stone formation in the bladder is seen in conjunction with long-term catheterisation. A urine culture is mandatory prior to surgery in order to direct the treatment and sterilise the urine before the intervention [28] (LoE 2b).

Surgical field classification in urology

Surgical wound classification

The **fourth** step in the planning of surgery is defining the level of contamination of the procedure or the expected microbial burden. The current classes of surgery/surgical field contamination were developed for war surgery and were subsequently updated for open surgery and determining the relative risk of surgical wound infection [29]. Urological interventions have not been classified and the current definitions do not include endoscopic surgery, ESWL or core prostate biopsy. The criteria for assessment of contamination categories in open surgery are the type of incision, the level of spillage and evidence of infection or inflammation (Table 4). *Clean* surgery means a planned procedure without the opening of any tract. It can probably be expanded to uncomplicated instrumentation in sterile urine, i.e. cystoscopy (LoE 4). It is, however, understood that opening the urinary tract, even in the presence of a neg-

Table 5 Tentative list of essential criteria for assessment of surgical class/surgical field contamination level of common urological procedures: The estimated risk of infectious complication is related to the surgical class or category

Operation/category	TURB	TURP	Endoscopy stone	ESWL	Prostate biopsy
Clean	Small tumours	–	Uncompl distal ureteral stone	Standard ureteral or kidney stone	–
	No history UTI		Not impacted	No history UTI	
	Sterile urine (similar cystoscopy)		No history UTI	Sterile urine	
			Sterile urine	No or mild obstruction	
			No or minor obstruction		
			No other RF		
Clean-contaminated	Large tumours	No history UTI/UGI	All other ureteral stone	Standard ureteral or kidney stone	*Transperineal*
					Sterile urine
	History UTI	Sterile urine	History UTI	History UTI	No history UTI/UGI
	Sterile urine	No catheter	Sterile urine	Sterile urine	
			Minor/moderate obstruction	Moderate obstruction	
				Other RF	
			No stent		
			Other RF		
Contaminated	Large tumours	History UTI/UGI	Proximal impacted stone	Complex stone	*Transperineal*
	Necrosis	Catheter prior to surgery	History UTI	History UTI	Sterile urine, history UTI/UGI
	Bacteriuria controlled	Bacteriuria controlled	Sterile urine or controlled bacteriuria	Obstruction	*Transrectal*
				Bacteriuria controlled	No or proven history UTI/UGI
			Moderate obstruction	Stent or nephrostomy tube	
			Stent/catheter		Sterile urine
Dirty or infected	Clinical infected	Clinical infected	Clinical infected drainage only	Clinical infected drainage only	*Transrectal*
	Emergency	Emergency			Presence of catheter or bacteriuria

* *UTI* urinary tract infection, *UGI* urogenital infection (i.e. prostatitis), *RF* risk factor

ative urine culture, should classify the intervention as a *clean-contaminated* infection [4, 29] (LoE 3). Opening the urinary tract in the presence of asymptomatic or controlled bacteriuria implies a *contamination* level while a symptomatic or uncontrolled infection means an infected environment [LoE 3]. It is also suggested here that the opening of the gastro-intestinal tract would theoretically implies a heavier bacterial load. Therefore, for practical and strategic reasons, in urology, *clean-contaminated* operations are divided into two sub-groups. In an extension, this classification could theoretically be widened to also cover endoscopic urological procedures, the *surgical site* being the urinary tract and the SSI being UTI. This model is also presented in Table 5 and the extended criteria of classification for common urological procedures are given in Table 5.

Criteria for assessment of contamination in endoscopic urological surgery and ESWL are mainly (1) a history of urogenital infection, (2) stone disease, (3) knowledge of contamination level including result of urine culture prior to surgery (mandatory, LoR A), (4) the presence of a catheter and 5) the site of entry (urethra, percutaneous channel, pouch). Evidently, an upgrade of the level of contamination has to be done according to findings at operation, i.e. infected urine, perforation.

In essence, these characteristics deal with the contamination due to the procedure per se, and the contamination of the surgical field, whenever present before surgery. For transrectal core biopsy of the prostate, the circumstances are particular as one initially sterile needle is used for several core biopsies in the same patient, passing the rectal contaminated field and not renewed or disinfected between each biopsy.

Risk of infectious complication associated with urological surgery

Table 6 gives baseline data without antibiotics on the range of infectious complications as reported in the literature for a limited number of urological procedures. Most data are older but are usually the only ones that present a *natural history* perspective to the different procedures. Figure 2a, b illustrate the type-related risk of infectious complications.

Risk factors associated with the surgical procedure

The **fifth** step is to estimate the complexity of the procedure in terms of severity, difficulty and size of the intervention (i.e. size of prostate, bladder tumour, stone localisation), time of operation, risk of bleeding and tissue trauma, surgeon's experience, all factors that have been linked to complications [4]. Obviously, these parameters may change during the procedure. A large prostate resection in an aged man with co-morbidity cannot be compared with a smaller resection in a healthy man; a large impacted, ESWL resistant proximal stone is different from a distal minor distal stone in an otherwise normal ureter [30].

Has the introduction of laparoscopic and robotic surgery changed the risk of infectious complications? No RCT

Table 6 Approximate rates of infectious complications after a selected number of urological instrumentations, in patients assumed free from infection within the genitourinary tract at time of the procedure and receiving no antibiotic prophylaxis

Procedure	Bacteriuria	Febrile or symptomatic UTI	Sepsis	References
Cystoscopy	1–9%	1–5%	No data	[38–41]
Urodynamic studies	13% (average; range 4–30%)	2–3%	No data	[42]
Transrectal core prostate biopsy	5–26%	3–10%	≤5%	[26, 37, 43–45]
TURB	4–6%	No data	No data	No data
TURP	6–70%	5–10%	0–4%	[46, 47]
ESWL	0–28%	5.7% (median probability)	1% but limited data	[48–50]
Ureteroscopy (standard)	Up to 13%	No data	No data	[24, 25, 51–54]
Percutaneous stone extraction and difficult ureterorenoscopy	Up to 35%	4–25%	15%	[24, 25, 51–54]
Open/Lap Nephrectomy	Skin	SSI ≤ 5%	No data	[31, 34]
	Catheter associated	Higher reported		
Open/Lap/robotic total prostatectomy	Dito	SSI < 5%	No data, no RCT	[55, 56]
Cystectomy and bladder substitution	Dito	SSI 10–15%	Limited data	[57]
Scrotal surgery	Skin	SSI 3–9%	No data	[58, 59]
Implantation of prosthetic devices	Skin	1–16.7%	No data	[60]

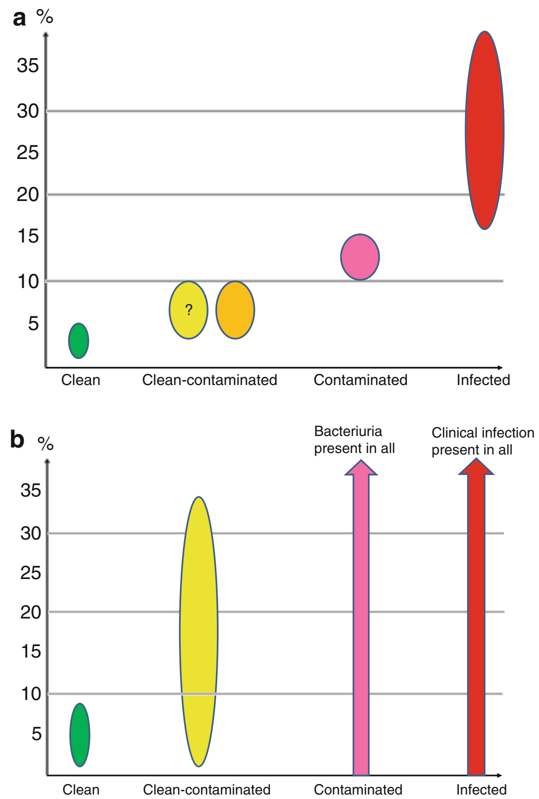

Fig. 2 **a** Visual illustration of the traditional data on risk for wound infection/surgical site infection (SSI) (Table 4) [4]. There are no data on possible differences when opening the urinary tract (yellow oval) or intestinal tract (orange oval). **b** Visual illustration of reported data on induced bacteriuria or UTI in clean and clean-contaminated urological procedures. It is understood that there is a given presence of bacteriuria in all contaminated procedures and an ongoing clinical infection in the infected category (Table 6)

covers the subject in urology. Montgomery showed a lower rate of wound infections in hand-assisted laparoscopic urologic surgery compared with open surgery, but more often than with standard laparoscopy [31]. We have to refer to information from other abdominal surgery. In one meta-analysis about laparoscopic versus open surgery for peptic ulcer, there was a significant lower frequency of surgical site wound infections in the laparoscopic group, 2.5% versus 6.9% [32]. Similar results have been shown for other laparoscopic gastrointestinal surgery [33]. The NNIS database supports this trend [34] (LoE 3).

Prolonged preoperative hospital stay

The risk of colonisation by resistant strains is increased. However, a long hospital stay may also be the indicator for the severity of illness and co-morbidity, influencing both the preoperative diagnostic and therapeutic procedures [4, 8] (LoE 2b).

Table 7 General operative and environmental risk factors associated with an increased risk of infectious complications [1, 4]

Preoperative and operative characteristics (patient and procedure related)	Surgical environment (related to theatre, staff, microbial environment)
Preoperative preparation of the patient	
Long preoperative hospitalisation	Staff related
Insufficient cleaning of surgical site	Hygiene and aseptic environment
Inappropriate antibiotic prophylaxis	Elimination of transmission between staff and patients
Operation characteristics	Operation theatre
Length of operation	Clean environment
Surgical technique	Ventilation
Tissue damage	Number of staff
Bleeding	Order of surgery
Experience of the surgeon	Sterilisation of instruments
Implantation of prosthetic devices	Microorganisms
Drainage	Burden
Perioperative oxygen tension	Virulence
	Sensitivity to antibiotics
	Special strains
	Specific pathogens
	Viruses (HIV, Hepatitis, Herpes)

Prolonged operation time

As for preoperative hospital stay, this factor may be related to more advanced disease and more complicated surgery [8, 34] (LoE 2b).

Surgical technique

Tissue traumas, poor haemostasis, failure to obliterate dead spaces and the experience of the surgeon have all been mentioned as risk factors for SSI. Conversely, meticulous surgery performed as quickly as is safe, with as little blood loss as possible followed by scrupulous postoperative care are obviously key factors that may keep the infection rate as low as possible (Table 7). This may also be extended to endoscopic surgery [4] (LoE 2a). Also the perioperative administration of supplementary oxygen reduces the rates of surgical wound infection [35] as does proper wound closure [36].

Evidence of risk factors for different type of urological procedures

Table 8 shows the risk factors by level of evidence for a certain number of procedures. Bacteriuria and any type of

Table 8 Risk factors and level of evidence for infectious complications in some urological procedures

Type of intervention	Evidence for	Inconclusive evidence for
Aspiration biopsy/cytology of the prostate	Connective tissue disease	Prostatitis
Transrectal Core biopsy of the prostate	Bacteriuria	Diabetes mellitus
	Indwelling catheter	Steroids
	History of UTI or Prostatitis	Pre-biopsy enema
	Absence of antibiotic prophylaxis	
Cystoscopy (diagnostic)	Bacteriuria	Bladder dysfunction
	Indwelling catheter	Impaired immune status
	History of associated UTI	Foreign body
Transurethral resection of the prostate (TURP)	Preoperative indwelling catheter	High age
	Renal failure	Bladder dysfunction
	Rupture of closed drainage	Surgeons experience
		Bleeding
		Duration of surgery
Other endoscopic surgery	Bacteriuria	High age
	Urethral stent	Renal failure
	Nephrostomy tubes	Duration of surgery
		Diabetes mellitus
		Absence of antibiotic prophylaxis
ESWL	Bacteriuria	High age
	Urethral stent	Renal failure
	Nephrostomy tubes	Diabetes
	Staghorn stones	
Open adenoma enucleation of the prostate	Bacteriuria	High age
	Indwelling catheter	Renal failure
	Rupture of closed drainage	Duration of surgery
		Diabetes mellitus
		Absence of antibiotic prophylaxis
Nephrectomy	Increasing number of risk factors	
Total prostatectomy		
Other operations with open urinary tract	Bacteriuria	Absence of antibiotic prophylaxis
	Indwelling catheter	
Surgery and urinary diversion with open bowel	Absence of antibiotic prophylaxis	Length of surgery
Implantation of prosthetic devices	Concomitant procedures	Diabetes mellitus
	Remote site infection	Transplanted and immune system deficiency
	Previous radiotherapy	Repeated implantation
		Spinal cord injury

catheter (urethral catheter, nephrostomy tubes, JJ-stents) and a recent history of UTI or prostatitis are reckoned to be risk factors with a high level of evidence, whilst other risk factors are reported inconclusively in the literature. Diabetes mellitus for instance was shown in prostate biopsy to be a risk factor in one study on core prostate biopsy [37], but most other studies have not been broken down into subgroups, making a conclusion impossible. For most urological studies, there are no prospective or case-controlled studies looking specifically at risk factors, leaving many questions to be answered in the forthcoming years.

Discussion

The present review shows the relative lack of systematic knowledge regarding the factors that might influence the development of infectious complications in conjunction with urological surgery. There are no international standards for a comprehensive assessment of patients before surgery. The ASA score is related to the risk of anaesthesia but reflect also the health state of the patient. The general risk factors are based on large registry of infectious complications in mainly general and gastrointestinal surgeries, cardiovascular and orthopaedic intervention, rarely on urological procedures. Data are not always consistent and most studies reporting on infectious complications have not specifically addressed the role of specific risk factors. For this reason, we advocate that contamination classes should be assessed according to the basic surgical principles and criteria, especially when new procedures or approaches are being introduced. Regularly, what was expected to be a *clean* or a *clean-contaminated* operation has to be upgraded during the procedure due to intra-operative findings.

We know of a few key risk factors such as the presence of bacteriuria, with or without an attachment to an indwelling catheter, kidney stones and a history of former genitourinary infection. However, the knowledge of the underlying mechanism, the exact source of the germs, the relative role of the host, the parasite and the environment are still poorly understood.

A key question is whether the patient harbours a virulent pathogen that is not detected by standard pre-operative means, as for instance in stone surgery [24] and prostate biopsy [26]. There is a lack of tools to identify 'hidden' infections. A urine culture is important if showing bacterial growth, but could also be a false predictor if it is negative, following a site-specific 'hidden' presence of bacterial growth (i.e. prostate, kidney stone). Thus, new methods have to be developed.

In the absence of large databases on infective complications after urological procedures, we are confined to assume criteria and categorise procedures on a reasonable ground in order to asses the patient's risk for complications and to give recommendations on antimicrobial prophylaxis.

Conclusions

It is essential to carefully assess patients before urological surgery to reduce postoperative morbidity and mortality. A stepwise assessment ladder is proposed including a risk factor analysis. We know of a few general key risk factors such as old age, nutritional and immunological deficiencies, high body mass index and prolonged preoperative hospital stay. It can be stated that the presence of bacteriuria, with or without an attachment to an indwelling catheter, kidney stones and a history of former urogenital infection are specific risk factors. However, there is a lack of evidence for a large number of factors that eventually have to be assessed. For this, large cohort studies and quality registries including infectious complication controls and risk factors recording have to be set up. We suggest a new frame of categorization of urological patients to undergo surgery into the classical surgical field contamination classes.

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