

비뇨기계 기구 관련감염 방지를 위한 비항생제적 예방법 및 관리법



서울의료원 비뇨의학과

이 신 우

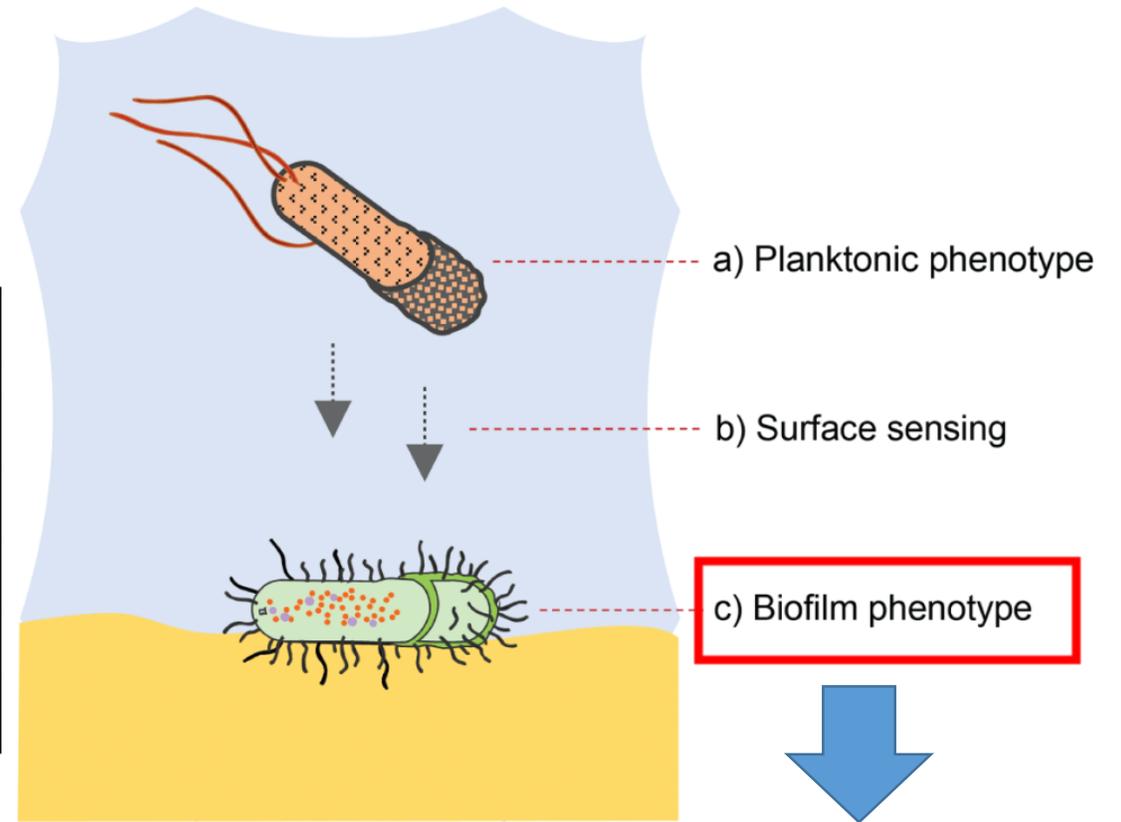
기구 관련 감염

- Host immune response to one or more microbial pathogens on an indwelling device
- 수술적 확인 또는 배양 검사를 통해 진단 가능

세균의 두가지 형태

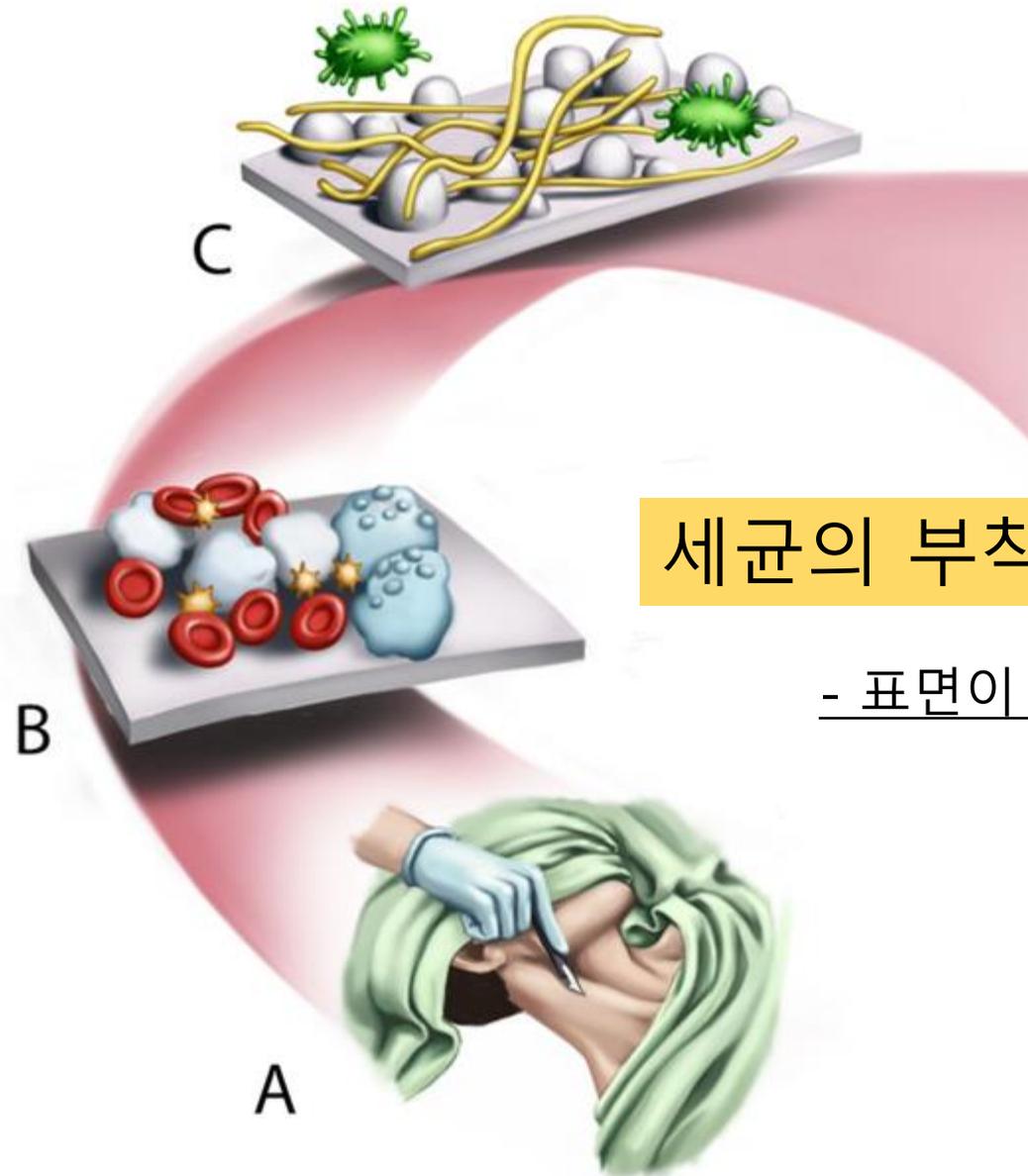
Planktonic	Biofilm
Single Cells	Cell aggregates
Free-floating in solution	Usually associated with a surface
Antibiotic responsive	Antibiotic tolerant (not true resistance)
Susceptible to host immune response	Resistant to host immune response
Rapid metabolism and cell growth	Slow metabolism and cell growth

Shock. 2016 December ; 46(6): 597-608



기구 관련 감염의 주요 원인

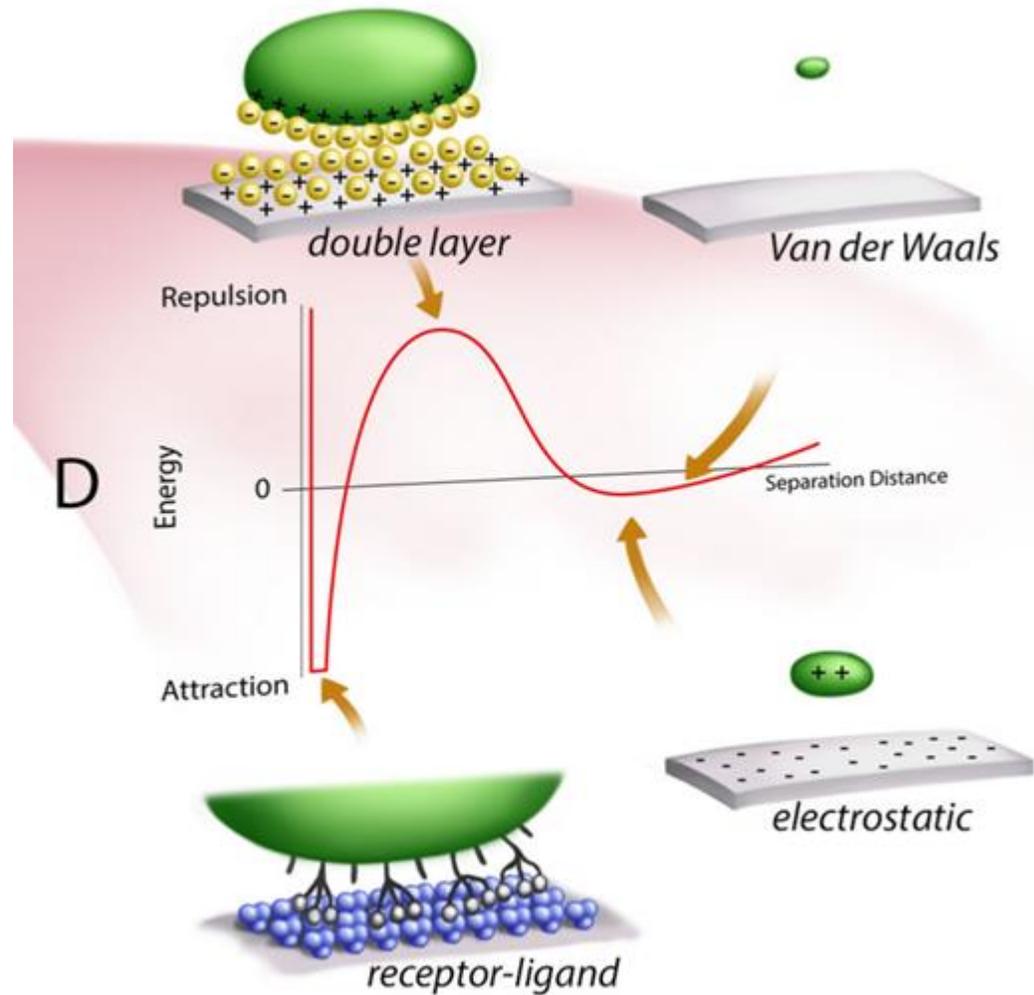
Biofilm pathogenesis



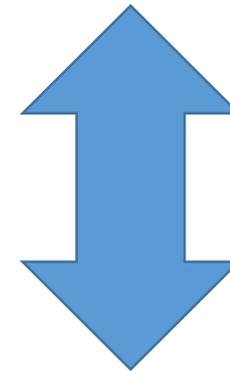
세균의 부착이 가장 중요한 단계

- 표면이 거칠고 소수성(hydrophobic)이면 부착이 잘됨

Biofilm pathogenesis



Electrostatic repulsive force



부속지 (Appendages)
- flagella, pili, fimbriae and glycocalyx formation

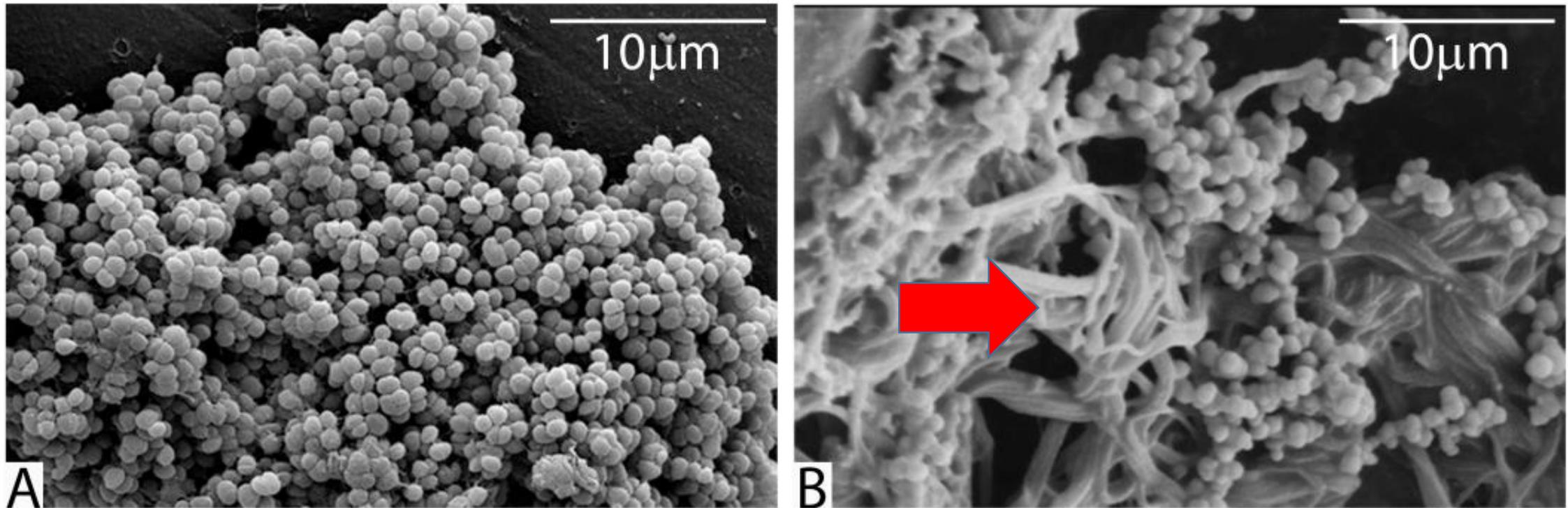


Figure 3.

Scanning electron micrographs of staphylococcal biofilms (A) grown *in vitro* on polystyrene culture pegs and (B) harvested from an infected ventriculoperitoneal shunt. Note the scant ECM on the *in vitro* biofilm in (A) and the bacteria adhered to dense fibrin clot matrix in (B).

부착 후: 부착 관련 단백질 감소, biofilm 생성 관련 extracellular polymers 증가

항생제에 대한 저항 기전

- 물리적 보호막

- 미생물 역학의 변화

: 영양부족, pH변화, Oxygen radical/살균제에 대비,
세균 성장을 억제(항생제 uptake↓)

- 바이오 필름 내부에서 항생제 저항 유전
정보를 공유 (다른 종/균주 포함)



비뇨의학과 기구

- 도뇨관 (Foley catheter)
- 요관경 Ureteroscope/flexible ureteroscope
- 음경 보형물 (Penile prosthesis)

Implantable Device Related Infection

[J. Scott VanEpps](#) and [John G. Younger](#)

Prosthetic joints	Incidence	References
Shoulder	1.2%	(31)
Hip	1-2%	(31, 32, 35)
Knee	1-4%	(31, 32, 35)
Elbow	5%	(34)
Urinary devices		
Foley catheter		
Other devices	Incidence	References
Mesh for ventral hernia repair	1-10%	(38, 39)
Ventriculoperitoneal shunt	0.25-1%	(43)
Peritoneal dialysis catheter	20%	(41)

3.1-7.5 infections per 1000 catheter days

도뇨관 감염 경로

• Extra-luminal inoculation(2/3)

- 주로 도뇨관 삽입 과정에서 오염
- 도뇨관-점막 사이 공간으로 세균 감염

- Enterococcus
- Candida

• Intra-luminal contamination(1/3):

- 부적절한 도뇨관 관리
- closed drainage system이 유지되지 않음

- E coli
- Klebsiella P.

위험 요소

- Duration of catheterization (most)
- Female
- Old age
- Not maintaining closed drainage system
- Hospital-acquired UTI : neutropenia, renal disease, male sex
- Urine bag of bacteriuric patient is reservoir for organism → could be transmitted by healthcare personnel

도뇨관 관리 및 요로감염 예방에 대한 가이드라인

- **IDSA guideline 2009**

Diagnosis, Prevention, and Treatment of Catheter-Associated Urinary Tract Infection in Adults:
2009 International Clinical Practice Guidelines
from the Infectious Diseases Society of America

IDSA GUIDELINES

Thomas M. Hooton,¹ Suzanne F. Bradley,³ Diana D. Cardenas,² Richard Colgan,⁴ Suzanne E. Geerlings,⁷
James C. Rice,^{5,a} Sanjay Saint,³ Anthony J. Schaeffer,⁶ Paul A. Tambayh,⁸ Peter Tenke,⁹ and Lindsay E. Nicolle^{10,11}

47개 항목

CA-UTI (catheter associated urinary tract infection)

CA-ASB (catheter associated asymptomatic bacteriuria)

도뇨관 관리 및 요로감염 예방에 대한 가이드라인

냄새나는 소변/탁한 소변

- 냄새는 bacterial urease에 의해 urine의 urea가 암모니아되면서 냄새가 발생함
- 도뇨관을 가진 환자에서 단독 증상으로 치료의 대상은 아님. 임상적 증상이 중요
- Hydration, continence manage가 중요

도뇨관 관리 및 요로감염 예방에 대한 가이드라인

Encrustation에 의한 반복적인 폐색

- Biofilm내 세균은 hydrolyze urea를 free ammonia로 바꾸면서 소변의 pH를 상승시킴 → 미네랄 침착을 유발 → hydroxyapatite or struvite or encrustation → 도뇨관 막힘
- Proteus or Providencia spp.
- Encrustation에 저항성 가지는 도뇨관 재질 (-)

도뇨관

도뇨관

Indication

Clinically significant urinary

Urinary incontinence

Accurate urine output m

Patient unable or unwilling

도뇨관



REMARKS

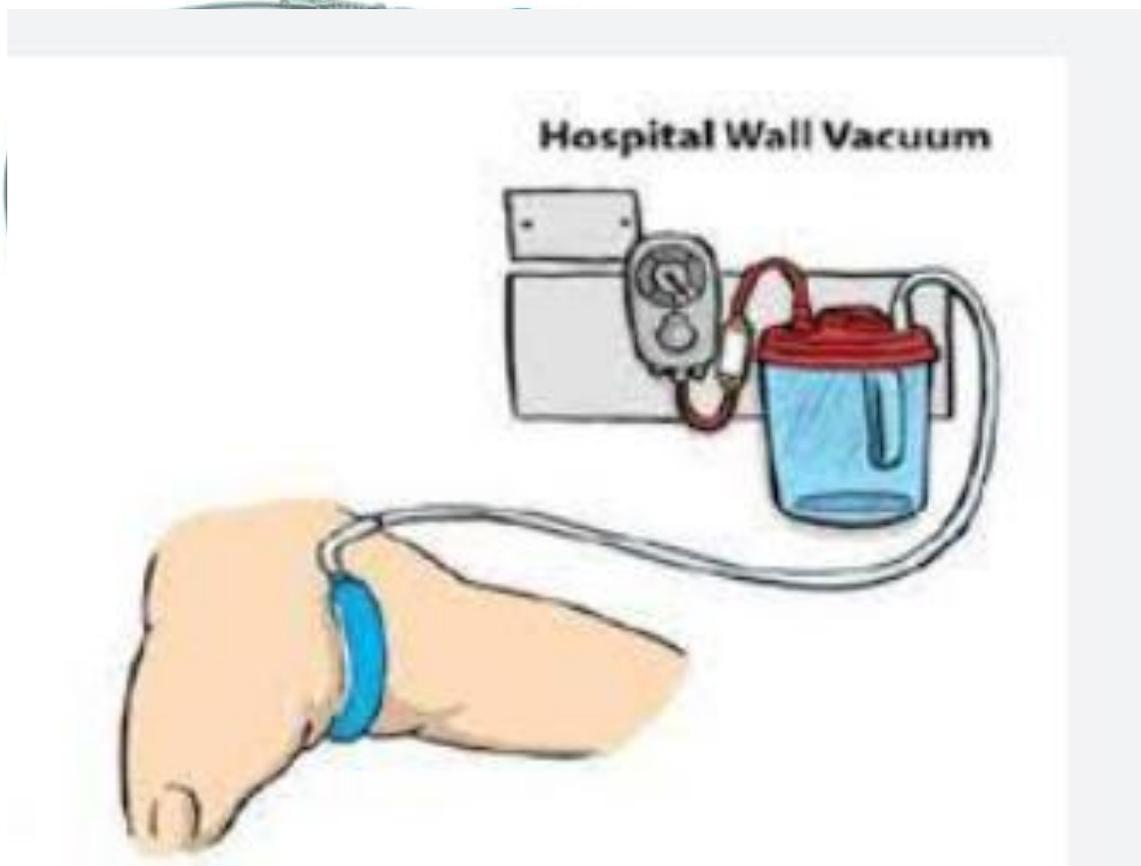
COF-

Pharmacological

Physical

Secure the catheter to the lateral aspect of the patient's thigh to prevent urethral trauma

도뇨관 관리 및 요로감염 예방에 대한 가이드라인



(short-term)

· Purewick™ (여성 환자)

→ 최근 해외 병원 중환자실에서 사용하는 경우 (+)

→ 마른 환자의 경우 urine leakage보일 수 있음

도뇨관 관리 및 요로감염 예방에 대한 가이드라인

Daily meatal care or cleansing ?

- 소독약, 연고, 물을 이용한 routine care는 권장되지 않습니다.
- catheter 반복된 조작 → 염증 발병 위험 증가!
- 연고 및 소독약의 효과 부족
- intra-luminal infection에 효과 없음

Daily bathing with 4% chlorhexidine gluconate in intensive care settings: a randomized controlled trial

C. Pallotto ^{1,*}, M. Fiorio ¹, V. De Angelis ², A. Ripoli ³, E. Franciosini ⁴,
L. Quondam Girolamo ⁵, F. Volpi ⁵, P. Iorio ⁴, D. Francisci ¹, C. Tascini ⁶, F. Baldelli ¹



Table 2

Incidence of infections per 1000 patient-days and mortality

	Study population <i>n</i> = 449 (3444 patient-days)	Intervention arm <i>n</i> = 226 (1857 patient-days)	Control arm <i>n</i> = 223 (1587 patient-days)	<i>p</i>
Total infections, <i>n</i> /1000 pd (95% CI)	31.3 (25.9–37.9)	23.2 (17–31.3)	40.9 (32–52.2)	0.034
VAP, <i>n</i> /1000 pd (95% CI)	11 (7.9–15.3)	11.3 (7.2–17.5)	10.7 (6.4–17.5)	1
BSI, <i>n</i> /1000 pd (95% CI)	9 (6.2–12.9)	5.4 (2.7–10.2)	13.2 (8.4–20.5)	0.113
CLABSI, <i>n</i> /1000 pd (95% CI)	6.4 (4.1–9.8)	3.8 (1.6–8.1)	9.4 (5.5–15.9)	0.204
CAUTI <i>n</i> /1000 pd (95% CI)	4.9 (3–8.1)	2.7 (0.9–6.7)	7.6 (4.1–13.6)	0.223
BSI+CLABSI, <i>n</i> /1000 pd (95% CI)	15.4 (11.6–20.2)	9.2 (5.5–14.9)	22.6 (16.2–31.6)	0.027
Mortality, <i>n</i> (%)	61 (13.6%)	29 (12.8%)	32 (14.3%)	0.74

Abbreviations: BSI, bloodstream infection; CAUTI, community-acquired urinary tract infection; CLABSI, central-line-associated BSI; pd, patient-days; VAP, ventilator-associated pneumonia.

비뇨의학과 기구

- 도뇨관 (Foley catheter)
- 요관경 Ureteroscope/flexible ureteroscope
- 음경 보형물 (Penile prosthesis)

요관경

- 주된 감염 경로는 **endogenous infections** (i.e. infections arising from the patient's own microbial flora)
- 기구의 건조가 중요함 : 액체를 매개로 한 기구의 감염 가능성을 줄여 줌
- 적절히 소독 건조하고 보관한 기구의 경우 재사용시 추가적인 re-process가 필요하지 않음

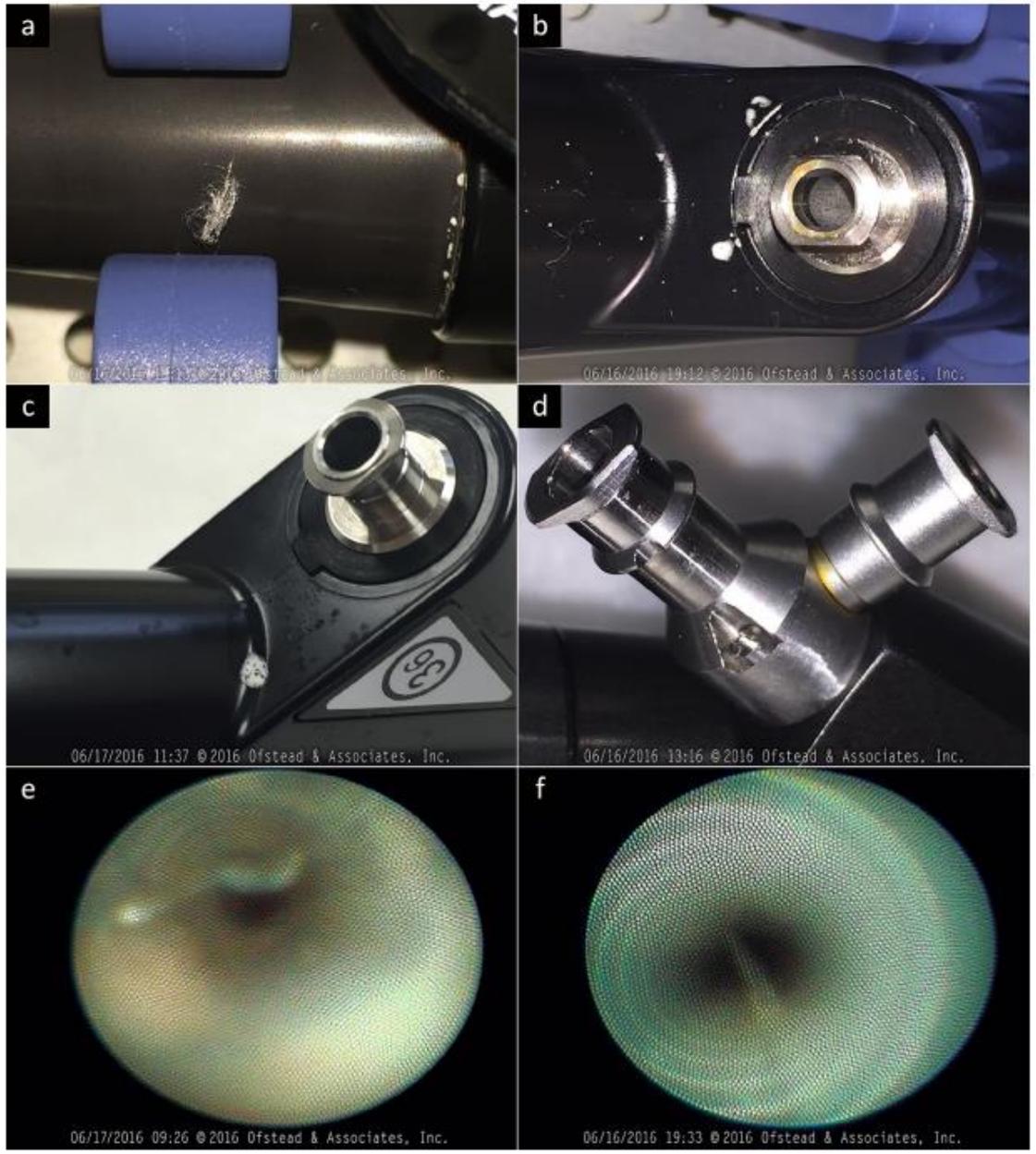
The effectiveness of sterilization for flexible ureteroscopes: A real-world study

Cori L. Ofstead MSPH *, Otis L. He;
John E. Eiland MS, RN, Harry P. W
Ofstead & Associates, Inc, Saint Paul, MN

White fibrous debris
Rusty discoloration

White foamy residue
oily deposit

Reprocessing:
manual cleaning +
Sterilization with
hydrogen peroxide gas



White residue near port
and yellow discoloration

yellow discoloration

Filamentous debris in channel

Fig 1. Irregularities found at site A. (A) White fibrous debris on control handle and rusty discoloration and white residue near junction. (B) White residue near port and yellow discoloration on port. (C) White foamy residue and oily deposits. (D) Yellow discoloration on port. (E and F) Filamentous debris in channel. *Am J Infect Control.* 2017 Aug 1;45(8):888-895

ID	Model	Insertion tube adenosine triphosphate (RLU)	Channel effluent			Microbial growth (CFU)
			Adenosine triphosphate (RLU)	Hemoglobin (µg/mL)	Protein (µg/mL)	
Results of encounters with patient-ready ureteroscopes						
A-1	URF-V2	46	26	1	26	0
A-2	URF-V2	44	28	1	21	0
A-3*	URF-V2	23	15	1	24	0
A-4*	URF-V2	338	41	1	20	0
A-5	URF-V2	33	20	Under range	20	0
A-6	URF-V2	47	28	1	17	0
A-7	DUR-8 ULTRA	36	30	Under range	13	0
A-8	AUR-7	39	19	Under range	12	0
A-9	URF-P6	37	17	3	32	1 (<i>Micrococcus luteus</i>)
A-10	URF-P6	30	26	1	21	0
A-11	URF-P6	39	20	Under range	17	0
A-12	URF-P6	36	17	1	21	0
B-1	URF-P6R	74	17	Under range	12	0
B-2	URF-P6R	134	19	1	16	0
B-3	URF-P6R	34	20	Under range	9	0
B-4	URF-P6R	43	17	1	15	1 (<i>Corynebacterium glaucum</i>)
Results of tests repeated after re-reprocessing due to high initial results						
A-4	URF-V2	7/16	31	10/16	16/16	2/16
A-9	URF-P6	37	27	1	15	0
A-12	URF-P6	39	29	1	15	0
B-2	URF-P6R	43	25	1	12	NA
ATP, protein : contamination level → reprocessing failure와 연관						
1회 사용						
A-P1†	Gastroscope	119	30	1	12	24 (<i>Klebsiella pneumoniae</i>)
B-P1†	Gastroscope	33047	591	2	11	TNTC (<i>Pseudomonas aeruginosa</i>)
Hb : blood or residual reprocessing chemicals or other contaminants introduced during reprocessing						
미사용						
A-N1	Tenaculum	33	31	1	11	0
B-N1	Towel clamp 4"	20	18	Under range	7	0
B-N2	Sterile water/cup	13	14	1	3	0

반복 사용

1회 사용

미사용

CFU, colony-forming units; NA, test not conducted or not applicable; RLU, relative light units; TNTC, too numerous to count.

*Brand-new ureteroscope tested after first time being reprocessed.

†Clinically used endoscopes tested before manual cleaning.

‡Brand-new ureteroscope that had not yet been used or reprocessed.

Pre-Use Ureteroscope Contamination after High Level Disinfection: Reprocessing Effectiveness and the Relation with Cumulative Ureteroscope Use



Jaap D. Legemate,* Guido M. Kamphuis, Jan Erik Freund, Joyce Baard,† Harry W. Oussoren, Ingrid J. B. Spijkerman and Jean J. M. C. H. de la Rosette

20개의 연성내시경으로 2-80회까지 총 400회 수술한 내시경 기구의 수술 전 배양검사 결과

Table 1. Characteristics of included ureteroscopes and use, and preoperative USC culture outcomes

	Overall	Karl Storz		Olympus	
		Flex-XC	Flex-X2	URF-V2	URF-P6
No. ureteroscopes	20	11	2	5	2
No. procedures (range)	398	248 (2–80)	40 (2–38)	83 (6–22)	27 (10–17)
Range:	–				
Ureteroscopy (hrs)		1.23–44.13	0.43–16.42	2.57–13.23	4.80–11.30
No. device passages through working channel		9–273	4–140	21–84	26–43
Laser energy (kJ)		9.1–182.7	0–50.3	3.9–81.8	11.5–24.7
No. preop culture:	389	27	7	9	4
Uropathogens (10 cfu/ml or greater)	9	6	1	2	0
Skin flora (30 cfu/ml or greater)	38	21	6	7	4

Table 3. *Univariate GEE model of 389 procedures for parameters related to cumulative USC use and positive pre-use cultures without additional covariates*

	OR (95% CI)	p Value
Cumulative USC use:		
No. procedures	0.983 (0.911–1.062)	0.665
Ureteroscopy time	0.974 (0.841–1.129)	0.730
Laser energy	0.979 (0.830–1.156)	0.804
No. accessory device passes through working channel	0.919 (0.701–1.205)	0.541
Other tested parameters:		
Karl Storz vs Olympus	1.009 (0.435–2.342)	0.984
Digital vs fiberoptic imaging system	1.674 (0.787–3.563)	0.181

Mortality and flexible ureteroscopy: analysis of six cases

Luca Cindolo¹ · Pietro Castellan² · Cesare Marco Scoffone³ · Cecilia Maria Cracco³ · Antonio Celia⁴ · Andrea Paccaduscio⁵ · Luigi Schips¹ · Silvia Proietti⁶ · Alberto Breda⁷ · Guido Giusti⁶

Table 1 Demographic data and clinical characteristics

No.	Age/sex	Stone size (cm)/HU	Anatomic abnormalities	Metabolic comorbidity	Cardiac or neurological comorbidity	Preoperative uroculture	Preoperative stent/nephrostomy	Prophylactic antibiotics	Operative time (min)	UAS or nephrostomy	Cause of death	Pathogens
1	66/F	1 + 1.5/550	Absent	Pathologic obesity	Mitral insufficiency, cardiac arrhythmia	N	Y	Y	113	No	Septic shock and acute respiratory failure	NA
2	70/F	NA	Filling defect in the renal pelvis	Absent	–	NA	Y	Y	20	Y (12/14)	Septic shock	<i>Enterococcus faecalis</i> (?)
3	44/F	1.7/600	Solitary kidney	Absent	Advanced multiple sclerosis	N	N	Y	55	Y (12/14)	Septic shock	<i>Candida glabrata</i>
4	75/F	3.3/NA	Absent	Absent	Arterial hypertension, cardiac arrhythmia	N	N	Y	90	Nephrostomy	Hemorrhagic complication	Multiresistant <i>E. coli</i>
5	48/M	1.2/NA	Absent	Absent	–	N	N	Y	65	No	Septic shock and acute respiratory failure	<i>Proteus mirabilis</i>
6	48/M	1.1/900	Absent	Absent	–	N	N	Y	NA	NA	Cardiac arrest	–

HU Hounsfield units, UAS ureteral access sheath, Ch Charrière, N negative, Y yes, NA not appropriate

Table 2 Best practices to minimize the risk of septic complications for endourological stone management

Practice	Reasons and alternative options	References
Operate only on patients with sterile urine	The use of prophylactic antibiotics is a recommendation (LE 4, Gr A) If history of UTIs starts antibiotics 2 days before If purulent urines are found above an obstructing stone, take a sample for culture and place an ureteral drainage, stop and delay the RIRS	[5, 8, 11]
Always try to reasonably place a UAS	If the UAS placement was impossible, a sheathless procedure (if possible, a sheathless procedure should be considered) a UAS should be placed for passive irrigation	[5]
Always irrigate with caution checking the continuous fluid outflow	If high pressures are necessary, planning a second look or the use of endoluminal isoproterenol irrigation could be helpful	[6]
Do not exceed an operative time of 2 h (1 for children)	If there is a complex case or high stone burden, a staged procedure is advisable	[1]
Carefully monitor patients in the early postoperative phase	If there is postoperative fever promptly check procalcitonin levels (90 % of septic complications occur within 6–12 h) and start with antibiotics	[9, 10]

요관경 기구 세척 및 관리에 대한 언급 (-)

Comparison of single-use and reusable flexible ureteroscope for renal stone management: a pooled analysis of 772 patients

Yongchao Li[†], Jinbo Chen[‡], Zewu Zhu, Huimin Zeng, Feng Zeng, Zhiyong Chen, Zhongqing Yang, Yu Cui, Hequn Chen, Yang Li[^]

C

Study or Subgroup	Experimental		Control		Weight	Odds Ratio M-H, Fixed, 95% CI	Year
	Events	Total	Events	Total			
Dingjie 2015	9	180	6	174	24.4%	1.47 [0.51, 4.23]	2015
Usawachintachit 2017	3	92	3	50	15.8%	0.53 [0.10, 2.72]	2017
Qi 2019	6	63	9	63	34.2%	0.63 [0.21, 1.89]	2019
Kam 2019 (1)	2	55	4	64	15.0%	0.57 [0.10, 3.22]	2019
Kam 2019 (2)	1	31	4	64	10.6%	0.50 [0.05, 4.67]	2019
Total (95% CI)		421		415	100.0%	0.80 [0.44, 1.46]	

Total events

21

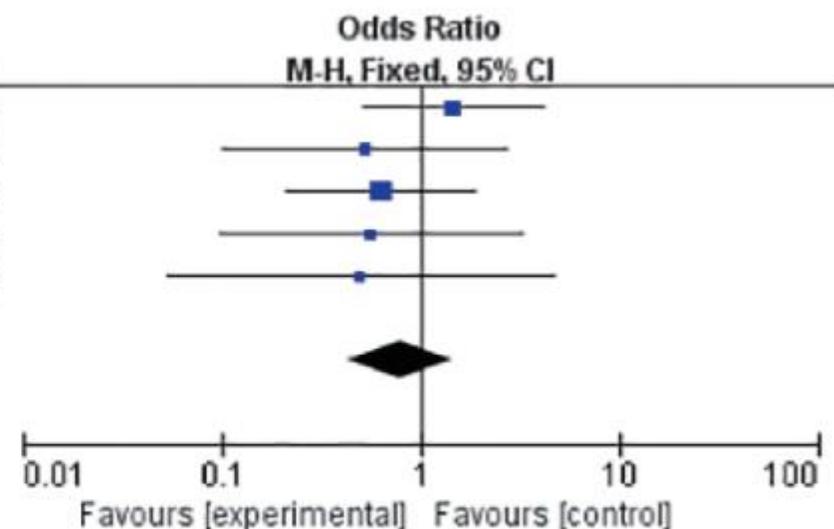
26

Heterogeneity: $\text{Chi}^2 = 2.04$, $\text{df} = 4$ ($P = 0.73$); $I^2 = 0\%$ Test for overall effect: $Z = 0.74$ ($P = 0.46$)

Footnotes

(1) Disposable 1

(2) Disposable 2



비뇨의학과 기구

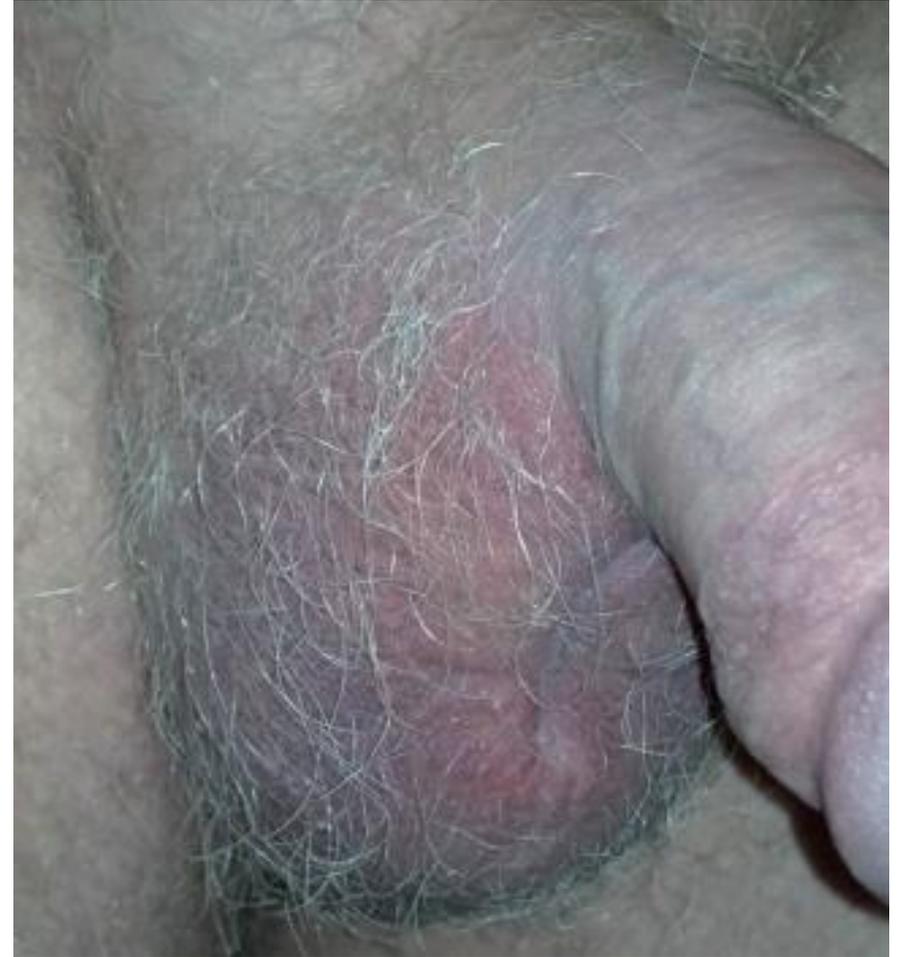
- 도뇨관 (Foley catheter)
- 요관경 Ureteroscope/flexible ureteroscope
- 음경 보형물 (Penile prosthesis)

발병 기전

1. 수술 중 상처를 통한 감염
2. 섬유피막(Fibrous capsule) : 이물질에 대한 면역반응이 섬유 피막을 만들고 내부로 혈액 순환이 줄어들고 host의 면역 시스템이 제한됨
3. 바이오 필름(Biofilm): 세균이 만든 extracellular matrix substances로 된 보호막

음경 보형물 감염

- 급성 감염 (< 8주)
- 시술 중 발생한 기구 직접 감염
- Skin flora, **S. aureus**



음경 보형물 감염

- 지연성 감염
- 증상이 모호함. 감염증상이 비교적 적게 나타나며 주로 첫 1년에 많이 발생함.
- Skin flora. **S. epidermidis**



음경 보형물 관련 감염 예방

Infection Prevention Strategies Prior to Penile Implant Surgery

Robert J. Carrasquillo^{a,*}, Martin S. Gross^b

Table 1: Strategies for reducing primary inflatable penile prostheses infections in the preoperative and intraoperative periods

	<i>Preoperative</i>	<i>Intraoperative</i>
Strategy	Optimization of comorbid conditions, particularly diabetes control and cardiovascular risk factors Assess for signs of infection or skin integrity issues Nasal swab and treatment for <i>Staphylococcus aureus</i> Preoperative chlorhexidine wash Preoperative antibiotics	Surgeon specializing in IPP placement Surgical checklist Surgical site preparation: hair removal and skin preparation No-touch technique Infection retardant prosthetic coatings Mummy wrap Corporal washout (revisions)

IPP: inflatable penile prosthesis

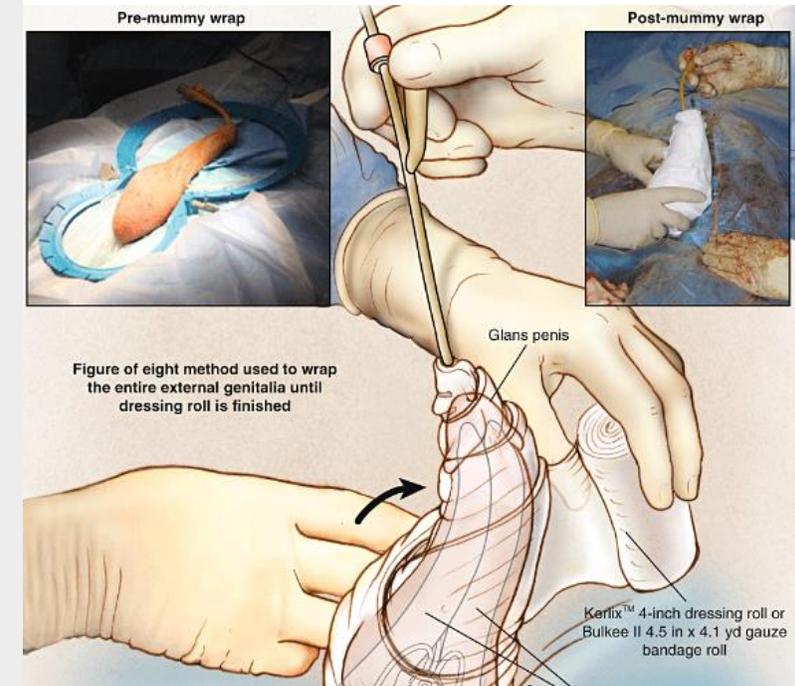
intraoperative glycemic control where applicable (goal <200 mg/dl serum glucose)

Prior penile implant

Careful patient selection
 Strategies as above where applicable
 Salvage washout

음경 보형물 관련 감염 예방

- 수술 부위 소독 : chlorhexidine
- 기구를 최대한 직접 만지지 않기!
- 수술 부위 출혈 예방
(기구 부풀리기, 배액관 삽입, **Mummy wrap**)



Summary

1. 도뇨관 : 꼭 필요한 경우에만! , 관리 및 감염 예방 manual이 필요하며 문제가 발생시 feedback 및 개선에 대한 관심이 필요합니다. non-invasive urine drainage에 대한 고려
2. 요관경(연성내시경) : 수술 전 infection control, access sheath 사용, 표준화된 세척 관리에 대한 매뉴얼
3. 음경보형물 : surgical site preparation, no touch technique, hematoma prevention

감사합니다