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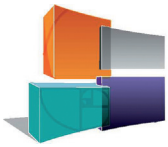

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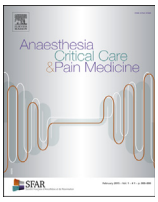

Guidelines

Antibioprophylaxis in surgery and interventional medicine (adult patients). Update 2017☆,☆☆

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ABSTRACT

Infection is a risk for any intervention. In surgery, for example, pathogenic bacteria are found in more than 90% of operative wounds during closure. This exists whatever the surgical technique and whatever the environment (the laminar flow does not entirely eliminate this risk). These bacteria are few in number but can proliferate. They find in the operative wound a favourable environment (haematoma, ischaemia, modification of oxido-reduction potential...) and the intervention induces anomalies of the immune defences. In the case of the installation of foreign material, the risk is increased. The objective of antibiotic prophylaxis (ABP) is to prevent bacterial growth in order to reduce the risk of infection at the site of the intervention. The preoperative consultation represents a privileged moment to decide on the prescription of a ABP. It is possible to define the type of intervention planned, the associated risk of infection (and therefore the necessity or not of ABP), the time of prescription before surgery and any allergic antecedents which may modify the choice of the selected antibiotic molecule.

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1. Preamble

Infection is a risk for any intervention. In surgery, for example, pathogenic bacteria are found in more than 90% of operative wounds during closure. This exists whatever the surgical technique and whatever the environment (the laminar flow does not entirely eliminate this risk). They find in the operative wound a favourable environment (haematoma, ischaemia, modification of oxidoreduction potential...) and the intervention induces anomalies of the immune system. In the case of the installation of foreign material, the risk is increased. The objective of antibiotic prophylaxis (ABP) is to prevent bacterial growth in order to reduce the risk of infection at the site of the intervention. The preoperative consultation represents a privileged moment to decide on the prescription of a ABP. It is possible to define the type of intervention planned, the associated risk of infection (and therefore the necessity or not of ABP), the time of prescription before surgery and any allergic antecedents which may modify the choice of the selected antibiotic molecule.

Since 1992, the SFAR has established and regularly updated recommendations for the prescription of ABP in surgery and interventional medicine for adult patients. The latest recommendations were established in 2010 and are being updated based on literature data published since then.

An exhaustive bibliographic search of the relevant articles was carried out on the available databases:

- the French-based health assessment (http://bfes.anaes.fr/HTML/index.html);
- the *National Guideline Clearinghouse* American (Http://www.guidelines.gov);
- the Lemanissier library in France (http://www.bmlweb.org/consensus.html);
- the Cochrane Library (http://www.cochrane.org/index0.htm);
- the PUBMED database (http://www.pubmed.org).

The keywords used were: antibioprophylaxis, antibiotic prophylaxis, surgery, interventional radiology, postoperative infection, antibiotic prophylaxis, perioperative antibiotics, surgery, interventional radiology, postoperative infection.

2. Methodology

2.1. General introduction to the GRADE method

The working method used for the preparation of these recommendations is the GRADE ® method. After a quantitative analysis of the literature, this method allows the quality of the evidence to be determined separately, and therefore an estimate of the confidence, which can be obtained from the quantitative analysis, and a level of recommendation are obtained. The quality of evidence is divided into four categories:

- high: future research will most likely not change the confidence in the estimate of the effect;
- moderate: future research will likely change the confidence in the estimate of the effect and may alter the estimate of the effect itself;
- low: future research will most likely have an impact on the confidence in the estimate of the effect and will likely change the estimate of the effect itself;
- very low: the estimate of the effect is very uncertain;

The quality of evidence analysis is performed for each judgment criterion and then an overall level of proof is defined based on the quality of the evidence of the critical criteria.

The final formulation of the recommendations is always binary: either positive or negative and either strong or weak:

- strong: we recommend/we do not recommend (GRADE 1+ or 1−);
- low: we suggest/we do not suggest (GRADE 2+ or 2−).

The strength of the recommendation is determined according to four key factors and validated by the experts after a vote, using the GRADE Grid method:

- estimate of the effect;
- the overall level of evidence: the higher the level of evidence, the more likely the recommendation;
- the balance between desirable and undesirable effects: the more favourable the balance, the stronger the recommendation;
- values and preferences: in case of uncertainty or great variability, the more likely the recommendation will be low; these values and preferences must be obtained as best as possible from the persons concerned (patient, doctor, decision-maker);
- costs: the higher the costs or the resource utilisation, the more lower the recommendation.
- to make a recommendation, at least 50% of the participants have to have an opinion and less than 20% must prefer the opposite proposition;
- to make a strong recommendation at least 70% of the participants must agree;
- if the experts do not have studies dealing specifically with the topic, or if there are no data on the main criteria, no recommendation will be issued. Expert advice may be given while clearly differentiating it from the recommendations.

3. Recommendations fields

The update of recommendations for the practice of antibiotic prophylaxis in surgery and interventional medicine (adult patients) is divided into 4 questions followed by recommendations in the form of tables framing the practice of prescribers.

1. Which surgeries of the classes of Altemeier must have antibiotic prophylaxis?
2. What are the principles for the choice of antibiotics used?
3. What is the time of prescription?
4. What is the duration of the antibiotic prescription?

4. Question 1: Which Altemeier classes of surgeries must have an antibiotic prophylaxis?

R1 - We recommend using antibiotic prophylaxis in certain surgeries considered ''clean'' (See the tables below for the relevant surgeries) and all surgeries considered ''clean-contaminated''
(Grade 1+) Strong Agreement

4.1. Rationale

Altemeier classes are clean surgery, clean-contaminated, contaminated, infected. ABP applies to certain interventions ''clean'' and all ''clean-contaminated'' [1–4]. For interventions considered ''contaminated'' and ''infected'', infection is already in place and needs curative antibiotics, which have different rules, particularly in terms of prescription time [5,6].

5. Question 2: What are the principles of choice of antibiotics used?

R2 - We recommend that the antibiotic include in its spectrum of activity the main bacteria involved in the surgical site infection.
(Grade 1+) Strong Agreement

5.1. Rationale

Antibiotic prophylaxis (ABP) must apply to defined bacterial targets, recognised as the most frequently involved. The protocol of ABP must include a molecule including in its spectrum bacterial targets. Methodologically acceptable work must have validated its activity, its local diffusion and its tolerance in this indication. It is essential to select molecules with a narrow spectrum of activity and which are approved in this indication [7–10].

Each team must determine in a written protocol which practitioner is responsible for prescribing and monitoring the ABP. This may be the anaesthesiologist, the surgeon, the gastroenterologist, the radiologist... In France, ABP is practically always managed by the anaesthesiologist. However, there is a shared responsibility with the operators. The protocol should clearly determine who does what in the field [11,12].

The initial (or loading) dose of antibiotic is usually twice the usual dose. This applies to a weight of 100 kg (the pharmacokinetic data can be assured of getting sufficient tissue concentrations of antibiotic. In obese patients (patients over 100 kg and body mass index > 35 kg/m$^{2)}$, even during non-bariatric surgery, the beta-lactams doses should be double those recommended for non-obese patients. For vancomycin and gentamicin see table for bariatric surgery. Re-injections are performed during the surgical period, every two half-lives of the antibiotic, at a dose that is similar to or half the initial dose. For example for cefazolin, with a half-life of 2 hours, reinjection is necessary only if the intervention lasts more than 4 hours.

ABP protocols are locally established after agreement between surgeons, anaesthesiologists, specialists in infectious diseases, microbiologists and pharmacists. They are the subjects of an economic analysis in relation to other possible choices. Their effectiveness is regularly reviewed by an oversight of surgical site infection rates and microorganisms responsible in surgical patients or not. Regular evaluation of professional practices (EPP) is highly recommended (see Collège Français des anesthésistes-réanimateurs www.cfar.org) [13,14].

Systematic rotation with other molecules equally valid for the same indication may be considered. Thus, in each institution or surgical wards, an ABP policy must be established, i.e. a list of interventions grouped according to whether or not they are subject to ABP with, for each group, the molecule chosen and its alternative in case of allergy. In the same WARD, it is recommended to distinctly choose the molecules used in ABP and curative antibiotic therapy. The selected protocols must be written, co-signed by the anaesthesiologists and the operators.

These protocols must be available and may be displayed in pre-anaesthetic consultation rooms, intervention rooms, post-intervention surveillance rooms and care units.

Patients with particular infectious risk.

Many factors are considered possibly or probably related to the occurrence of surgical site infection. Their presence is not, however, the justification for prescribing ABP in situations where this is not recommended. Only studies with a high level of evidence on these patients would, if positive, allow the prescription of ABP in the presence of a given risk factor.

Subjects potentially colonised by nosocomial bacterial flora and early re-intervention for non-infectious cause.

This concerns hospitalised subjects in the three previous months in units with high risk of acquiring this type of flora: Intensive care units, nursing home or rehabilitation centres, travel abroad in the year before. The risk of colonisation by multi-resistant Enterobacteriaceae or methicillin-resistant Staphylococcus aureus then exists.

Patients undergoing early reoperation for a non-infectious cause.

For these patients, screening colonisation by multiresistant bacteria can be recommended. The usual choice of ABP can be modified by using, alone or in combination, antibiotic molecules normally used in curative treatment (3rd generation cephalosporins, systemic quinolones, aminoglycosides and vancomycin).

In all cases:

- derogations from the usual protocols must remain exceptional. The potential benefit to the patient should be assessed against the risk for the community: emergence of bacterial resistances, cost;
- the potential infectious risk should be clearly identified;
- prescription must be short, limited to the operating period.

Patients who received radiotherapy, chemotherapy or corticosteroids, patients with diabetes, elderly patients, obese or anorexic.

Although these patients are at high risk of surgical site infection, they will have infections due to ''bacteria targets'' covered by the usual ABP. No modification of the protocols is justified in these patients.

Transplants (see www.agence-biomedecine.fr Biomedicine Agency - Recommendations Organ Transplant Infection Prevention graft).

The prevention of opportunistic infections linked to immunosuppression (viral, fungal and parasitic) is beyond the scope of the guidelines. With regard to prevention of infection of the surgical site, two situations can be summarised:

- outpatient: postoperative infection caused by community bacteria. ABP is chosen according to the grafted organ;
- patient potentially colonised by nosocomial flora: ABP is adapted according to the local ecology and includes molecules usually reserved for the treatments of the declared infections;
- in all cases, the period of limitation remains limited; single dose or, at most, prescription up to 48 hours [15,16].

6. Question 3: What is the time of prescribing?

R3 - We recommend starting antibiotic prophylaxis (ABP) before surgery within a period of about 30 minutes. When using vancomycin, we recommend infusion be started early enough to be completed 30 minutes before the procedure.
(Grade 1+) Strong Agreement

6.1. Rationale

The optimal time of prescription has generated a very important debate in recent years especially for gynaecological surgery [17–45]. ABP must always precede the operation within approximately 30 minutes [9,17,18,45]. This is a fundamental point. The injection of the anaesthetic drugs should be separated by 5 to 10 minutes from that of ABP, so that, in the event of an allergic reaction, it is possible to determine what drug is responsible for what.

7. Question 4: What is the duration of the prescription?

R4 - We suggest prescription be limited to the operative period, sometimes 24 hours, exceptionally 48 hours and never beyond.
(Grade 2) Strong Agreement

7.1. Rationale

ABP should be brief, limited to the operative period, sometimes 24 hours and exceptionally to 48 hours and never beyond [46–66]. The presence of drainage of the surgical site does not allow transgressing these recommendations. There is no reason to prescribe reinjection during removal of drains, probes or catheters [67–89]. The outpatient nature of surgery does not change the protocols usually used.

Not to be forgotten

The prescription of ABP is an integral part of the preoperative consultation. The anaesthesiologist and surgeon have all the necessary elements to make the best decision: planned intervention, patient history (allergies, infectious etc.), and ecology of the surgical wards. Efficiency of ABP is proven for many interventions, but its prescription must obey certain rules, established from the data of numerous studies on the subject. ABP protocols must be re-evaluated on a regular basis. It takes into account new scientific data, the evolution of interventional techniques and bacterial resistance profiles.

- The antibiotics used must be effective against the main bacteria responsible for post-operative infection.
- It must be started before the procedure (within 30 minutes), so that the antibiotic is present before bacterial contamination occurs.
- The duration of prescription should be brief, to minimise the ecological risk of resistant organisms to any antibiotic. A single preoperative injection has proven effective for many interventions and prescription beyond 48 hours is prohibited in all cases.
- Effective tissue concentrations must be maintained throughout the procedure. Coverage of prolonged surgery is achieved either by using an antibiotic with a long half-life, or with intraoperative reinjection.
- With equal efficiency, the practitioner must opt for the cheapest product.

Important note for prescribers

The proposed recommendations may not cover all clinical situations. Some procedures have not been scientifically evaluated as irrigation or topical antibiotics intraoperatively. Future publications will specify further what to do in these unclear situations.

In the absence of specific recommendations for a given situation, practitioners can, by assessing the risk/benefit ratio, prescribe ABP, and try to get similar conditions or techniques.

In Tables 1–16 are presented the recommendations from the expert in the different types of surgeries.

R5. Antibiotic prophylaxis in neurosurgery
(Expert opinion)

7.2. Rationale

Without antibiotic prophylaxis (ABP) in neurosurgery craniotomy with and without implantation of foreign material, the risk of infection is 1 to 5%. This risk is on average 10%, when a

Table 1
Neurosurgery.

Surgery	Product	Initial dose	Re-injection and duration
CSF shunt	Cefazolin	2g IV slow	Single dose (if duration > 4h reinject 1g)
	Allergy: vancomycin[a]	30 mg/kg/120 min	Single dose
External CSF shunt	No ABP		
Craniotomy	Cefazolin	2g IV slow	Single dose (if duration > 4h reinject 1g)
	Allergy: vancomycin[a]	30 mg/kg/120 min	Single dose
Neurosurgery transsphenoidal routes and trans-labyrinthine	Cefazolin	2g IV slow	Single dose (if duration > 4h reinject 1g)
	Allergy: vancomycin[a]	30 mg/kg/120 min	Single dose
Spine surgery with implantation of prosthetic material	Cefazolin	2g IV slow	Single dose (if duration > 4h reinject 1g)
	Allergy: vancomycin[a]	30 mg/kg/120 min	Single dose
Cranio-cerebral wounds	Peni A + IB[b]	2g IV slow	2 g every 8 hours 48h maximum
	Allergy: vancomycin[a]	30 mg/kg/120 min	30 mg/kg/day 48h maximum
Fracture of skull base with rhinorrhoea	No ABP		

[a] Indications of vancomycin: allergy to beta-lactams; suspected or proven colonisation by methicillin-resistant staphylococcus, reoperation in a patient hospitalised in a unit with an ecology including methicilline-resistant *Staphylococcus aureus*, previous antibiotic therapy. The injection lasts 120 minutes and must end at the latest at the beginning of the intervention and the best 30 minutes before.
[b] Aminopenicillin + beta-lactamase inhibitor.

Table 2
Ophtalmology.

Surgery	Product	Initial dose	Dosage and duration
Open eye surgery other than cataracts with risk factors (see above)	Levofloxacin oral	500 mg	1 tab 12 hours before + 1 tab 2 to 4 hours before
Cataract[a]	Intracameral injection cefuroxime[a]	1 mg in 0.1 mL	At the end of the procedure
Open eye trauma	Levofloxacin	500 mg	500 mg IV on day 1 + 500 mg orally on day 2
Lacrimal ducts wounds	Peni A + IB[b]	2g	Reinjection of 1g if > 2 h
Puncture of the anterior chamber	No ABP		
Subretinal fluid puncture	No ABP		
Closed globe surgery	No ABP		
Intravitreal injections	No ABP		

[a] For cataract surgery with and without risk factors, a single injection into the anterior chamber of cefuroxime (1 mg) is approved since 2014.
[b] Aminopenicillin + beta-lactamase inhibitor.

Table 3
Cardiac surgery.

Surgery	Product	Initial dose	Re-injection and duration
Cardiac surgery	Cefazolin	2g IV + 1g in priming	1g at the 4th hour intraoperatively
	Cefamandole or cefuroxime	1.5g IV + 0.75g priming	1 reinjection 0.75g every 2 hours intraoperatively
	Allergy: vancomycin[a]	30 mg/kg/120 min	Single dose
Pacemaker	See above heart surgery	See above heart surgery	Single dose
Endovascular procedure	See above heart surgery	See above heart surgery	Single dose
Pericardial drainage	No ABP		
Coronary dilatation +/- stent	No ABP		
ECMO…	No ABP		

[a] Indications of vancomycin: allergy to beta-lactams; suspected or proven colonisation by methicillin-resistant staphylococcus, reoperation in a patient hospitalised in a unit with an ecology including methicilline-resistant *Staphylococcus aureus*, previous antibiotic therapy. The injection lasts 120 minutes and must end at the latest at the beginning of the intervention and the best 30 minutes before.

Table 4
Vascular surgery.

Surgery	Product	Initial dose	Re-injections and duration
Surgery of the aorta, arteries of the lower limbs, supra-aortic trunks	Cefazolin	2g IV slow	Single dose (if time > 4 h, reinject 1g)
	Cefamandole or cefuroxime	1.5g IV slow	Single dose (if duration > 2 h, reinject 0.75g)
Arterial endoprosthesis. Carotid surgery with patch	Allergy: vancomycin[a]	30 mg/kg/120 min	Single dose
Expansion with or without stent	See above Aortic surgery	See above Aortic surgery	Single dose
Carotid surgery without patch	No ABP	No ABP	
Limb amputation	Peni A + IB[b]	2g IV slow	1g/6 hours for a period of 48 hours
	Allergy: clindamycin + gentamicin	900 mg IV slow 5 mg/kg/d	600 mg/6 hours for 48 hours Reinject 5 mg/kg at hour 24
Vein surgery	No ABP		

[a] Indications of vancomycin: allergy to beta-lactams, suspected or proven colonisation by methicillin-resistant staphylococcus, reoperation in a patient hospitalised in a unit with an ecology including methicilline-resistant *Staphylococcus aureus*, previous antibiotic therapy. The injection lasts 120 minutes and must end at the latest at the beginning of the intervention and the best 30 minutes before.
[b] Aminopenicillin + beta-lactamase inhibitor.

cerebrospinal fluid shunt (CSF) is present. Infection can be localised at the surgical site or extended to the brain or ventricles. The decrease in the risk of infection by antibiotic prophylaxis is unquestionable in the presence of a craniotomy and very likely during the installation of a CSF shunt valve. In spinal surgery, a meta-analysis recommends the use of an ABP but does not specify whether it applies to surgeries with implementation or not of material.

Target bacteria: Enterobacteriaceae (especially after craniotomies), staphylococci (*S. aureus* and *S. epidermidis*, anaerobic bacteria flora (especially after cranio-cerebral wound) (Table 1).

R6. Antibiotic prophylaxis in ophthalmic surgery (Expert opinion)

7.3. Rationale

The major risk of infection of eye surgery is represented by endophthalmitis whose consequences can lead to the loss of the eye.

For cataract surgery (800,000 patients/year in France), the risk of postoperative endophthalmitis, in the absence of antibiotic prophylaxis, is 2 to 3/1000. Following the recommendations of the AFSSAPS published in 2011, the vast majority of surgeons use systematically intracameral injection of 1 mg of cefuroxime after surgery. In exceptional cases of allergy to cefuroxime, the recommendations are the same as for other intraocular surgeries, adding as a risk factor extracapsular extraction and secondary implantation.

For other surgeries, antibiotic prophylaxis is recommended only in the presence of the following risk factors:

Table 5
Orthopaedic surgery.

Surgical act	Product	Initial dose	Re-injection and duration
Joint prosthesis(upper limb, lower limb)	Cefazolin	2g IV slow	1g if duration > 4 h Limited to the operative period (24 hours max)
	Cefamadole	1.5g IV slow	0.75g if duration > 2 h Limited to the operative period (24 hours max)
	Cefuroxime	1.5g IV slow	0.75g if duration > 2 h Limited to the operative period (24 hours max)
	Allergy: clindamycine or vancomycin	900 mg IV slow 30 mg/kg/120 min	Limited to the operative period (24 hours max)
Foreign material (resorbable or not, cement, bone graft…) and whatever the technique (percutaneous, videoscopy…)	Cefazolin	2g IV slow	1g if duration > 4 h
Joint surgery arthrotomy			
	Allergy: clindamycin or vancomycin	900 mg IV slow 30 mg/kg/120 min	Single dose
Arthroscopy without implant (with or without meniscectomy) extra-articular soft tissue surgery without implant	No ABP		
Spine surgery with implantation of prosthetic material	Cefazolin	2g IV slow	Single dose (if duration > 4h reinject 1g)
	Allergy: vancomycin[a]	30 mg/kg/120 min	Single dose

[a] Indications of vancomycin: allergy to beta-lactams, suspected or proven colonisation by methicillin-resistant staphylococcus, reoperation in a patient hospitalised in a unit with an ecology including methicilline-resistant *Staphylococcus aureus*, previous antibiotic therapy. The injection lasts 120 minutes and must end at the latest at the beginning of the intervention and the best 30 minutes before.

Table 6
Trauma.

Surgical act	Product	Dosage	Reinjection and duration
Closed fracture requiring isolated extrafocal osteosynthesis	No ABP		
Closed fracture requiring intrafocal osteosynthesis Open fracture stage I Cauchoix	Cefazolin	2g slow IV	1g if duration > 4 h Limited to the operative period (24 hours max)
Soft tissue wound non-contused, with or without lesion of artery, nerve, tendon	Cefamandole	1.5g slow IV	0.75g if duration > 2 h Limited to the operative period (24 hours max)
Articular wound	Cefuroxime	1.5g slow IV	0.75g if duration > 2 h Limited to the operative period (24 hours max)
	Allergy: clindamycin + gentamicin	900 mg slow IV 5 mg/kg/d	600 mg if duration > 4 h
Open fracture stage II and III Cauchoix	Peni A + IB[a]	2g IV slow	1g if duration > 2 h 48 h maximum
Large wound soft tissue contused with or without lesion of artery, nerve, tendon	Allergy: clindamycin	900 mg IV slow	600 mg if duration > 4 h 48 h maximum
	+ gentamicin	5 mg/kg/d	48 h maximum

[a] Aminopenicillin + beta-lactamase inhibitor.

- diabetes, intraocular implantation of a device other than during cataract;
- special cases: history of endophthalmitis, monophthalmic patient.

Topical antibiotic prophylaxis is a prescription of the ophthalmologist. It is not within the competence field of anaesthetists.

Target bacteria: staphylococci, streptococci, *H. influenzae,* enterobacteria (Table 2).

R7. Antibiotic prophylaxis in cardiac surgery (Expert opinion)

7.4. Rationale

Cardiac surgery is a clean surgery (class 1 Altemeier). Extracorporeal circulation, duration of response and the complexity of procedures may increase the risk of infection. The usefulness of antibiotic prophylaxis has been clearly demonstrated. Its prescription beyond the operative period is not recommended. The use of local antibiotics is not recommended.

Target bacteria: *S. aureus, S. epidermidis,* some Gram-negative bacteria (Table 3).

R8. Antibiotic prophylaxis in vascular surgery (Expert opinion)

Vascular surgery is a clean surgery (class 1 Altemeier) but some procedures can be classified as clean-contaminated if distal trophic disorder or even dirty for amputations of infected gangrene. The effectiveness of antibiotic prophylaxis has been clearly demonstrated in this type of surgery. Antibiotic prophylaxis should be practiced even if antibiotic therapy is given before surgery to treat a distal trophic disorder. The use of prostheses soaked in antibiotics is always associated with IV antibioprophylaxis. Antibiotic prophylaxis should be made regardless of the surgical approach (laparoscopic or open).

Target bacteria: *S. aureus*, *S. epidermidis*, gram-negative bacilli (Table 4).

R9. Antibiotic prophylaxis in orthopaedic surgery (Expert Opinion)

7.5. Rationale

The incidence of postoperative infection in prosthetic joint surgery without ABP is 3 to 5%. The ABP can reduce this rate to less than 1%.

Table 7
Thoracic surgery.

Surgery	Product	Initial dose	Re-injection and duration
Pulmonary resection (including video-assisted surgery)	Peni A + IB[a]	2g IV slow	Single dose (if duration > 2h reinject 1g)
	or	1.5g IV slow	Single dose (if duration > 2h reinject 0.75g)
	cefamandole	1.5g IV slow	Single dose (if duration > 2h reinject 0.75g)
	or	2g IV slow	Single dose (if time > 4h reinject 1g)
	cefuroxime	900 mg IV slow	Single dose (if duration > for 4h, inject 600 mg)
	or	5 mg/kg/d	Single dose
	cefazoline		
	Allergy:		
	clindamycine		
	+		
	gentamicin		
Mediastinal surgery	Cefamandole	1.5g IV slow	Single dose (if duration > 2h reinject 0.75g)
Surgery for pneumothorax	or	1.5g IV slow	Single dose (if duration > 2h reinject 0.75g)
Decortication (uninfected patient)	cefuroxime	2g IV slow	Single dose (if time > 4h reinject 1g)
Isolated parietal resection	or	900 mg IV slow	Single dose (if time > 4h inject 600 mg)
	cefazoline	5 mg/kg/d	Single dose
	Allergy:		
	clindamycine		
	+		
	gentamicin		
Mediastinoscopy, videothoracoscopy	No ABP		
Tracheostomy	No ABP		
Thoracic drainage	No ABP		

[a] Aminopenicillin + inhibitor of beta-lactamases.

Table 8
ENT.

Surgery	Product	Initial dose	Re-injection ans duration
Rhinologic surgery with placement of a graft or reoperation	Cefazolin	2g IV slow	Single dose
	Peni A + IB[a]	2g IV slow	Single dose
Neck Surgery with oropharyngeal opening. Surgery of the salivary glands with access through the oropharyngeal cavity	Peni A + IB[a]	2g IV slow	Re-injection of 1g every 2h during intraoperative then 1g every 6 hours for 24 hours
	Allergy: clindamycin + gentamicin	900 mg IV slow 5 mg/kg/d	Re-injection of 600 mg if duration > 4h and then 600 mg/6 hours for 24 hours Single dose
Stapes surgery, middle ear	No ABP		
Alveolar surgery	Prevention of endocarditis (see endocarditis prophylaxis)		
Salivary glands surgery without access by the oropharyngeal cavity	No ABP		
Cervicotomy	No ABP		
Lymphadenectomy	No ABP		
Velopalatin surgery	No ABP		
Tonsillectomy	No ABP		

[a] Aminopenicillin + beta-lactamase inhibitor.

Table 9
Maxillo facial surgery.

Surgery	Product	Initial dose	Re-injection and duration
Maxillofacial surgery with oropharyngeal opening. Surgery of the salivary glands with access through the oropharyngeal cavity	Peni A + IB[a]	2g IV slow	Re-injection of 1g every 2h during intraoperative then 1g every 6 hours for 24 hours
	Allergy: clindamycin + gentamicin	900 mg IV slow 5 mg/kg/day	Re-injection of 600 mg if duration > 4h and then 600 mg/6 hours for 24 hours Single dose
Alveolar surgery	Prevention of endocarditis (see endocarditis prophylaxis)		
Salivary glands surgery without access by the oropharyngeal cavity	No ABP		
Cervicotomy	No ABP		
Lymphadenectomy	No ABP		
Velopalatin surgery	No ABP		
Tooth extraction in non-septic environment	Prevention of endocarditis (see endocarditis prophylaxis)		

[a] Aminopenicillin + beta-lactamase inhibitor.

Table 10
Digestive surgery.

Surgery	Product	Initial dose	Re-injection and duration
Oesophageal Surgery (without coloplasty) Gastroduodenal surgery (including endoscopic gastrostomy and duodenopancreatectomy) Pancreatic surgery Liver surgery	Cefazolin	2g IV slow	Single dose (if duration > 4 pm reinject 1g)
	Cefuroxime or Cefamandole	1.5g IV slow	Single dose (if duration > 2h reinject 0.75g)
	Allergy: gentamicin + clindamycin	5 mg/kg/d 900 mg IV slow	Single dose Single dose (if duration > for 4h, inject 600 mg)
Biliary tract surgery (the biliary prosthesis patients are excluded from recommendations)	Cefazolin	2g IV slow	Single dose (if duration > 4h, reinject 1g)
	Cefuroxime or Cefamandole	1.5g IV slow	Single dose (if duration > 2h, reinject 0.75g)
	Allergy: gentamicin + clindamycin	5mg/kg/d 900 mg IV slow	Single dose Single dose (if duration > 4h, inject 600 mg)
Gallbladder surgery laparoscopically without risk factors[a]	No ABP		
Colonic and intestinal surgery	Cefoxitin + metronidazole	2g IV Slow 1g infusion	Single dose (if duration > 2h reinject 1g) Single dose
	Allergy: imidazolé + gentamicine	1g (infusion) 5 mg/kg/d	Single dose Single dose
Anal surgery	Imidazole	1g (infusion)	Single dose
Hernia without prosthetic plate	No ABP		
Hernia with establishment of a prosthetic plate	Cefazolin	2g IV slow	Single dose (if duration > 4h, reinject 1g)
	Cefuroxime or Cefamandole	1.5g IV slow	Single dose (if duration > 2h, reinject 0.75g)
	Allergy: gentamicin + clindamycin	5 mg/kg/day 900 mg IV slow	Single dose Single dose (if duration > for 4h, inject 600 mg)
Eventration	Cefazolin	2g IV slow	Single dose (if duration > 4h, reinject 1g)
	Cefuroxime or Cefamandole	1.5g IV slow	Single dose (if duration > 2h, reinject 0.75g)
	Allergy: gentamicin + clindamycin	5 mg/kg/d 900 mg IV slow	Single dose Single dose (if duration > for 4h, inject 600 mg)
Abdomen wounds	See colorectal surgery	See colorectal surgery	See colorectal surgery
Prolaps (any surgical approach)	Peni A + IB[b]	2g IV slow	Single dose. 1g if duration > 2h
	Allergy: gentamicin + metronidazole	5 mg/kg/d 1g	Single dose Single dose

[a] Laparoscopic cholecystectomy without risk factors: absence of recent cholecystitis, no conversion to laparotomy (on the event of conversion to ABP), no pregnancy, no immune suppression, no exploration of bile duct intraoperatively. If risk factors refer to the "biliary tract surgery".
[b] Aminopenicillin + beta-lactamase inhibitor.

For the primary arthroplasty the use of cement impregnated with antibiotic must be associated with IV antibiotic.

Secondary arthroplasty during the same hospitalisation for non-infectious cause (haematoma, dislocation...) requires ABP different of the initial ABP. Methicillin-resistant *S. aureus* should probably be considered.

Late re-intervention (within one year after surgery) for mechanical causes in an ambulatory patient does not require modification of the initial ABP.

Target bacteria: *S. aureus, S. epidermidis, Propionibacterium, Streptococcus spp, E. coli, K. pneumoniae* (Table 5)

R10. Antibiotic prophylaxis in traumatology
(Expert opinion)

7.6. Rationale

The frequency of postoperative infections in trauma surgery is higher than for elective surgery regardless of the stage of severity.

Target bacteria: *S. aureus, S. epidermidis, Propionibacterium, Streptococcus spp, E. coli, E. cloacae, K. pneumoniae, Bacillus cereus,* anaerobic telluric (Table 6).

R11. Antibiotic prophylaxis in thoracic surgery
(Expert opinion)

7.7. Rationale

Non-cardiac thoracic surgery may be a clean surgery (class 1 Altemeier) (mediastinal surgery, VATS) or clean contaminated surgery (class 2) in case of opening of bronchi or trachea. Despite the complexity of situations, the utility of ABP is no longer contested today as shown by the number of validated scientific studies.

Target bacteria: Staphyloccoques, *S. pneumoniae, H. inflenzae,* Gram-negative bacteria (Table 7).

R12. Antibiotic prophylaxis ENT surgery
(Expert opinion)

Table 11
Urology.

Surgery	Product	Initial dose	Re-injection and duration
Prostate surgery			
Endoscopic resection of the prostate,	Cefazolin	2g IV slow	Single dose (if duration > 4h reinject 1 g)
cervical-prostatic incision prostatectomy	Cefamandole or cefuroxime	1.5g IV slow	Single dose (if duration > 2h, reinject 0.75 g)
	Allergy: gentamicin	5 mg/kg	Single dose
Radical prostatectomy	No ABP		
Prostate biopsy	Ofloxacin orally	Single dose 400 mg	Single dose
	Allergy: ceftriaxone	(1 hour prior to biopsy)	Single dose
		1g	
Kidney surgery, adrenal and urinary tract			
Endoscopic treatment of the renal and ureteral	Cefazolin	2g IV slow	Single dose (if duration > 4h reinject 1 g)
ithiases; ureteroscopy, percutaneous	Cefamandole and cefuroxime	1.5g IV slow	Single dose (if duration > 2h, reinject 0.75 g)
nephrolithotomy, nephrostomy,	Allergy: gentamicin	5 mg/kg/day	Single dose
JJ probe mounted or ureteral			
Nephrectomy and other upper tract surgery	No ABP		
Adrenalectomy	No ABP		
Extracorporeal lithotripsy	No ABP		
Bladder surgery			
Transurethral resection of the bladder	Cefazolin	2g IV slow	Single dose (if duration > 4 pm reinject 1g)
	Cefamandole and cefuroxime	1.5g IV slow	Single dose (if duration > 2h reinject 0.75g)
	Allergy: gentamicin	5 mg/kg	Single dose
Cystectomy (Bricker, bladder replacement)	PENI A + IB[a]	2g IV slow	Single dose
	Allergy: gentamicin	5 mg/kg	(if duration > 2h reinject 1g)
	+ metronidazole	1 g infusion	Single dose
			Single dose
Surgery of the urethra			
Urethroplasty, urethrotomy	Cefazolin	2g IV slow	Single dose
	Cefamandole and cefuroxime	1.5g IV slow	Single dose
	Allergy: gentamicine	5 mg/kg	Single dose
Artificial sphincter	Cefoxitin or amoxicillin + clavulanic acid	2g IV slow	Single dose
	Allergy: gentamicin	5 mg/kg	
	+ metronidazole	1g infusion	
Urethral support (TOT, TVT)	PENI A + IB[a]	2g IV slow	Single dose
	Allergy: gentamicin	5 mg/kg	
	+ metronidazole	1g infusion	
Male genital system			
Scrotal surgery or rod (not replacement)	No ABP		
Penile prosthesis or testicular	Cefazolin	2g IV slow	Single dose (if duration > 2h, inject 1 g)
	Allergy: vancomycin[b]	30 mg/kg/120 min	Single dose
Female genital system			
Treatment of prolapse (any surgical approach)	PENI A + IB[a]	2g IV slow	Single dose (reinject 1g if > 2h)
	Allergy: metronidazole	1g	Single dose
	+ Gentamicine	5 mg/kg/d	Single dose
Diagnostic investigations, bladder fibroscopy,	No ABP		
urodynamic evaluation, ureteroscopic diagnostic			

[a] Indications of vancomycin: allergy to beta-lactams; suspected or proven colonisation by methicillin-resistant staphylococcus, reoperation in a patient hospitalised in a unit with an ecology including methicilline-resistant *Staphylococcus aureus*, previous antibiotic therapy. The injection lasts 120 minutes and must end at the latest at the beginning of the intervention and the best 30 minutes before.
[b] Aminopenicillin + beta-lactamase inhibitor.

7.8. Rationale

In ENT surgery with oropharyngeal opening (primarily neoplastic surgery) the risk of infection is high (about 30% of patients). Many studies have clearly demonstrated the value of ABP in this type of surgery. The duration of the ABP should not exceed 24 hours as evidenced by the methodologically correct studies. Beyond this period, it is a curative antibiotic therapy. The presence of drainage is not an argument for extending the duration of the ABP.

Target bacteria: *Streptococcus*, anaerobic bacteria, *S. aureus, K. pneumoniae, E. coli* (Table 8).

R13. Antibiotic prophylaxis in dentistry and maxillofacial surgery (Expert opinion)

7.9. Rationale

In stomatology and maxillofacial surgery with oropharyngeal opening (primarily neoplastic surgery) the risk of infection is high (about 30% of patients). Many studies have clearly demonstrated the value of ABP in this type of surgery. The duration of ABP should not exceed 48 hours as evidenced by the methodologically correct studies. Beyond this period, it is a curative antibiotic therapy. The presence of drainage is not an argument for extending the duration of the ABP.

Target bacteria: *Streptococcus,* anaerobic bacteria, *S. aureus, K. pneumoniae, E. coli* (Table 9)

R14. Antibiotic prophylaxis in gastrointestinal surgery (Expert opinion)

Table 12
Gynecology obstetrics.

Surgery	Product	Initial dose	Re-injection and duration
Hysterectomy (high or low road)	Cefazolin	2g IV slow	Single dose (if duration > 4 h, inject 1 g)
Coeliosurgery	Cefamandole	1.5g IV slow	Single dose (if duration > 2 h, reinject 0.75 g)
	Cefuroxime	1.5g IV slow	Single dose (if duration > 2 h, reinject 0.75 g)
	Allergy: clindamycin + gentamicin	900 mg IV slow	Single dose
		5 mg/kg/day	Single dose
Laparoscopy diagnostic or exploratory without vaginal incision or digestive	No ABP		
Hysteroscopy hysterosalpingography	No ABP		
Endometrial biopsy	No ABP		
In vitro fertilisation	No ABP		
Laying of an intrauterine device	No ABP		
Abortion	No ABP		
Caesarean section	Cefazolin	2g IV	Single dose
	Cefamandole	1.5g IV	The addition of IV azithromycin to conventional antibiotic prophylaxis significantly reduces surgical site infections. The IV formulation is only available in France in 2016 for temporary authorization procedure but if it is marketed in the future the antibiotic protocols should be modified with prescribing this drug
	Cefuroxime	1.5g IV	
	Allergy: clindamycin	900 mg IV slow	
Mastectomy	Cefazolin	2g IV	Single dose (1g if duration > 4 hours)
Reconstruction and/or mammoplasty	Cefamandole	1.5g IV	Single dose (0.75g if duration > 2h)
	Cefuroxime	1.5g IV	Single dose (0.75g if duration > 2h)
	Allergy: clindamycin + gentamicin	900 mg IV slow	Single dose. 600 mg if time > 4h
		5 mg/kg/d	Single dose
Simple breast lumpectomy	No ABP		
Prolaps (all surgical approaches; only in case of implementation of prosthetic material: promontofixation, implant placement or strip…)	Peni A + IB[a]	2g IV slow	Single dose. 1g if duration > 2h
	Allergy: gentamicin + metronidazole	5 mg/kg/d	Single dose
		1g	Single dose

[a] Aminopenicillin + beta-lactamase inhibitor.

Table 13
Interventional surgery.

Act	Product	Initial dose	Reinjection and duration
Embolization of uterine fibroids	No ABP		
Trans-jugular intrahepatic portosystemic shunt	No ABP		
Biliary drainage for malignant or benign obstruction or calculi	Cure		
Nephrostomy	No ABP		
Endoscopic gastrostomy, sclerosis of oesophageal varicose veins	Peni A + IB[a]	2g IV slow	Single dose
	Allergy: clindamycin + gentamicin	900 mg IV slow	Single dose
		5 mg/kg/d	Single dose
Puncture under endoscopic ultrasonography (except trans-colorectal puncture)	No ABP		
Endoscopic dilatation, digestive prosthesis, laser, argon plasma coagulation	No ABP		
Chemoembolization	No ABP		
Radio frequency	No ABP		
Catheter and implantable chamber	No ABP		
Angiography, Angioplasty	No ABP		
Stent	Cefazolin	2g IV slow	Single dose (if duration > 4h, reinject 1g)
Stent (excluding intra-coronary)			
	Cefamandole and cefuroxime	1.5g IV slow	Single dose (if duration > 2h, reinject 0.75g)
	Allergy: vancomycin[b]	30 mg/kg/120 min	Single dose

[a] Indications of vancomycin: allergy to beta-lactams; suspected or proven colonisation by methicillin-resistant staphylococcus, reoperation in a patient hospitalised in a unit with an ecology including methicilline-resistant *Staphylococcus aureus*, previous antibiotic therapy. The injection lasts 120 minutes and must end at the latest at the beginning of the intervention and the best 30 minutes before.
[b] Aminopenicillin + beta-lactamase inhibitor.

7.10. Rationale

The surgery of the digestive tract and/or its appendices is either a clean surgery (class 1 Altemeier) without opening of the digestive tract, or more often a clean-contaminated surgery (class 2 of Altemeier) when the gut is open.

Laparoscopic surgery follows the same principles as traditional surgery. Conversion to laparotomy is always possible and infectious complications are then identical.

For hernia surgery with placement of prosthesis, antibiotic prophylaxis is recommended.

In colorectal surgery, an oral antibiotic given the day before surgery is associated with IV antibiotic prescribed prior to surgery.

In biliary surgery, biliary prosthesis patients were excluded from the recommendations in the absence of acceptable data.

Target bacteria: *E. coli* and other Enterobacteriaceae, *S. aureus* methicillin-susceptible anaerobic bacteria (submesocolic surgery) (Table 10).

Table 14
Bariatric surgery.

Surgery	Product	Initial dose	Re-injection and duration
Gastric band	Cefazolin	4g (30 min infusion)	Single dose (if duration > for 4h, inject 2g)
	Cefuroxime or Cefamandole	3g (30 min infusion)	Single dose (if duration > 2h, inject 1.5g)
	Allergy: vancomycin[a]	30 mg/kg/120 min minimum[a]/ (dose based on actual weight)	Single dose
Performing a gastric bypass or "sleeve" gastrectomy	Cefoxitin	4g (30 min infusion)	Single dose (if duration > 2h, reinject 2g)
	Allergy: clindamycin + gentamicin	2100 mg slow IV 5 mg/kg/d[b]	Single dose Single dose
Abdominoplasty (dermolipectomy)	Cefazolin	4g (30 min infusion)[b]	Single dose (if duration > 4h, reinject 2g)
	Cefuroxime or Cefamandole Allergy: clindamycin + gentamicin	3g (30 min infusion)[b] 2100 mg IV slow 5 mg/kg/day (dose based on actual weight)	Single dose (if duration > 2h, inject 1.5g) Single dose Single dose

[a] Indications of vancomycin: allergy to beta-lactams, suspected or proven colonisation by methicillin-resistant staphylococcus, reoperation in a patient hospitalised in a unit with an ecology including methicilline-resistant *Staphylococcus aureus*, previous antibiotic therapy. The injection is done at 1000mg/hour maximum and must end at the latest at the beginning of the intervention and at best 30 minutes before. Maximum dose is 4g.
[b] Dose calculated on the actual weight.

Table 15
Plastic and reconstructive surgery.

Plastic and reconstructive surgery			
Surgery	Product	Initial dose	Re-injection and duration
Plastic and reconstructive surgery: class 1 Altemeier	No ABP in the absence of implant		
	Cefazolin	2g IV slow	Single dose (if duration > 4h reinject 1g)
	Allergy: clindamycin	900 mg	Single dose (if duration > 4h, inject 600 mg)
Plastic and reconstructive surgery: class 2 Altemeier	Cefazolin	2g IV slow	Single dose (if duration > 2h reinject 1g)
	Allergy: clindamycin	900 mg IV slow	Single dose (if duration > 4h, inject 600 mg)

Table 16
Prophylaxis of endocarditis.

Antibiotics (30–60 min prior to the procedure)			
Situation	Antibiotic	Adults	Children
No allergy to beta-lactams	Amoxicillin or ampicillin	2g oral or IV	50 mg/kg orally or IV
Allergy to beta-lactams	Clindamycin	600 mg orally or IV	20 mg/kg orally or IV

R15. Antibiotic prophylaxis in urological surgery (Sterile urine)
(Expert opinion)

7.11. Rationale

Fluoroquinolones have no place for ABP in urological surgery (except the prostate biopsy).

Target bacteria: Enterobacteriaceae (*Escherichia coli, Klebsiella, Proteus mirabilis...*), *Enterococcus,* Staphylococcus (*S. epidermidis* above) (Table 11).

R16. Antibiotic prophylaxis in gynaecological surgery and obstetrics
(Expert opinion)

7.12. Rationale

For hysterectomies by vaginal or abdominal route (and by extension laparoscopic), the effectiveness of antibiotic prophylaxis and modalities (single dose before induction) are well documented. For simple intrauterine procedures (endometrial biopsy, insertion of an intrauterine device, curettage, in vitro fertilisation...), the very low risk of infection (<1%) and/or the absence of compelling evidence for its effectiveness do not justify a systematic antibiotic prophylaxis. The risk of infection after scheduled or emergency caesarean section is high and the administration of an antibiotic prophylaxis reduces by half the risk. We recommend injecting an antibiotic 30 min before incision and not after clamping the umbilical cord.

Target bacteria: *Staphylococcus aureus* and intestinal flora in case of skin incision, and/or vaginal flora (aerobic and anaerobic polymicrobial flora) if incision of the uterus or vagina (Table 12).

R17. Antibiotic prophylaxis in radiology and interventional medicine
(Expert opinion)

7.13. Rationale

Prescription of ABP is common when performing an act of interventional radiology. However, the level of scientific evidence is very low. If for a given individual prescription of ABP is considered, the risk/benefit ratio should be weighted (Table 13).

R18. Antibiotic prophylaxis for bariatric surgery and obese patients (BMI > 35)
(Expert opinion)

7.14. Rationale

Morbid obesity is a risk factor for surgical site infection. Antibiotic prophylaxis appears justified whether the gut is open or not, and whatever the surgical approach.

Higher antibiotic doses should be considered.

The usual dosages for prophylactic antibiotics are calculated for patients weighing less than 100 kg. For individuals of small size, it is not reasonable to target only abnormal BMI to prescribe high doses such as those presented in the table below. For these patients, if the weight is less than 100 kg, the usual dose is sufficient to ensure the pharmacokinetic objectives of prophylaxis.

Target bacteria: staphylococci, streptococci, gram-negative aerobic and anaerobic (Table 14).

R19. Antibiotic prophylaxis in plastic and reconstructive surgery
(Expert opinion)

7.15. Rationale

According to surveys of practice, practice is often distant recommendations. The trend is the extensive use of antibiotics. The reasons are probably the functional nature of the surgery and legal issues.

In the absence of methodologically correct studies, the following is proposed (Table 15).

8. Prophylaxis of infective endocarditis

The recommendations are extracted from the document published by the European Society of Cardiology (European Heart Journal doi: 10.1093/eurheartj/ehp 285 pp 1–45). These recommendations are supported by the French Society of Cardiology.

The interventions with a risk of bacteraemia that can lead to endocarditis are those of the dental sphere involving manipulations of the gingiva or the periapical region of the teeth, as well as perforation of the oral mucosa. Prophylaxis is prescribed to patients described in the first table to the exclusion of all others. Glycopeptides are not recommended.

For all other interventions (respiratory, gastrointestinal, genitourinary, dermatological or musculoskeletal surgery) prophylaxis of endocarditis is not recommended.

The European Society of Cardiology is well aware that the new 2009 recommendations vary widely from very ancient practices. These recommendations are based on the opinion of experts and the physician makes the final decision after discussion with the patient.

8.1. Target bacteria: oral streptococci

Heart disease at high risk of endocarditis for which prophylaxis is recommended. Antibiotic prophylaxis should be considered for these heart diseases.

Prosthetic valve or prosthetic material used for valve repair.
History of infective endocarditis.
Congenital heart disease:

- cyanogen non-operated, or a residual leak, or implementation of a surgical bypass.
- congenital heart disease with prosthetic repair surgically or percutaneously placed, up to 6 months after the establishment
- with a residual leakage site of implantation of a prosthetic material, surgically placing or percutaneously.

Recommendations for prophylaxis in high-risk patients, depending on the type of procedure

Bronchoscopy, laryngoscopy, nasal or tracheal intubation: no prophylaxis.

Gastroscopy, colonoscopy, cystoscopy, and transesophageal echocardiography: no prophylaxis.

Skin and soft tissue: no prophylaxis.

Dental surgery: gingival intervention or peri-apical region of the tooth, or perforation of the oral mucosa (Table 16).

Disclosure of interest

M. Leone: MSD, Basilea.

P. Montravers: Astellas, Astra-Zeneca, Basilea, Bayer, Cubist, Menarini, MSD, Parexel, Pfizer, Tetraphase, and The Medicines Company unrelated to the submitted work.

The remaining authors declare that they have no competing interest.

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