



The use of prophylactic antibiotics for the prevention of postoperative infections

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Despite use of the best surgical techniques, some operations still carry a high risk of wound infection. Basic and clinical studies have shown that this risk can be reduced by the administration of prophylactic antibiotics. There are certain inherent risks associated with the use of these agents, however, such as toxic and allergic reactions, emergence of resistant bacteria, drug interactions, and superinfections. Moreover, prophylactic antibiotics do not prevent all postoperative infections. For these reasons, their use should be based on an understanding of certain basic principles. This article reviews these principles and discusses their application in specific clinical situations.

Principles of prophylactic antibiotics

Antibiotic prophylaxis has been defined as the preoperative use of antibiotics to prevent infection. Prophylactic use of antibiotics is in contradistinction to the therapeutic use of antibiotics, which are given to treat an already existing infection. Not only are the purposes different but also the manner in which the drugs should be administered for an optimum effect are different. A review of the literature clearly indicates that, in many instances, antibiotics are given postoperatively rather than preoperatively, although it is still referred to as a prophylactic procedure. This difference must be taken into consideration when evaluating the conclusions that are reached and the

recommendations that are made by the authors. It also may account for some of the contradictory findings that have been reported in the literature.

As the result of the basic studies of Miles and Burke et al [1,2] and several well-controlled clinical studies, the principles of proper antibiotic prophylaxis have been established for general surgery, and they are applicable to the field of oral and maxillofacial surgery. These principles are (1) that the intended procedure must carry a significant risk of postoperative infection, (2) that the correct antibiotic must be selected, and (3) that the antibiotic is administered properly. To these principles one may add a fourth principle: not to rely solely on prophylactic antibiotics to prevent postoperative infections.

Risk of infection

Although such factors as age of the patient, nutritional status, nature of any underlying disease, presence of necrotic tissue, and a decreased blood supply can increase the potential for postoperative infection, perhaps the most important factor is wound contamination. Altemeier et al [3] developed a classification of general surgical wounds relating contamination to the risk of infection. In this classification, operative wounds are categorized as clean, clean-contaminated, contaminated, or dirty, with contamination resulting from planned or unplanned entry into the respiratory, gastrointestinal, or genitourinary tracts. Because of the difference in host response to such contamination and oral contamination, this classification cannot be used for intraoral wounds. It can be modified, however, to

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establish the indications for prophylactic antibiotics in other forms of oral and maxillofacial surgery.

According to this modified classification, extraoral wounds are still categorized in terms of increasing risk of infection as clean, clean-contaminated, contaminated, and dirty. However, the definitions must be altered to fit the regional differences. Clean surgical wounds, which have a low infection rate, usually involve no significant tissue trauma or inflammation, the incision is closed primarily, the wound is not drained, and there is no communication with the oral cavity. Clean-contaminated surgical wounds are similar to clean wounds except that there is a greater risk of infection because communication with the oral cavity occurs. Contaminated wounds are fresh traumatic injuries that involve the oral cavity, whereas dirty wounds are traumatic injuries with delayed treatment that communicate with the oral cavity and contain devitalized tissue or foreign bodies.

Clean surgical wounds do not require antibiotic prophylaxis; however, it should be used in clean-contaminated wounds. Contaminated wounds usually can be managed with preoperative prophylactic antibiotics if there are no other significant risk factors. Otherwise, patients with such wounds also should receive postoperative prophylactic antibiotics. Patients with dirty wounds, which are already infected, require preoperative and postoperative therapeutic antibiotics.

The decision not to use antibiotics or to use only preoperative prophylactic antibiotics is always based on the assumption that the patient does not have any significant medical risk factors that could affect the body's humoral and cellular defense mechanisms. These risk factors include poorly controlled diabetes, end-state renal disease and uremia, severe alcoholism, an immunocompromising disease (eg, leukemia, lymphoma, or an advanced malignant neoplasm), and the use of chemotherapeutic agents or other immunosuppressive drugs. In such patients, one is concerned not only with preventing the initial contamination of the wound but also with the possibility of recontamination during the postoperative period. Therefore, postoperative prophylaxis is also indicated.

Antibiotic selection

Once it has been determined that prophylactic antibiotics are indicated in a particular patient, the second principle involves making the appropriate selection. The choice of antibiotic is determined largely by its effectiveness against the pathogens commonly encountered at the specific surgical site. It need not be able to eradicate every potential

pathogen that may be encountered. Expanded antibiotic coverage serves only to increase the rate of bacterial resistance and the development of superinfections. The most commonly encountered organisms from oral contamination are the streptococci, anaerobic gram-positive cocci, and anaerobic gram-negative rods, whereas contamination from the sinus and nose may include *Haemophilus influenzae*, diphtheroids, and peptostreptococci [4]. When the skin is involved, the presence of *Staphylococcus aureus* and *epidermidis* also must be considered.

Although the first consideration is that the antibiotic selected is effective against the major contaminating organisms, it also must be nontoxic and relatively nonallergenic, bactericidal, capable of achieving therapeutic tissue concentrations, and have a long half-life so that redosing is generally not required during the procedure. The antibiotic that currently still fulfills these requirements best is penicillin. When skin contaminants are a concern, however, a first-generation cephalosporin, such as cefazolin, can be used because of its effectiveness against most staphylococci.

Antibiotic administration

Although one selects the appropriate antibiotic for prophylaxis, its ultimate effectiveness in preventing infection still depends on proper administration. This decision varies according to whether one is dealing with normal patients, in whom there is only concern about the initial bacterial contamination that can occur during the operation, or patients with other significant risk factors that decrease the body's defenses and retard healing, which makes them more susceptible to recontamination during the healing period. In the first instance, the antibiotic must be administered intravenously or intramuscularly within 30 minutes of the incision time at twice the therapeutic dose [5]. For penicillin, the dose is 2 million U, and for cefazolin it is 1 g. This dose generally provides adequate coverage for up to 4 hours. If the procedure is prolonged, however, it is advisable to administer additional doses every 4 hours until the operation is completed. In patients who are medically compromised or immunosuppressed, it may be advisable to continue prophylactic oral antibiotics until biologic sealing of the wound has occurred. No data exist on how long this period should be or even if it prevents postoperative infections. In fact, one must be concerned about promoting the emergence of resistant strains and causing superinfections. In a wound that is healing by primary intention, the period should

probably be no longer than 48 hours postoperatively and in a wound healing by secondary intention it should be no longer than 3 to 5 days, at which time a biologic seal should have occurred.

Adjunctive procedures

Although the correct use of prophylactic antibiotics significantly reduces the incidence of postoperative infections, their occurrence can be reduced further by careful attention to proper surgical technique. Proper technique involves adequate cleansing of the surgical site, strict adherence to sterile technique, avoiding tissue trauma, and minimizing operating time. In general, the risk of infection has been shown to increase with each hour of surgery. Shaving the skin in the surgical site with a razor the evening before the operation also has been shown to increase the infection rate, probably because of bacterial proliferation in the areas of minor trauma produced by shaving [6]. When shaving is necessary, it should be done just before preparation of the surgical site.

The use of drains also may contribute to postoperative infections. When drains are necessary in noninfected wounds, the closed-suction type is preferable to open drains. They should not be placed through the operative incision and should be removed as soon as possible. Paying proper attention to these details during management of the surgical patient greatly improves the effectiveness of antibiotic prophylaxis.

Specific applications in oral and maxillofacial surgery (Table 1)

Exodontia and dentoalveolar surgery

Although intraoral surgical wounds are contaminated by the oral flora, the ability of patients normally to tolerate this bacterial population and the excellent blood supply to the oral tissues allow such wounds to be managed similarly to clean wounds. It is unnecessary to use prophylactic antibiotics to prevent infection when performing most types of exodontia and dentoalveolar surgery unless there are other contributing risk factors (Table 1). If the procedure involves the maxillary sinus or nasal cavity, however, this can result in cross-contamination with new organisms, and prophylactic antibiotics should be used except when there is already infection in these areas. In the latter instance, therapeutic antibiotics are indicated.

Impacted third molar surgery

Although many practitioners routinely prescribe antibiotics for patients who have impacted third molars removed [7,8], they are generally prescribed postoperatively. This practice does not accomplish the true purpose of using prophylactic antibiotics: having a high tissue concentration present at the time of surgery when the wound is exposed to bacterial contamination. It is not surprising that no convincing data show a significant reduction in postoperative infections after third molar removal when antibiotics are used in this manner [7,9]. The fact that such infections are relatively uncommon also may be a contributing factor to such findings [10,11]. Most studies that report high postoperative infection rates [12] include alveolar osteitis (dry socket) and fascial space infections. In such studies, however, there is still not a significant reduction in either type of problem, whether the antibiotics are given postoperatively or preoperatively [13–15].

Although isolated cases of severe fascial space infections after third molar removal have been reported [16], the incidence is too low to justify the routine use of prophylactic antibiotics. Such treatment should be reserved only for patients with significant medical risk factors for infection [1,17]. In these cases it should be given immediately before surgery and for 3 to 5 days after surgery to provide an adequate period of coverage.

Dental implants

Few studies have been conducted on the effect of antibiotics on the infection rate after implant placement. Two studies in which no control group was used [18,19] concluded that preoperative prophylactic antibiotics were effective in preventing postoperative infections. In a subsequent, better controlled study [20], however, no difference in postoperative infections or implant failure was found between the two groups.

In a more recent, large, multicenter study, Dent et al [21] analyzed implant failures (which probably included some cases with infection) and found significantly fewer failures up to stage 2 surgery, when high-dose preoperative antibiotics (penicillin in 69% of cases) were administered. These findings were confirmed in a follow-up study at 36 months in the same patient population (4.6% versus 10% failure) [22]. Thus, there seems to be a benefit in using prophylactic antibiotics in dental implant patients.

Table 1

Indications for prophylactic antibiotics

Procedure	Antibiotic regimen	Exceptions ^a
Exodontic and dentoalveolar surgery	None	High risk for infection; communication with sinus or oral cavity
Impacted third molar surgery	None	High risk for infection
Dental implants	Preoperative	Also postoperative prophylaxis when high risk of infection
Orthognathic surgery (extraoral approach)	None	Preoperative when anticipate possible oral contamination
Orthognathic surgery (intraoral approach)	Preoperative and 1-day postoperative	None
Mandibular fractures (no oral communication)	None	None
Mandibular fractures (oral communication)	Preoperative and 12 hours postoperative	Use prophylactic antibiotics 3–5 days postoperatively when treatment delayed
Facial bone fractures	Preoperative	None
Soft tissue trauma (oral injuries)	None	Preoperative when high risk for infection
Soft tissue trauma (clean extraoral lacerations)	None	Preoperative when high risk for infection
Soft tissue trauma (blunt trauma, gunshot wounds, bites, orocutaneous communication)	Preoperative	Postoperative prophylaxis for 3–5 days when high risk for infection
Major head and neck surgery	Preoperative	Postoperative prophylaxis 3–5 days when packs or drains used; lack of watertight closure; high risk for infection

^a High risk for infection refers to such factors as poor nutritional status, complicating medical problems, presence of necrotic tissue or foreign bodies, and decreased blood supply to the region.

Orthognathic surgery

Orthognathic surgery performed via an extraoral approach is considered a clean procedure and prophylactic antibiotics should not be necessary unless communication with the mouth is anticipated [23]. Intraoral procedures and procedures that involve the maxillary sinus and nasal passages are clean-contaminated operations, and short-term prophylactic antibiotics have been shown to reduce the postoperative infection rate [24,25]. There seems to be no advantage in prolonged postoperative antibiotic administration [25,26]. In one study in which a 5-day regimen was shown to be better than a 1-day regimen [27], as pointed out by Abubaker [24], the difference was caused by the difference in the criteria used to establish wound infection.

Mandibular fractures

Patients with condylar process fractures treated by either open or closed reduction require no prophylactic antibiotics. The same is true for fractures in other non-tooth-bearing areas that are not in communication with the mouth, because these are all clean wounds. In patients with compound mandibular fractures, however, which are contaminated wounds, studies have shown that the use of anti-

biotics is effective in reducing postoperative infections [28,29]. In most of these studies, however, the antibiotics were given not only preoperatively but also for a long period postoperatively. More recent investigations [28,30] have shown that prophylactic antibiotics given preoperatively and for no longer than 12 hours postoperatively are just as effective as long-term use in preventing postoperative infections. These findings apply only to fractures that are treated shortly after the injury has occurred. Fractures for which there is delayed treatment should be considered dirty wounds, and such patients should receive therapeutic antibiotics postoperatively.

Facial bone fractures

Although it has been suggested that any mid-facial fracture compounded into the mouth, nose, or paranasal sinuses requires antibiotic coverage [31,32], other studies [28,33] have shown that it may not be necessary. Because one of these studies [33] was not well controlled and the other [28] had a relatively small number of cases, the issue remains unresolved. Based on the fact that such compound fractures communicate with a contaminated cavity, they should be considered as clean-contaminated wounds and preoperative prophylactic antibiotics should be used.

Soft tissue trauma

Patients with traumatic injuries that involve the oral mucosa, gingiva, or tongue do not require prophylactic antibiotics because such wounds, although contaminated, generally heal without infection. Simple extraoral lacerations from relatively clean objects that are closed within 4 hours also have a low infection rate and do not require prophylactic antibiotics [34]. Extraoral soft tissue injuries, such as those caused by blunt trauma, gunshot wounds, and bites and injuries that involve orocutaneous communication, fall into either the category of clean-contaminated or contaminated wounds, and the patient should receive pretreatment antibiotic prophylaxis. If the wounds are extremely dirty, the patient also should receive postoperative therapeutic antibiotics.

Major head and neck surgery

Researchers generally agree that patients who undergo major surgical procedures in the head and neck region, such as oncologic and reconstructive surgery, should receive preoperative prophylactic antibiotics [31,35–39]. There is a question regarding how long they should be used postoperatively. Several studies [31,35,36,38,39] that have shown that there is no advantage in extending the prophylactic antibiotics beyond 1 day after surgery in such cases unless there are packs or drains in the wound or it is not possible to obtain a watertight closure and there is prolonged leakage of saliva into the wound [40].

Summary

Although prophylactic antibiotics do not prevent all postoperative infections, they can reduce the incidence significantly when administered correctly. However, they should be used only in patients in whom the surgical procedure or the medical condition puts them at a high risk of developing such infections. As a general rule, the anticipated risk should exceed 10% [41]. Use of antibiotics in low-risk cases in an attempt to prevent postoperative infections, especially when used for prolonged periods, can result in adverse drug effects, superinfections, and the emergence of resistant strains without providing any significant benefits. As Furstenburg [42] stated so succinctly more than 50 years ago: “With the discovery of penicillin, its allied agents, and their mass production, clinicians have employed them in different forms and by various methods for almost every illness in the category of medicine. The urge to

administer appears to transcend therapeutic rationale and provokes the use of antibiotics for purposes often obscure and irrelevant. It is only natural that great inventions and discoveries should gain wide acclaim and enthusiastic endorsement and enjoy universal acceptance far in excess of which they merit.”

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