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Antibiotic Prophylaxis of Infective Endocarditis: from the History of the Concept to Modern Recommendations (Review)

Abstract

This review highlights current ideas about the prevention of infective endocarditis. The history of the concept development, the main approaches and the rationale for changing the principles of antibiotic prophylaxis in recent years are described. Current international and national guidelines, in particular, guidelines of the European Society of Cardiology, the American Heart Association / American College of Cardiology and the Japanese Circulation Society, are covered in detail. A critical assessment of previously approved international guidelines is presented with an analysis of the effect of relative or complete limitation of antibiotic prophylaxis on the incidence of infective endocarditis and the frequency of its complications.

Key words: *infective endocarditis, prophylaxis, antibiotics, antibiotic prophylaxis, international guidelines*

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AB — antibiotic, ABP — antibiotic prophylaxis, ABR — antibiotic resistance, CHD — congenital heart disease, IE — infective endocarditis, ARF — acute rheumatic fever, RCT — randomized clinical trial, AHA — American Heart Association, ACC — American College of Cardiology, ESC — European Society of Cardiology, NICE — National Institute for Health and Clinical Excellence of Great Britain, JCS — Japanese Circulation Society

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Introduction

Despite significant progress in diagnosis, antibiotic therapy, and cardiac surgery procedures for infective endocarditis (IE), the adoption of consensus documents defining optimal patient management approach, this disease today, in the 21st century, is characterized by severe complications and an unfavorable prognosis [1–6]. The in-hospital mortality in IE reaches 20% [7–9], and one-year mortality is 40% [10–13], which exceeds that of some types of cancer. In such conditions, the prevention of IE appears to be one of the most important tasks of scientific and practical medicine. The development and implementation of antibiotic prophylaxis (ABP) of IE has been performed since the middle of the 20th century. ABP affects bacteremia, which is a key factor for the development of valvular infection in patients with an increased risk of IE, and is indicated before invasive procedures [14–16]. Such patients, in particular, include those with congenital heart disease and acquired valvular defects, prosthetic heart valves, and previous IE [15, 17, 18]. ABP is used to prevent the first episode of IE of the native valve and recurrent IE, as well as IE of the prosthetic valve [10, 19]. ABP of IE is among the most complex and debatable issues of all strategic aspects of the IE management, despite the regularly updated international guidelines of authoritative cardiac societies [4, 16]. Largely, this is due to the relative rarity of IE and, consequently, the absence of randomized clinical trials (RCTs) on ABP [6]. Various opinions exist regarding the identification of categories of high-risk patients subject to the prescription of prophylactic antibiotics (AB), types of medical procedures, the regimen of ABP, etc. In addition, approaches to ABP of IE are changed over time as scientific data, mostly obtained from observational studies, accumulate. Decision-making on ABP of IE should consider such aspects as antibiotic resistance (ABR) and side effects of ABs, including the development of anaphylaxis [20, 21].

This review was carried out by a team of authors with experience in managing patients with IE. We attempted to analyze historical and current approaches to IE ABP, including that in different countries; to evaluate the results of the ABP guidelines implementation on the incidence of IE; and to discuss the existing controversial points.

Background

In 1909, Thomas Horder suggested the etiological role of *S. viridans* in the oral cavity in patients with heart disease based on an analysis of 150 cases of IE [22]. In 1923, T. Lewis and R. Grant [23] suggested that bacteria that enter the systemic circulation after dental procedures could cause IE. A little later, C.C. Okell and S.D. Elliot isolated *S. viridans* in blood culture in 84 of 138 (61%) patients with IE [24]. In 1941, C.B. Thomas et al. [25] reported the first results of the prophylaxis of acute rheumatic fever (ARF) with sulfanilamide. Researchers compared the course of ARF and its outcome in groups of patients who received and did not receive sulfanilamide. Although the work is aimed to assess the effect of prophylactic administration of sulfanilamide in patients with ARF, the authors describe two cases of fatal IE in the group of patients without antibiotic therapy. In the same group, two more deaths were reported that were related to ARF and "acute disease of unknown nature". Moreover, there were no fatal outcomes in the group of patients receiving sulfanilamide [25]. At the end of the 1930s, the first guidelines on the use of various sulfanilamides for IE ABP in patients with valvular defects who underwent various dental interventions were published [26].

In 1955, for the first time, the official guidelines of the American Heart Association (AHA) on ABP included recommendations for ABP of IE in patients with predisposing cardiac diseases [14]. The guidelines refer to ABP of IE as a "good medical and dental practice". After this, the recommendations on ABP were updated nine times before 1997, and the changes mainly concerned dental and pulmonary interventions, as well as the choice, route of administration and dosage of AB [27]. Following the American guidelines, recommendations of other scientific societies have begun to appear in different countries [16].

Oral *Streptococci* are commensal bacteria, responsible for 10–30% of cases of IE depending on the geographical location, profile of risk factors, sociodemographic characteristics of the studied population [3, 15, 28].

The approach to ABP of IE, developed on the basis of observational studies and the results obtained in animal models, is aimed at preventing the

attachment of bacteria to the endocardium after transient bacteremia related to invasive procedures [28]. Transient bacteremia is believed to occur in poor oral hygiene, periodontal diseases, after dental procedures or manipulations of teeth and gums in a person's daily activity (e.g., brushing, using of toothpicks, chewing gum, etc.) and, in some cases, precedes the development of IE [28–31]. Of course, bacteremia predisposing to the development of IE can occur not only as a result of odontogenic bloodstream infection, but also after coronary artery bypass grafting, procedures involving skin damage, wound surface interventions, bone marrow biopsy, some types of endoscopy, in particular bronchoscopy, etc. [32, 33].

For more than 50 years, ABP has been administered orally to patients at risk of IE before a variety of dental interventions. Significant changes in ABP of IE occurred over the past 10–12 years, and their main feature was a significant limitation of indications for the use of AB for the prevention of IE [34]. In 2007–2009, a number of associations, including the European Society of Cardiology (ESC), the American College of Cardiology (ACC), AHA, and the UK National Institute for Health and Care Excellence (NICE), issued recommendations that limit the use of ABP to some extent [27, 35, 36].

In Europe and the USA, relative ABP restrictions have been introduced for patients at the highest risk of IE (e.g., previous IE, congenital heart disease (CHD), history of rheumatic endocarditis and selected recipients for heart transplantation) before invasive dental procedures [10, 37]. In the UK, in 2008, the NICE recommendations offered to abandon IE prophylaxis completely (a total restriction of ABP). However, later, in July 2016, NICE experts softened this statement [38].

The idea of a relative or total restriction of ABP was based on three factors. Firstly, the characteristic feature of modern medicine is the increasing commitment to evidence-based practice, which means that the recommendations are based on the results of thoroughly designed RCTs. However, in the near future, RCTs that objectively evaluate the effectiveness of ABP of IE are not expected. Secondly, the relative importance of dental procedures as almost the only source of bacteremia and the immediate cause of IE is questionable, especially in comparison with other "portals of entry" or transient bacteremia that occurs in everyday life [29–31, 39]. Thirdly, in moderate-risk groups (in England, high-risk), the general harm from the use of AB (in particular, anaphylactic reactions and ABR) served as a strong argument against the use of ABP. The NICE Guideline Committee also considered that ABP was not economically viable due to a lack of evidence of its effectiveness and supposed high risks associated with the occurrence and treatment of anaphylaxis [15, 31].

When discussing one of the most important arguments against the widespread use of AB, ABR, it should be noted that the gap between the development of new drugs and the constant variability of bacterial strains has widened recently [40–42]. Under the influence of drugs, a whole range of counteracting microbial mechanisms that can reduce or completely neutralize the effectiveness of AB are activated [40–42]. ABR, which is inherent in many pathogens for almost any AB and complicates the management of patients with infective diseases, including IE [21], is partly due to the unjustified frequent administration of antibacterial agents in clinical practice.

Current National and International Guidelines for the Prevention of Infective Endocarditis

1. Recommendations of the European Society of Cardiology, 2015

The published 2015 ESC recommendations [37, 43] regarding IE ABP were developed taking into account the experience described in the previous guideline [36] and the results of the implementation of strict ABP restrictions in the 2008 NICE guideline [44].

The 2015 ESC recommendations support the principle of prescribing ABP to patients with a high risk of IE for the following reasons:

- uncertainty remains regarding IE risk assessments;
- worse prognosis of IE in high-risk patients, especially in patients with endocarditis, prosthetic heart valve (PHV);
- the number of patients with a high risk of IE is much smaller than patients with an intermediate risk, which generally reduces the potential harm of the adverse effects of ABP.

Table 1. *Recommended regimens of antibiotic prophylaxis in high-risk patients before high-risk dental procedures*

Situation	Antibiotic	Single dose 30–60 minutes before the procedure	
		Adults	Children
No allergy to penicillin or ampicillin	Amoxicillin or ampicillin[a]	2 g per os or IV	50 mg/kg per os or IV
Allergy to penicillin or ampicillin	Clindamycin	600 mg per os or IV	20 mg per os or IV

Notes: [a] — as an alternative, cephalexin 2 g IV in adults or 50 mg/kg IV in children; cefazolin 1 g IV in adults or 50 mg/kg IV in children. Cephalosporins should not be prescribed to patients with anaphylactic reactions, angioedema or urticaria after penicillin or ampicillin use due to their cross-sensitivity. Adapted from G. Habib et al. [37].

According to the ESC 2015 recommendations, patients with the highest risk of IE are represented by three categories:

1. Patients with a prosthetic heart valve or prosthetic material used in cardiac valve repair. This group also includes patients, transcatheter-implanted prostheses and homografts.
2. Patients with previous IE.
3. Patients with untreated cyanotic congenital heart disease (CHD) and those with CHD who have postoperative palliative shunts, conduits or other prostheses

The Task Force recommends prophylaxis for the first 6 months after the procedure without residual defects until complete endothelialization of the prosthetic material.

Patients with an intermediate or high risk of IE should be advised to follow dental and skin hygiene measures. These general hygiene measures are applicable to patients and healthcare workers and are ideal for the general population, given the fact that IE may develop without cardiac risk factors [37].

ABP is recommended for all patients undergoing "risk procedures", which includes manipulations the gingival or periapical region of the teeth (including plaque removal and procedures in the root canal), or perforation of the oral mucosa.

The Task Force believes that due to lack of data, there are no contraindications to installing implants for all persons at risk of IE. There is also no convincing evidence that bacteremia that occurs after procedures on the respiratory, gastrointestinal and genitourinary tracts, including vaginal delivery or cesarean section, after dermatological or musculoskeletal manipulations, can lead to IE. Therefore, in these cases, ABP is not required.

Thus, ABP is indicated only for patients with the highest risk of IE who are subject to high-risk dental procedures [37]. Table 1 presents the main regimens of ABP recommended before dental procedures. It is not recommended to use fluoroquinolones and glycopeptide AB due to their unproven effectiveness and the possible development of ABR [37].

Systematic ABP is not recommended when performing non-dental interventions. ABP of IE is necessary if invasive procedures are performed during the treatment of infections. For example, patients who are at high risk of IE due to existing cardiac disease and need an invasive respiratory tract procedure (in particular, drainage of an abscess) should receive antibacterial drugs. The recommendations indicate, as examples, systemic or local infections of the gastrointestinal tract, genitourinary system, dermatological and musculoskeletal infections for the selection of adequate AB in high-risk patients to prevent IE [37].

2. The Russian Society of Cardiology endorses the 2015 ESC recommendations [45], which were translated and published in a timely manner [43].

3. NICE Recommendations, 2008 (updated in 2015–2016)

UK Guidelines for IE prevention dated 2008 were slightly updated in 2015–2016 [44]. In particular, the following phrase was added: "Antibiotic prophylaxis against infective endocarditis is not routinely recommended". The addition of "routinely" emphasizes the standard advice from the NICE committee to healthcare providers: "Doctors and dentists should offer the most appropriate treatment options, in consultation with the patient and/or their carer or guardian. In doing so, they should take account the recommendations in this guideline, and the values and preferences of patients, and apply their clinical judgment" [44].

4. American Heart Association / American College of Cardiology Guidelines, 2014

AHA/ACC recommendations for the prevention of IE were published in the Guidelines for the Management of Patients with Valvular Heart Disease in 2014 [10], a year before the publication of the "IE in Adults: Diagnosis, Antimicrobial Therapy and Treatment of Complications" guideline [19]. They emphasize that at present, ABP is indicated only for patients with the highest risk of an adverse outcome in the event of IE (Table. 2, [6, 10, 37, 46, 47]). We would like to emphasize the exact wording for the characteristics of patients with indications for ABP: "for patients with the highest risk of IE adverse outcome before dental procedures" [10], since in the literature they are often limited to the term "high risk". This wording is also available in the 2015 ESC recommendations [37] on the list of cardiac conditions associated with the "highest risk of IE".

It was noted that when using artificial material to repair a valve defect (with the exception of surgically created palliative systemic pulmonary shunts or conduits), such as annuloplasty, implantation of neochords, Amplatzer devices, clips (MitraClips), only a few cases of infection of such materials were observed [10]. Given the low level of frequency and lack of information, there is no convincing evidence that there is a need for IE ABP in such patients, if there is no other high risk of intracardiac infection.

The American guideline notes that the incidence rate of IE is significantly higher in patients who underwent heart transplantation than in the

Table 2. *Comparison of the main statements of the guidelines of the American Heart Association / American College of Cardiology 2014 and the European Society of Cardiology 2015 on the use of antibiotic prophylaxis of infective endocarditis.*

Procedures	AHA/ACC, 2014 †	Class, LE	ESC, 2015 §	Class, LE
Dental procedures that involve manipulating gum tissue, the periapical region of the teeth or perforation of the oral mucosa	1. Patients with PHV 2. Patients with history of IE. 3. Recipients of a donor heart due to structural changes in the valvular apparatus 3. Patients with CHD, including: a. Non-operated cyanotic CHD, including those with palliative shunts and conduits; b. Fully restored CHD using artificial materials or devices installed by cardiac surgery or catheter method for 6 months after the procedure; or c. Reconstructed CHD with residual defects in place or adjacent to the site of an artificial flap or device	IIa, B	1. Patients with any PHV, including those placed using transcatheter procedure, or persons who have used any artificial material for the heart valve repair 2. Patients with history of IE. 3. Patients with CHD, including: a. Any type of cyanotic CHD; b. Any type of CHD reconstructed using artificial material placed using cardiac surgery procedure or percutaneous techniques up to 6 months after the procedure or during lifetime if residual shunts or valve regurgitation persist.	IIa, C
Vaginal Delivery*	1. Patients with PHV or artificial material used to repair a heart valve ‡ 2. Patients with unoperated or palliatively corrected cyanotic CHD, including surgically performed palliative shunts and conduits ‡	IIa, C	Not recommended: "During childbirth, the indications for ABP are contradictory and, given the lack of convincing evidence that IE is associated with childbirth via the vaginal delivery or cesarean section, prophylaxis is not recommended. It is important that non-specific hygiene and aseptic measures be taken to prevent IE	III, C

Notes: † — Recommendations of the American College of Cardiology / American Heart Association (ACC/AHA) 2014 on the management of patients with valvular heart disease; § — Recommendations for the management of patients with infective endocarditis (IE) of the European Society of Cardiology (ESC) 2015.* — ACC/AHA 2008 Guidelines for the management of adult patients with CHD;** — 2018 ESC Guidelines for the treatment of cardiovascular diseases during pregnancy; ‡ — Prevention of IE during vaginal delivery is controversial and is not included as evidence in the 2014 ACC/AHA Valvular Heart Disease Guidelines and the main recommendations of the ESC 2015; LE — level of evidence; PHV — prosthetic heart valve; CHD — a congenital heart disease. Modified from T. J. Cahill et al. (2017) [6].

general population. The highest risk of IE exists during the first 6 months after surgery due to the endothelium injury, intensive immunosuppressive therapy, endomyocardial biopsy, and frequent central venous catheter placement. The importance of oral hygiene to reduce the sources of bacterial dissemination is also emphasized. In this regard, a follow-up by a professional dentist and the use of appropriate facilities (manual, electric, ultrasonic; dental floss and other dental plaque devices) are recommended. There is no evidence of the usefulness of IE ABP when performing procedures on the gastrointestinal or genitourinary tract in the absence of established enterococcal infection [10].

5. Japanese Circulation Society Recommendations, 2019

When developing the Japanese Circulation Society (JCS) guidelines for the prevention and treatment of IE, the experts also relied on the experience of implementing the guidelines of other scientific societies [48], which is reflected in the recommendations, rationale and references. The presented statements (the latest available guidelines) recommend the ABP use for patients with high-risk of IE, including those at highest and moderate risk (Table. 3, [48]).

In addition, there was a graduation in the need for AB for the prevention of IE, depending on the type and place of the invasive treatment and diagnostic procedures from "highly recommended" to "not recommended". In our opinion, the 2019 JCS guidelines deserve close attention and the study of the possibility of their application in individual clinical situations. In real practice, IE develops not only in patients with previous cardiac disorder of the highest risk and only after dental procedures, but also in patients undergoing other invasive procedures (tonsillectomy, adenoidectomy, transurethral resection of the prostate, etc.) [48]. Therefore, it is reasonable to discuss the prescription of AB to patients who, for example, have a moderate risk of IE and have undergone invasive diagnostic and treatment interventions on an infected organ or tissue.

Assessment of the Effectiveness of the 2007–2009 Recommendations

Today, only data that evaluate the effectiveness of recommendations published in 2007–2009 have been obtained. It should be noted that the interpretation of data on changes in the incidence of IE under conditions of relative or absolute limitations of ABP is quite difficult [49]. The obtained contradictory results can be due to not only and not so much by the policy of limiting the ABP of IE, as by heterogeneous methodological approaches when conducting research.

Table 3. *The risk of infective endocarditis in adults according to underlying heart disease, recommendations of antibiotic prophylaxis during dental and oral surgical procedures.*

Risk of IE	Class of recommend.	LE
1. Highest risk: high incidence rate, complications and mortality in IE		
• Patients after implantation of PHV (bioprosthesis / mechanical valve) • Patients with history of IE • Patients with complex, "cyanotic" CHD (one ventricle, complete transposition of large arteries, Fallot's tetrad) • Patients undergoing shunting between systemic and pulmonary circulation	**I**	**B**
2. Moderate risk: lower levels of complications and mortality, despite the high incidence of IE		
• Most CHD * • Acquired heart valve diseases § • Hypertrophic cardiomyopathy with obstruction • Mitral valve prolapse with regurgitation	**IIa**	**C**
• Patients with intracardiac devices (CP, ICD) • Patients with a long-term central venous catheter	**IIb**	**C**

Notes: * — except a simple atrial septal defect (such as *ostium secundum*); § — in mitral valve stenosis without regurgitation, the risk of infective endocarditis (IE) is low. LE — level of evidence; CHD — congenital heart disease; CP — cardiac pacemaker; ICD — implanted cardioverter defibrillator. Adapted from S. Nakatani et al. (2019) [48].

Some surveys have studied the effect of limiting oral ABP on the incidence rate of IE. In France, where ABP was limited to high-risk patients, the incidence rate of IE over three years of study (in 1991, 1999, and 2008) remained steady, amounting to 35, 33, and 32 cases per 1 million people, respectively. This suggested that there was no significant change in the incidence of IE after the implementation of limited oral ABP [50, 51].

Analysis of the incidence rate of streptococcal IE (*Viridans* group), conducted before and after changes to the 2007 ACC/AHA guidelines based on data of the Rochester Epidemiology Project (Rochester, USA), D.C. DeSimone et al. [52, 53], did not reveal increase in IE incidence. On the contrary, there was a decrease in the incidence of IE from the level of 3.6 cases per 100 thousand people in the period 1999–2002 to 1.5 cases per 100 thousand in the period 2011–2013.

In turn, the results of three national epidemiological studies in the United States, United Kingdom and Canada provided a matter for reasonable concern. S. Pant et al. [54] found a significant increase in the incidence rate of streptococcal IE, although there was no significant increase in overall hospital admission rate or cases of staphylococcal IE. In calculating the incidence rate of IE, this study included cases caused by streptococci of all groups, without defining of the *Viridans* group spp. In addition, no information was provided on changes in the number of AB prescribed by doctors, which would make it possible to assess the effect of the recommended limitations of ABP on the incidence rate of IE more accurately. The authors themselves are not sure what a reason of the rise in the IE cases: improving the coding of the disease in accordance with the International Classification of Diseases or a real increase in the incidence rate [54].

In the UK, where national guidelines recommended to avoid the use of any type of AB for the prevention of IE in 2008 [35, 44], there was no increase in IE incidence rate in early studies [55]. However, in 2015, M.J. Dayer et al. [56] published an extended analysis of the diagnoses established upon discharge from the Hospital of the National Health Service before April 2013. After the introduction of NICE guidelines, the number of ABP prescriptions dropped sharply, from 10.9 thousand/month to 2,236 thousand/month. Along with this, there was a significant increase (above the predicted trend) in the number of IE cases — by 0.11 cases per 1 million people/month (or by an additional 35 cases in England), which coincided with the implementation of new recommendations [56].

The systematic review and meta-analysis of research results performed by T. Cahill et al. are of undeniable interest [15]. They directly or indirectly studied the clinical experience of the use of ABP in patients at risk of IE development and undergoing dental procedures. In all countries where ABP is recommended to the categories of patients with the highest risk of IE, there was no significant increase in the incidence rate of IE, although some studies showed an increase in streptococcal endocarditis [15].

In 2019, another study was published, which assessed the impact of the 2007 AHA revised guidelines on prescribing ABP among groups of patients with moderate/high risk of IE and determined significant changes in its incidence rate after the implementation of these recommendations [57]. The study included data from adults of moderate/high risk of IE, divided into two age groups: 18–64 years old and ≥65 years old. Among people aged over 65 in the groups of high and moderate risk, there was an increase in the quarterly level of the number of new cases of IE: from 336 to 1,915 new cases per 1 million people at the highest risk of IE and from 180 to 440 per 1 million in patients with moderate risk. The most significant increase in new cases of IE was noted in the second half of 2010, that is, more than 3 years after the publication of recommendations for the prevention of IE.

A similar rise in new cases of IE was also observed among patients aged 18–64: the most significant change was recorded in the second quarter of 2010 in both groups (of moderate and high risk): from 1,061 to 1,754 in the high-risk group and from 308 to 423 cases per 1 million in the moderate-risk group [57]. The authors suggest that such a time difference (about 3 years), along with an increase in the incidence rate of IE in both risk groups, is not associated with a change in the principles of ABP described in the 2007 AHA guidelines.

All these data are obtained during observational studies and cannot be used to establish a relationship

between the limitation of ABP and the incidence rate of IE reliably. Many studies contain methodological inaccuracies, for example, the inclusion of implantable cardiac devices and related complications in recent years, although this factor has been corrected in some works. Despite the long-term controversy and problems with the data obtained from observational studies, it is rather difficult to conduct RCTs due to the high costs, the complexity of the logistics and ethical debate whether there is a real balance to perform a placebo-controlled study. Nevertheless, a more extensive evidence base is required with respect to the justification of the implementation of national and international recommendations on ABP of IE.

It is worth discussing a parameter that determines the attitude to the prescription of ABP: an assessment of the risk group of IE. There are two groups of patients in the 2015 ESC Guidelines with the highest and intermediate risk of IE [37], who are advised to comply with dental and skin hygiene measures. In the highest-risk patients, ABP should be considered during high-risk procedures. On the other hand, there are certain groups of patients in whom IE develops much more often than in the general population. For example, among patients undergoing dialysis, the incidence rate of IE is 17 times higher than in the general population [58], and in intravenous drug addicts it is approximately 100 times higher [59]. IE often develops in older people [60], people suffering from diabetes mellitus [61], cancer [62] and other disorders. Is it possible to ignore patients without cardiac diseases of the highest risk and undergoing various diagnostic and treatment procedures, while the incidence rate of IE in this group is tens to hundreds of times higher than that in the general population?

In conclusion, we would like to cite the very reasonable argument made by F. van den Brink et al., published in November 2019 in the Annals of Cardiothoracic Surgery [63]. "And so, we have arrived at 2019. Guidelines on chemoprophylaxis for IE are just as strict as they were when we designed them between 2007–2009. In the meantime, we have seen a rise in IE in almost all studies. What we have not seen an improvement in survival of patients suffering from the devastating disease. Still, despite an increasing number of studies that show not only an increase in IE incidence, but also a relationship between stricter IE chemoprophylaxis and an increase in preventable IE, we still consider the evidence not to be enough to change the guidelines back to what they were. Another thing that we have also not witnessed is patients suffering from chemoprophylaxis with lethal consequence [64]. In short, we do very little harm in giving patients chemoprophylaxis and we probably do a lot of good in giving patients chemoprophylaxis to prevent IE from rearing its ugly head" [63].

F. van den Brink et al. [63] believe that physicians now have "a rare opportunity to conduct an almost worldwide study in restoring the principles of ABP, as it was before 2007, and then analyze what happens with the incidence of IE".

Conclusions

1. Considering the severity and unfavorable prognosis of IE, it is advisable to conduct ABP before invasive procedures in order to prevent endocarditis and its relapses.
2. Based on the accumulated evidence, ABP of IE should be used in patients at the highest risk of IE, who are undergoing high-risk dental procedures. The decision on its use in other patients and for non-dental interventions is taken by a specialist depending on the individual clinical situation and taking into account the degree of risk, the individual characteristics of the patient and other circumstances.
3. In patients with intermediate and high risk of IE, the compliance with dental and skin hygiene measures detailed in national and international recommendations is of great importance.
4. When assessing the risk of IE or selecting the scheme/regimen of ABP, a physician should rely on the recommendations of the relevant sections of international/national consensus documents.
5. In IE prevention, interdisciplinary interaction of specialists (cardiologists, cardiac surgeons, dentists, etc.) is important, as well as informing high-risk patients about the need for ABP during invasive procedures.
6. Further studies are needed to evaluate the impact of the ABP of IE implementation on the incidence rate of new cases or recurrent IE, as well as possible changes in the microbiological spectrum of the main causative agents of the disease.

Contribution of Authors

All authors made a significant contribution to the preparation of the article, read and approved the final version before publication.

G. G. Taradin (ORCID ID: https://orcid.org/0000-0003-3984-8482): principal creation of review idea, literature search, collection and an analysis of data, writing of separate sections, final text editing.

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