Available online at www.rajournals.in

RA JOURNAL OF APPLIED RESEARCH
ISSN: 2394-6709
DOI:10.47191/rajar/v8i5.03
Volume: 08 Issue: 05 May -2022

International Open Access

Impact Factor- 7.108

Page no.- 351-356

The Use of Prophylactic Antibiotics as a Prevention of Surgical Site Infection for Patients with Open Fracture: A Scoping Review

Agam Meureza Prabowo[1], Elsye Maria Rosa[2]
[1]Researcher Scholar, Master of Hospital Administration, Muhammadiyah University of Yogyakarta
[2]Lecturer, Master of Hospital Administration, Universitas Muhammadiyah Yogyakarta

ARTICLE INFO

Published Online:
05 May 2022

ABSTRACT

Background: Fracture is a serious injury condition characterized by structural discontinuity of the bone that occurs in the form of cracks to complete, and bone fragments are not in their proper position. The incidence of open fractures is 30.7 out of 100,000 people per year. Based on the relationship with the outside world, fractures are divided into two, if the skin is still intact after breaking, it is called a closed fracture, and if there is a wound, it is called an open fracture. An open fracture is an emergency condition that can be life-threatening if not treated adequately. This is due to the relationship of fracture fragments with the outside world, which allows contamination to occur. Complications resulting from contamination are the occurrence of infection. The event of infection can cause a worsening of the patient's clinical condition. Thus, the socio-economic burden of the sufferer will increase. Therefore, prompt and appropriate treatment is needed, one of which is prophylactic antibiotics.

Objectives: This scoping review aims to analyze the effectiveness of prophylactic antibiotics in cases of open fractures for the prevention of surgical site infection.

Methods: Article searches were conducted using two online databases, PubMed and Scopus. The articles searched were published between 2017-2021, with the main keywords used being prophylactic antibiotics, surgical site infections, and open fracture.

Results: Four articles were selected from the article search process. Based on the article review results, it is known that Staphylococcus aureus is the most common microorganism causing surgical site infection. The use of prophylactic antibiotics should be given as soon as possible after an open fracture. The most used prophylactic antibiotics are cephalosporins. The duration of use of prophylactic antibiotics is still not according to existing recommendations.

Conclusion: The incidence of surgical site infection can affect healing time, length of hospitalization, repeated procedures, and increased costs. In open fractures of GA type I and II, it is recommended to use prophylactic antibiotics of first or second-generation cephalosporin. For open fractures of GA type III, it is recommended that third-generation cephalosporin be used with an aminoglycoside as prophylactic antibiotics. The duration of prophylactic antibiotics is 24-72 hours. Further research is needed to determine the most effective prophylactic antibiotics and the optimal period to prevent surgical site infections and bacterial resistance.

Corresponding Author:
Agam Meureza Prabowo

KEYWORDS: Antibiotic Prophylaxis, Surgical Site Infection, Open Fracture

I. INTRODUCTION

Fractures are a severe injury condition characterized by structural discontinuity of bone which can be in the form of cracks to occur ultimately, and bone fragments are not in their proper position. The primary mechanism for open fractures is high energy trauma such as traffic accidents, gun attacks, and falls from a height. The incidence of open fractures is 30.7 out of 100,000 people per year. The highest incidence of open fractures in men occurs at the age of 15-19 years with 54.5 of 100,000 people per year, while in women, it occurs at the age of 80-89 years with 53 of 100,000 people per year [1]. In America, it is estimated that the incidence of open fractures reaches 11.5 out of 10,000 people [2]. According to data from Basic Health Research (2018), there

were around 5113 people who had broken bones out of 92,976 people who had injuries.

Based on the relationship with the outside world, fractures are divided into two, if the skin is still intact after the fracture is called a closed fracture, and if there is a wound, it is called an open fracture. In the case of open fractures, contamination and infection can occur more quickly [4]. An open fracture is an emergency condition that can be life-threatening if not treated adequately. This is due to the relationship of fracture fragments with the outside world, which allows contamination [2], [5].

Complications resulting from contamination are the occurrence of infection. Bacteria can penetrate the damaged skin layer and attach to the damaged soft tissue, and then contamination occurs so that infection can occur. Prolonged infection can cause biofilm formation in the wound area. These biofilms make wound infection challenging to treat [7]. The occurrence of infection can potentially cause a worsening of the patient's clinical condition. Thus, the socio-economic burden of the sufferer will increase. Therefore, prompt and appropriate treatment is needed, one of which is prophylactic antibiotics.

In connection with the high incidence of fractures, the high possibility of infectious complications in open fracture injuries, and the potential of prophylactic antibiotics in reducing the incidence of infection in open fracture wounds, this scoping review was prepared to determine the effectiveness of prophylactic antibiotics in patients with open fractures.

II. MATERIALS AND METHODS

This research is structured based on research questions that form the basis for effective and efficient study. The research question is how effective are prophylactic antibiotics in cases of open fractures as prevention of infection in the operating area?

Scoping review was compiled based on the preparation method and a systematic selection process using two databases, namely Pubmed and Scopus. In the search process, we use keywords related to the research question. The keywords used include: antibiotic prophylaxis, surgical site infection, open fractures, and developed first by looking for synonyms of each keyword before doing a library search. The search for relevant articles was adjusted according to the inclusion criteria consisting of: a) articles discussing the use of prophylactic antibiotics in patients with open fractures, b) articles in Indonesian or English, c) articles published in the last five years (2017-2021), d) the article is a clinical study using a randomized control trial design, case-control, or cohort studies. The exclusion criteria in this study include: a) the article is not available in full, and b) the article uses a systematic review or review method. After searching for articles in the database, then organizing the articles using bibliographic software Zotero. Articles are grouped according to the origin of the database. The same article is deleted, and the title and abstract are thoroughly screened. After reviewing the articles, the relevant articles are put in a 'synthesis' folder. Each stage of the selection of this article was carried out by the author and one of the author's friends, who carried out every step as the author did to avoid bias. The search results will be presented in the final report following the Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA-P) guidelines.

Repeated readings were made to ensure all information was included in the selected articles. Tables were compiled to map and include relevant important information. The components of the table include: (a) name of researcher and year, (b) title, (c) location, (d) research objectives, (e) research design, (f) inclusion criteria, (g) exclusion criteria, (h) results, (I) conclusions.

III. RESULT

The search results found 344 articles, 117 articles in the Pubmed database, and 227 on Scopus. After 46 duplicate articles were removed, 298 were screened, and found seven articles relevant to the study. Then three articles were found that did not meet the inclusion criteria.

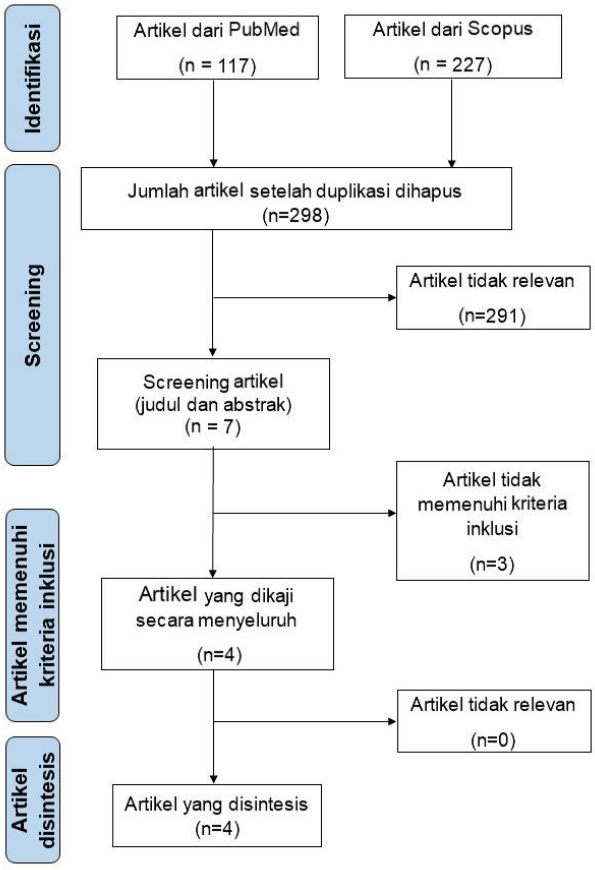

Figure 1. PRISMA Diagram

The results of the synthesis of articles were four articles. Of the four remaining articles assessed for eligibility, none were excluded. The methodological quality of 4 articles was assessed; two articles were retrospective cohort studies, one prospective cohort article, and one cross-sectional article. The articles obtained were published in 2017-2021 and carried out in 3 different countries, including India (n=2), the Netherlands (n=1), and Japan (n=1). Total respondents who participated were 1,591, including 401 orthopedic specialists and 1,190 patients with open fractures.

In the study of Sanders et al. (2020), who examined the comparison of the incidence of infection between antibiotics Cefazolin 1g vs Cefazolin 2g, found that in the 1g group, there were ten patients infected with Staphylococcus Aureus, four patients infected with Enterobacter Cloacae, and one patient infected with Enterococcus Faecalis. While in group 2g, there were two patients infected with Staphylococcus aureus, one patient infected with Enterobacter Cloacae, one patient infected with Enterococcus Faecalis, one patient infected with Pseudomonas, and one patient was infected with Staphylococcus Epidermidis. The research of Doshi et al. (2017), who examined the incidence of infection after internal fixation in open fractures and closed fractures, found that in the open fracture group, there were four patients infected with Staphylococcus aureus and one patient infected with Pseudomonas spp. In the closed fracture group, there are five patients infected with Staphylococcus Aureus and one patient infected with Enterobacter Serus. Ukai et al. (2020), in their research on risk factors for deep infection in open fractures, said that there were nine patients infected with methicillin-resistant Staphylococcus Aureus (MRSA), one patient infected with methicillin-resistant Staphylococci (MRS), and eight patients infected with other bacteria.

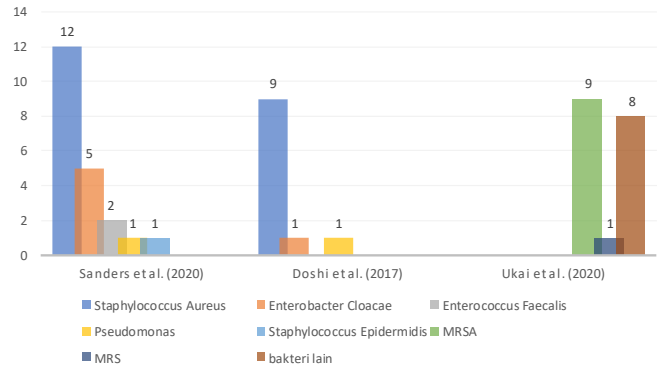

Figure 2. Bacteria that Cause Infection

Santoshi et al. (2021) stated that, respondents who are orthopedic surgeons generally use a cephalosporin or penicillin with an aminoglycoside in type I and II open fractures of GA. In contrast, type III open fractures of GA generally use a cephalosporin or penicillin with an aminoglycoside and metronidazole. Ukai et al. (2020) said that there was no significant difference between cephalosporins compared with cephalosporins plus aminoglycosides in contaminated open fractures on the incidence of surgical site infection. In their study, Sanders et al. (2020) also did not find a significant difference between cefazolin 1g and cefazolin 2g in the incidence of surgical site infections. However, Sanders et al. (2020) said that there was a decrease in the incidence of surgical site infections in the group receiving cefazolin 2g. Therefore, further research with a larger sample is needed. In his study, Redfern et al. (2016), which compared cefazolin plus gentamicin with piperacillin/tazobactam as prophylactic antibiotics against the incidence of surgical site infections, said that there was no significant difference. Therefore, in line with Ukai et al. (2020), an investigation is needed to determine the most practical combination of antibiotics in future studies.

Table 1. Comparison of Prophylactic Antibiotics

Study	Location	Antibiotik Prophylaxis	SSI Rate	P-Value
Ukai et al. (2020)	Japan	*Cephalosporin*	16/96 (16,7%)	P = 0.3
		Cephalosporin + aminoglikosida	3/15 (20%)	
Sanders et al. (2020)	Netherland	Cefazolin 1g	19/293 (6,5%)	OR, 0.770; P = 0.608
		Cefazolin 2g	6/126 (4,8%)	
Redfern et al. (2016)	America	Cefazolin + gentamicin	12/37 (32.4%)	P = 1.000
		Piperacillin/tazobactam	11/35 (31.4%)	

In the research of Santoshi et al. (2021) and Doshi et al. (2017), the average duration of prophylactic antibiotics in patients after surgery is 2-9 days. While in the study of Ukai et al. (2020), the average course of prophylactic antibiotics is 11.9 days.

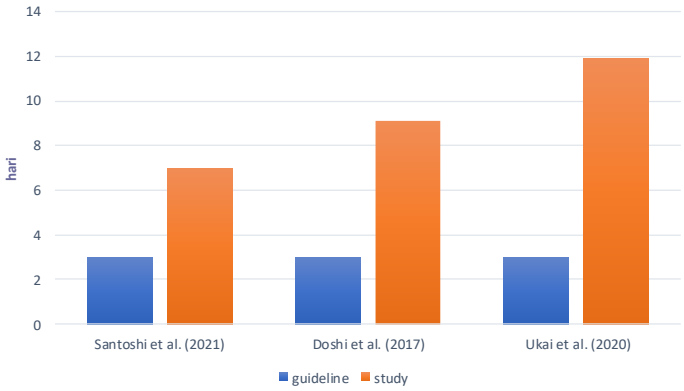

Figure 3. Duration of Antibiotics

IV. DISCUSSION

This Scoping review provides a comprehensive review of the research evidence on prophylactic antibiotic administration in patients with open fractures. Several essential discussions were obtained, such as bacteria that cause infection, the selection of antibiotic use, and the recommended time for giving antibiotics. In this regard, adjustments are still needed for implementation in each hospital.

A. Open Fracture

Patients with open fractures have a great chance of developing an infection if not treated quickly and appropriately. This can be related to the increase in the duration of treatment, the increasing costs, repeated procedures, and the increased use of antibiotics [9], [10].

Matters related to open fractures can be seen in Figure 4. Based on the analysis of VOSviewer, open fractures are generally associated with prophylactic antibiotics, surgical infections, management, and microorganisms. Open fractures are closely related to the incidence of infection due to direct exposure to the outside world. Therefore, infection prevention is needed, one of which is prophylactic antibiotics.

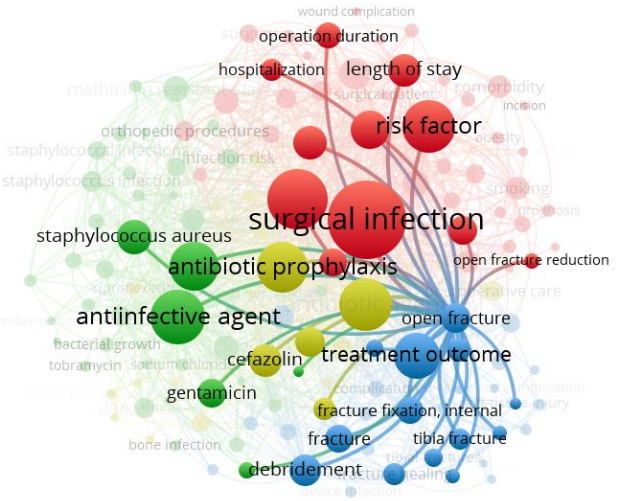

Figure 4. Matters Related to Open Fractures

B. Bacteria that cause infection

Many microorganisms can contaminate open fractures, including Staphylococcus aureus, Enterobacter cloacae, Enterococcus faecalis, Pseudomonas, and Staphylococcus Epidermidis. Of all the bacteria that can cause infection, Staphylococcus aureus is the bacteria most commonly found from culture examination in infected patients [9], [11]–[13].

C. Selection of Antibiotics

There is not much literature that presents the choice of prophylactic antibiotics that can be used for open fracture cases. In general, *cephalosporins* are recommended to be the first choice given as soon as possible after an open fracture occurs as prophylactic antibiotics covering both gram-positive and negative bacteria [10], [11], [14], [15]. The most used *cephalosporin* is Cefazolin, followed by Ceftriaxone and Cefepime. There is a tendency to use only *cephalosporins* as prophylactic antibiotics in open fractures of GA type I and II, where contamination is usually from normal skin flora. This can generally be overcome with the use *of cephalosporins* of the first generation. Cefazolin has been shown to be effective in preventing *staphylococcal* and is used in various surgical procedures, so it is recommended by several *guidelines* for use in surgical implants [16]–[18]. For open fractures of GA type III, a combination of *cephalosporin* and a gram-negative antibiotic is recommended. High-dose penicillin is recommended for open fractures exposed to soil or potentially contaminated with clostridium. If there is a penicillin allergy, penicillin can replace with *clindamycin.* Meanwhile, the use of metronidazole still requires scientific evidence although in fact it is quite often used [1], [12], [17], [19], [20].

D. Time of administration of Antibiotics

Prophylactic antibiotics are one of the measures to prevent infection. Prophylactic antibiotics can be given before, during, and after surgery [21]. Prophylactic antibiotics should be given as soon as possible after the occurrence of an open fracture because the sooner, the better [22]. Lack et al. (2015), in their study, said that the incidence of infection was 0% if prophylactic antibiotics were given in the first 66 minutes after injury and would increase to 17% if it was delayed beyond that time. Another study stated that delaying prophylactic antibiotics for more than three hours could increase the infection rate sixfold [1]. Atwan et al. (2020), in an article, stated that the infection rate in patients receiving antibiotics for less than 3 hours was 4.7%, while the infection rate in patients receiving antibiotics for more than 3 hours was 7.4%. During surgery, additional prophylactic antibiotics may be given if the operation lasts more than 4 hours or if the patient loses more than 1500cc of blood during surgery [9], [10], [24].

From the articles obtained, it is known that the most extended duration of antibiotic use is 11.9 days. This is not in accordance with the recommendations for the duration of prophylactic antibiotics use. In open fractures of GA type I and II, prophylactic antibiotics were given for 24 hours after the wound was successfully closed. In open fractures of GA type III, prophylactic antibiotics were given for 72 hours after the injury or not later than 24 hours after the wound was closed [7], [12], [20]. There was no significant difference in a study comparing the use of prophylactic antibiotics for 24 hours with a longer duration of use on the incidence of surgical site infections [25], [26]. Puetzler et al.

(2018), in their study, stated that the use of prophylactic antibiotics cefuroxime for 72 hours is better than giving it for 24 hours or a single dose in preventing infection at the surgical site in the animals studied. The prolonged duration of prophylactic antibiotics has the risk of causing bacterial resistance to the antibiotics given [10], [11], [15]. Therefore, scientific research is needed to determine the duration of prophylactic antibiotics that are most effective and can avoid bacterial resistance to antibiotics.

V. CONCLUSIONS AND RECOMMENDATIONS

The high incidence of open fractures is closely related to the risk of surgical blood infection due to wounds contaminated by the outside world. These infections can affect healing time, length of hospitalization, repeated procedures, and increased costs. Staphylococcus aureus is known to be the most common microorganism contaminating open fractures; therefore, for open fractures of GA type I and II, it is recommended to use first-generation cephalosporin such as cefazolin or second-generation cephalosporin such as cefuroxime. For open fractures of GA type III, prophylactic use of third-generation cephalosporin such as ceftriaxone is recommended in combination with an aminoglycoside such as gentamicin. If open fractures are exposed to soil and possibly contaminated with clostridium, they may be given additional penicillin high-dose or clindamycin if allergic to penicillin. Prophylactic antibiotics were given as soon as possible since open fractures and were given up to 24 hours after wound closure in GA type I and II open fractures. Whereas in open fracture GA type III is given up to 72 hours after the open fracture occurs or not more than 24 hours after wound closure.

Research on prophylactic antibiotics in open fractures is still needed to determine which prophylactic antibiotics are most effective in preventing infection at the surgical site. In addition, the duration of the use of prophylactic antibiotics still needs to be researched to achieve the most optimal period that can prevent infection in the operating area while preventing bacteria from becoming antibiotic-resistant.

REFERENCES

1. J. L. Sop and A. Sop, Open Fracture Management. StatPearls Publishing, 2021. Accessed: Apr. 02, 2022. [Online]. Available: https://www.ncbi.nlm.nih.gov/books/NBK448083/
2. G. D. D. Wikananda, "JURNAL MEDIKA UDAYANA, VOL. 8 NO.9,SEPTEMBER, 2019," vol. 8, p. 6, 2019.
3. Riset Kesehatan Dasar, "Laporan Nasional RISKESDAS," 2018. http://labdata.litbang.kemkes.go.id/images/download/laporan/RKD/2018/Laporan_Nasional_RKD2018_FINAL.pdf (accessed Mar. 22, 2022).
4. L. Solomon, D. Warwick, and S. Nayagam, Apley System of Orthopaedics and Fractures, 9th ed. London, UK: Hodder Arnold, 2010.
5. R. O. Kasman, "Diajukan Sebagai Salah Satu Syarat untuk Memperoleh Gelar Sains dalam Program Pendidikan Dokter Spesialis Ilmu Bedah Fakultas Kedokteran Universitas Sumatera Utara," p. 54, 2019.
6. A. R. Elniel and P. V. Giannoudis, "Open fractures of the lower extremity: Current management and clinical outcomes," EFORT Open Rev., vol. 3, no. 5, pp. 316–325, May 2018, doi: 10.1302/2058-5241.3.170072.
7. Y. Atwan, T. Miclau, E. H. Schemitsch, and D. Teague, "Antibiotic utilization in open fractures," OTA Int. Open Access J. Orthop. Trauma, vol. 3, no. 1, p. e071, Mar. 2020, doi: 10.1097/OI9.0000000000000071.
8. J. Redfern, S. M. Wasilko, M. E. Groth, W. D. McMillian, and C. S. Bartlett, "Surgical Site Infections in Patients With Type 3 Open Fractures: Comparing Antibiotic Prophylaxis With Cefazolin Plus Gentamicin Versus Piperacillin/Tazobactam," J. Orthop. Trauma, vol. 30, no. 8, pp. 415–419, Aug. 2016, doi: 10.1097/BOT.0000000000000554.
9. F. R. K. Sanders, R. M. G. Kistemaker, M. van 't Hul, and T. Schepers, "Comparison of 2g vs 1 g of Prophylactic Cefazolin in Surgical Site Infections in Trauma Surgery Below the Knee," Foot Ankle Int., vol. 41, no. 5, pp. 582–589, May 2020, doi: 10.1177/1071100720903723.
10. J. A. Santoshi, P. Behera, M. Nagar, R. Sen, and A. Chatterjee, "Current Surgical Antibiotic Prophylaxis Practices: A Survey of Orthopaedic Surgeons in India," Indian J. Orthop., vol. 55, no. 3, pp. 749–757, Jun. 2021, doi: 10.1007/s43465-020-00306-0.
11. P. Doshi, H. Gopalan, S. Sprague, C. Pradhan, S. Kulkarni, and M. Bhandari, "Incidence of infection following internal fixation of open and closed tibia fractures in India (INFINITI): a multi-centre observational cohort study," BMC Musculoskelet. Disord., vol. 18, no. 1, p. 156, Dec. 2017, doi: 10.1186/s12891-017-1506-4.
12. M. R. Garner, S. A. Sethuraman, M. A. Schade, and H. Boateng, "Antibiotic Prophylaxis in Open Fractures: Evidence, Evolving Issues, and Recommendations," J. Am. Acad. Orthop. Surg., vol. 28, no. 8, pp. 309–315, Apr. 2020, doi: 10.5435/JAAOS-D-18-00193.
13. B. Wang, X. Xiao, J. Zhang, W. Han, S. A. Hersi, and X. Tang, "Epidemiology and microbiology of fracture-related infection: a multicenter study in

Northeast China," J. Orthop. Surg., vol. 16, no. 1, p. 490, Dec. 2021, doi: 10.1186/s13018-021-02629-6.
14. C. J. Hauser, C. A. Adams, and S. R. Eachempati, "Prophylactic Antibiotic Use in Open Fractures: An Evidence-Based Guideline," Surg. Infect., vol. 7, no. 4, pp. 379–405, Aug. 2006, doi: 10.1089/sur.2006.7.379.
15. T. Ukai, K. Hamahashi, Y. Uchiyama, Y. Kobayashi, and M. Watanabe, "Retrospective analysis of risk factors for deep infection in lower limb Gustilo–Anderson type III fractures," J. Orthop. Traumatol., vol. 21, no. 1, p. 10, Dec. 2020, doi: 10.1186/s10195-020-00549-5.
16. D. W. Bratzler et al., "Clinical practice guidelines for antimicrobial prophylaxis in surgery," Am. J. Health. Syst. Pharm., vol. 70, no. 3, pp. 195–283, Feb. 2013, doi: 10.2146/ajhp120568.
17. T. L. Hand, E. O. Hand, A. Welborn, and B. A. Zelle, "Gram-Negative Antibiotic Coverage in Gustilo-Anderson Type-III Open Fractures," J. Bone Jt. Surg., vol. 102, no. 16, pp. 1468–1474, Aug. 2020, doi: 10.2106/JBJS.19.01358.
18. C. A. Lin et al., "Low Adherence to Recommended Guidelines for Open Fracture Antibiotic Prophylaxis," J. Bone Jt. Surg., vol. 103, no. 7, pp. 609–617, Apr. 2021, doi: 10.2106/JBJS.20.01229.
19. D. C. Carver, S. B. Kuehn, and J. C. Weinlein, "Role of Systemic and Local Antibiotics in the Treatment of Open Fractures," Orthop. Clin. North Am., vol. 48, no. 2, pp. 137–153, Apr. 2017, doi: 10.1016/j.ocl.2016.12.005.
20. W. S. Hoff, J. A. Bonadies, R. Cachecho, and W. C. Dorlac, "East Practice Management Guidelines Work Group: Update to Practice Management Guidelines for Prophylactic Antibiotic Use in Open Fractures," J. Trauma Inj. Infect. Crit. Care, vol. 70, no. 3, pp. 751–754, Mar. 2011, doi: 10.1097/TA.0b013e31820930e5.
21. World Health Organization, Preventing surgical site infections: implementation approaches for evidence-based recommendations. Geneva: World Health Organization, 2018. Accessed: Apr. 18, 2022. [Online]. Available: https://apps.who.int/iris/handle/10665/273154
22. A. Diwan, K. R. Eberlin, and R. M. Smith, "The principles and practice of open fracture care, 2018," Chin. J. Traumatol., vol. 21, no. 4, pp. 187–192, Aug. 2018, doi: 10.1016/j.cjtee.2018.01.002.
23. W. D. Lack et al., "Type III Open Tibia Fractures: Immediate Antibiotic Prophylaxis Minimizes Infection," J. Orthop. Trauma, vol. 29, no. 1, pp. 1–6, Jan. 2015, doi: 10.1097/BOT.0000000000000262.
24. Y. Aprilia and I. Fajriaty, "GAMBARAN PENGGUNAAN ANTIBIOTIK PROFILAKSIS PADA PASIEN BEDAH TULANG FRAKTUR TERBUKA EKSTREMITAS BAWAH DI RSUD DOKTER SOEDARSO PONTIANAK," p. 9, 2017.
25. J. N. Ondari, M. M. Masika, R. B. Ombachi, and J. E. Ating'a, "Unblinded randomized control trial on prophylactic antibiotic use in gustilo II open tibia fractures at Kenyatta National Hospital, Kenya," Injury, vol. 47, no. 10, pp. 2288–2293, Oct. 2016, doi: 10.1016/j.injury.2016.07.014.
26. N. Vanvelk et al., "Duration of Perioperative Antibiotic Prophylaxis in Open Fractures: A Systematic Review and Critical Appraisal," Antibiotics, vol. 11, no. 3, p. 293, Feb. 2022, doi: 10.3390/antibiotics11030293.
27. J. Puetzler et al., "Antibiotic Prophylaxis With Cefuroxime: Influence of Duration on Infection Rate With Staphylococcus aureus in a Contaminated Open Fracture Model," J. Orthop. Trauma, vol. 32, no. 4, pp. 190–195, Apr. 2018, doi: 10.1097/BOT.0000000000001053.