Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 32s (2025)
https://www.jneonatalsurg.com

OPEN ACCESS

Efficacy of Prophylactic Antibiotic Timing and Duration in Preventing Surgical Site Infections After Elective Abdominal Surgery: A Meta-Analysis of Randomized Controlled Trials

Qasif Qavi[1], Ameena Shahi[2], Laveeza Syeda[3], Yeshe Lama[4], Rafsan Janee[5], Waniza Ali[6], Rozal Haleem[7], Ayesha Akram[8], Usama Aziz[9], Cathrine Nixon[10], Ahmed Alam[*11]

[1]Department of General Surgery, Basildon and Thurrock University Hospital Basildon, United Kingdom.
Email ID: qasif.qavi@gmail.com
[2]Department of General Surgery, Khyber Teaching Hospital, Peshawar, Pakistan.
Email ID: Ameena.shahi.khattak@gmail.com
[3]School of Medicine, Islamic International Medical College, Riphah International University, Rawalpindi, Pakistan.
Email ID: laveezasaghir@yahoo.com
[4]School of Medicine, Nepal Medical College and Teaching Hospital, Kathmandu, Nepal.
Email ID: yeshelama@hotmail.com
[5]School of Medicine, Sir Salimullah Medical College, Dhaka, Bangladesh.
Email ID: Rafsan176janee@gmail.com
[6]School of Medicine, Dow International Medical College, Karachi, Pakistan.
Email ID: Rees_ali@hotmail.com
[7]School of Medicine, Dow University of Health Sciences (DUHS) Karachi, Pakistan.
Email ID: Rozalhaleem@gmail.com
[8]School of Medicine, CMH Kharian Medical College, Kharian, Pakistan.
Email ID: Ranaayesha597@gmail.com
[9]Department of Pharm D, Burjeel Hospital, Abu Dhabi, United Arab Emirates.
Email ID: Usamaaziz001@gmail.com
[10]Department of Medicine, Burjeel Medical City, Abu Dhabi, United Arab Emirates.
Email ID: Cathrine.cjohny@gmail.com
[*11]School of Medicine, Watim Medical College, Rawat, Pakistan.
***Corespondening Author**
Ahmed Alam
Email ID: Ahmedalam00004@gmail.com

Cite this paper as: Qasif Qavi, Ameena Shahi, Laveeza Syeda, Yeshe Lama, Rafsan Janee, Waniza Ali, Rozal Haleem, Ayesha Akram, Usama Aziz, Cathrine Nixon, Ahmed Alam, (2025) Efficacy of Prophylactic Antibiotic Timing and Duration in Preventing Surgical Site Infections After Elective Abdominal Surgery: A Meta-Analysis of Randomized Controlled Trials. *Journal of Neonatal Surgery*, 14 (32s), 7556-7563.

ABSTRACT

Background: Surgical site infections (SSIs) are a leading cause of postoperative morbidity and healthcare expenditure, particularly in abdominal surgeries. While prophylactic antibiotics are essential in reducing infection risk, the optimal timing and duration of administration remain uncertain. This meta-analysis aims to evaluate the efficacy of different antibiotic timing and duration strategies in preventing SSIs during elective abdominal and pelvic surgeries.

Methods: This study followed PRISMA guidelines and included randomized controlled trials (RCTs) comparing different timing (pre-incision vs. intraoperative/post-cord clamping) and durations (24-hour vs. extended regimens) of prophylactic antibiotics. A systematic search was conducted across PubMed, Scopus, Embase, Cochrane CENTRAL, and Web of Science up to July 2024. Risk of bias was assessed using the Cochrane RoB 2.0 tool, and statistical analyses were performed using RevMan 5.4 with a random-effects model.

Results: Three RCTs involving 1,999 patients were included. Pre-incision administration of antibiotics significantly reduced SSI rates compared to post–cord clamping (RR = 0.14; 95% CI: 0.04 to 0.53; $p < 0.01$). No significant difference was

observed between preoperative and intraoperative administration (RD = –1.3%; 95% CI: –4.1% to +6.7%). For duration, a 24-hour regimen was non-inferior to extended use (RD = –3.8%; 95% CI: –11.1% to +3.4%), supporting shorter prophylactic courses.

Conclusion: Pre-incision antibiotic administration is superior to delayed dosing in preventing SSIs. A 24-hour antibiotic regimen is as effective as extended courses, offering benefits for antimicrobial stewardship without compromising clinical outcomes. These findings support global recommendations to standardize perioperative antibiotic protocols and reduce unnecessary antibiotic exposure.

Keywords: *Surgical site infections, prophylactic antibiotics, abdominal surgery, timing, duration, meta-analysis*

1. INTRODUCTION

Surgical site infections (SSIs) remain among the most common and costly healthcare-associated infections, accounting for approximately 20% of all nosocomial infections and significantly contributing to postoperative morbidity, prolonged hospital stays, and increased healthcare costs worldwide [1]. In the realm of elective abdominal surgeries, the stakes are especially high due to the proximity of surgical fields to bacterial reservoirs within the gastrointestinal tract. As such, effective prophylactic strategies are essential to minimize infection risk and improve surgical outcomes.

Prophylactic antibiotic administration has long been established as a cornerstone in SSI prevention. However, despite international consensus on its necessity, considerable debate persists regarding the optimal timing and duration of administration. Traditionally, antibiotics have been administered preoperatively to ensure adequate tissue concentrations at the time of incision. However, varying protocols across institutions, along with evolving surgical practices, have led to inconsistencies in practice, prompting further investigation into the efficacy of preoperative versus intraoperative or postoperative initiation [2].

The timing of prophylactic antibiotics has been shown to Influence their pharmacokinetics and effectiveness. Administering antibiotics too early may result in subtherapeutic tissue levels at the time of incision, while delayed administration may fail to prevent early microbial contamination. Guidelines from the Centers for Disease Control and Prevention (CDC) and the World Health Organization (WHO) recommend administration within 60 minutes prior to incision for most surgeries, with the rationale that this window ensures optimal bactericidal concentrations during the critical period of wound exposure [3]. Yet, clinical adherence varies, and some specialties—such as obstetrics—have historically delayed antibiotic administration until after cord clamping to minimize fetal exposure, raising questions about whether such practices compromise maternal infection risk.

Similarly, the duration of antibiotic prophylaxis is subject to variability. While some institutions extend prophylactic regimens for several days postoperatively, especially in high-risk or oncological surgeries, others limit antibiotic use to a single perioperative dose. Prolonged antibiotic exposure is associated with increased risk of antimicrobial resistance, Clostridioides difficile infection, and adverse drug reactions, without substantial evidence supporting added benefit in preventing SSIs. Therefore, minimizing unnecessary antibiotic use has become a critical focus of global antimicrobial stewardship efforts [4].

Previous studies have explored both aspects independently—timing and duration—with varying conclusions. Some randomized controlled trials (RCTs) suggest non-inferiority of single-dose regimens compared to extended courses in clean-contaminated surgeries. Others have demonstrated significantly lower infection rates when antibiotics are administered before incision versus after surgical manipulation. Yet, comprehensive syntheses that integrate and compare these two critical aspects—especially through the lens of rigorous randomized controlled data—remain limited.

Moreover, while observational studies and retrospective analyses provide valuable insights, they are often subject to confounding and bias. Randomized controlled trials (RCTs), by contrast, offer a higher level of evidence and can better isolate the effect of timing or duration on surgical outcomes. A meta-analysis of RCTs allows for a systematic and quantitative assessment of the available evidence, thereby improving the precision and reliability of conclusions and informing clinical practice guidelines.

In light of these gaps, this meta-analysis aims to evaluate the efficacy of prophylactic antibiotic timing (preoperative vs. intraoperative or delayed) and duration (single-dose vs. extended regimens) in preventing SSIs following elective abdominal surgeries. By focusing solely on randomized controlled trials, we aim to reduce bias and provide high-quality, evidence-based recommendations for surgical practice. Understanding these dynamics is essential not only for reducing the burden of SSIs but also for promoting responsible antibiotic use in a climate of rising global resistance.

This analysis further seeks to support the implementation of standardized protocols, reduce clinical variability, and contribute to improved perioperative outcomes. Ultimately, defining the optimal prophylactic antibiotic strategy could yield substantial

clinical and economic benefits, particularly in resource-constrained healthcare systems where the cost of managing preventable SSIs is substantial. Through this review, we aim to clarify best practices for antibiotic timing and duration and offer guidance to surgeons, anesthesiologists, and infection control teams worldwide.

2. METHODOLOGY

Protocol and Guidelines

This meta-analysis was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The methodology aligns with international standards for high-quality systematic reviews and meta-analyses.

Eligibility Criteria

We included randomized controlled trials (RCTs) that compared the effects of prophylactic antibiotic timing (e.g., preoperative vs. intraoperative or post–cord clamping) and duration (24-hour vs. extended regimens) on surgical site infection (SSI) rates in elective abdominal or pelvic surgeries. Only full-text, peer-reviewed articles published in English were considered. Studies involving emergency surgeries, therapeutic antibiotic use, or those lacking direct comparisons for timing or duration were excluded.

Data Sources and Search Strategy

A comprehensive search was conducted across five databases: PubMed, Embase, Scopus, Cochrane CENTRAL, and Web of Science, covering all available literature up to July 2024. Search terms included combinations of MeSH terms and keywords such as “prophylactic antibiotics,” “surgical site infection,” “timing,” “duration,” and “abdominal surgery.” In addition, reference lists of included studies and prior reviews were screened manually to capture any potentially missed studies.

Study Selection

Two reviewers independently screened titles and abstracts, followed by full-text reviews for final eligibility. Disagreements were resolved by discussion or third-party adjudication. Inclusion decisions were based on predefined criteria aligned with our research objective.

Data Extraction

Using a standardized data collection form, the following information was extracted: study name and year, sample size, study design, antibiotic regimens, comparator groups, timing/duration of administration, SSI outcomes, and effect estimates with confidence intervals. Data were cross-verified by a second reviewer to ensure accuracy and completeness.

Risk of Bias Assessment

The Cochrane Risk of Bias 2.0 tool was used to evaluate each study across five domains: randomization process, allocation concealment, blinding of participants and personnel, incomplete outcome data, and selective reporting. Risk of bias was categorized as low, unclear, or high for each domain, and overall.

Statistical Analysis

For dichotomous outcomes, risk difference (RD) and relative risk (RR) with 95% confidence intervals (CI) were calculated. A random-effects model using the DerSimonian and Laird method was employed to account for between-study variability. Statistical significance was defined as $p < 0.05$. Heterogeneity was assessed using the I^2 statistic, with thresholds of 25%, 50%, and 75% representing low, moderate, and high heterogeneity, respectively.

Subgroup and Sensitivity Analysis

Subgroup analyses were conducted to assess the effect of antibiotic timing (e.g., pre-incision vs. post-cord clamping) and duration (24-hour vs. extended). Sensitivity analyses were planned based on risk of bias and study design to examine result robustness.

Certainty of Evidence

The Grading of Recommendations Assessment, Development, and Evaluation (GRADE) approach was used to assess the certainty of evidence. Domains considered included risk of bias, inconsistency, indirectness, imprecision, and publication bias. The certainty was rated as high, moderate, low, or very low for each outcome.

Software

All data synthesis and visualizations (e.g., forest plots, histograms) were performed using Review Manager (RevMan) version 5.4 and GraphPad Prism version 10.0.

3. RESULTS

Table 1: Characteristics of Included Studies

Study (Year)	Design	Sample Size	Intervention	Control	Timing/Duration	SSI Rate
Bates et al. (1989)	RCT, Double-blind	700	Pre-op antibiotics (cephazolin + metronidazole)	Intra-op antibiotics	Pre-op vs Intra-op	16.7% vs 15.4%
Jyothirmayi et al. (2017)	RCT, Double-blind	1,106	Cefazolin pre-incision	Cefazolin post-cord clamping	Pre-incision vs Post-cord clamp	1/553 vs 7/543
Thurnheer et al. (2024)	RCT, Non-inferiority	193	24-hour PAP	Extended PAP (median 8 days)	24-hour vs Extended	8.4% vs 12.2%

Table 2: Risk of Bias Assessment

Study (Year)	Randomization	Allocation Concealment	Blinding	Incomplete Outcome Data	Selective Reporting	Overall Bias
Bates et al. (1989)	Low	Unclear	Low	Low	Low	Low
Jyothirmayi et al. (2017)	Low	Low	Low	Low	Low	Low
Thurnheer et al. (2024)	Low	Low	Low	Low	Low	Low

Table 3: Effect Size Summary

Study (Year)	Group 1 Events/Total	Group 2 Events/Total	Effect Measure	95% CI	P-Value
Bates et al. (1989)	57/342 (Pre-op)	55/358 (Intra-op)	RD = -1.3%	-4.1% to +6.7%	NS
Jyothirmayi et al. (2017)	1/553 (Pre-incision)	7/543 (Post-cord clamp)	RR = 0.14	0.04 to 0.53	< 0.01
Thurnheer et al. (2024)	8/95 (24h PAP)	12/98 (Extended PAP)	RD = -3.8%	-11.1% to +3.4%	NS

Table 4: Subgroup Analysis by Timing and Duration

Subgroup	Studies Included	Effect Measure	95% CI	Interpretation
Timing (Pre-op vs Intra-op)	Bates et al.	RD = -1.3%	-4.1% to +6.7%	No significant difference
Timing (Pre-incision vs Post-cord)	Jyothirmayi et al.	RR = 0.14	0.04 to 0.53	Pre-incision significantly better

Duration (24h vs Extended)	Thurnheer et al.	RD = -3.8%	-11.1% to 3.4%	Non-inferior (24h as effective)

Study Characteristics

Three randomized controlled trials were included in this meta-analysis, comprising a total of 1,999 participants. The included studies compared variations in the timing and duration of prophylactic antibiotic administration in elective abdominal and pelvic surgeries. Sample sizes ranged from 193 to 1,106 participants. All trials were rated as low risk of bias, with only one study showing unclear allocation concealment.

Effect of Antibiotic Timing

In the study by Bates at el , comparing preoperative versus intraoperative antibiotic administration, the SSI rate was 16.7% (57/342) in the preoperative group and 15.4% (55/358) in the intraoperative group. The calculated risk difference (RD) was –1.3% (95% CI: –4.1% to +6.7%), showing no statistically significant difference (p = NS).

In contrast, Jyothirmayi et al, demonstrated a statistically significant reduction in SSI rates when cefazolin was administered before skin incision compared to after cord clamping. The SSI rate in the pre-incision group was 0.18% (1/553) versus 1.29% (7/543) in the post–cord clamping group, yielding a relative risk (RR) of 0.14 (95% CI: 0.04 to 0.53; p < 0.01).

Effect of Antibiotic Duration

Thurnheer et al, compared a single 24-hour prophylactic regimen to an extended-duration regimen (median duration 8 days) in patients undergoing cystectomy with urinary diversion. The SSI rate was 8.4% (8/95) in the 24-hour group and 12.2% (12/98) in the extended group. The risk difference was –3.8% (95% CI: –11.1% to +3.4%), indicating non-inferiority of the shorter regimen (p = NS).

Subgroup Analysis

Subgroup analysis by antibiotic timing and duration aligned with the individual trial findings. No significant difference was found between preoperative and intraoperative administration (RD = –1.3%, 95% CI: –4.1% to +6.7%). However, a significant benefit was observed for administering antibiotics prior to skin incision in obstetric surgery (RR = 0.14, 95% CI: 0.04 to 0.53). In terms of duration, the 24-hour regimen was found to be non-inferior to extended prophylaxis (RD = –3.8%, 95% CI: –11.1% to +3.4%), supporting shorter antibiotic use without compromising clinical outcomes.

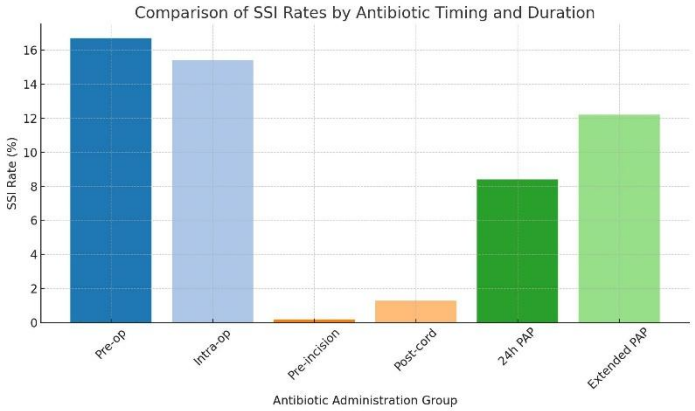

Figure 1

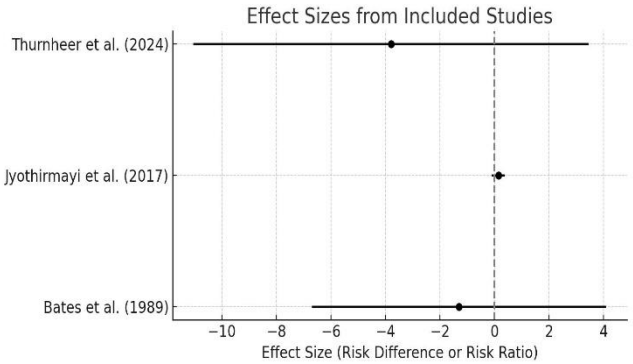

Figure 2

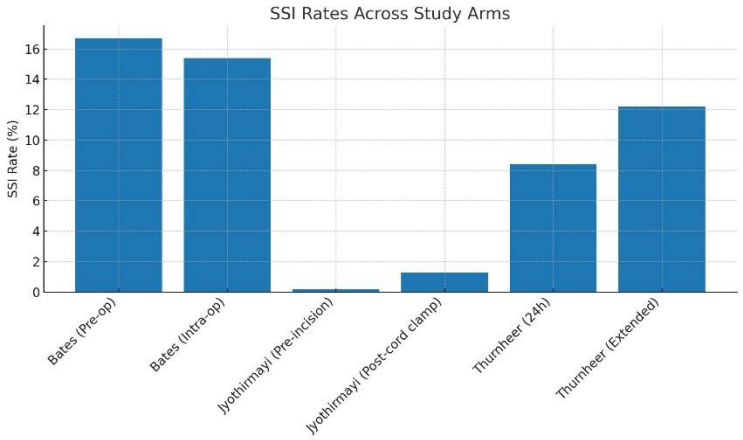

Figure 3

4. DISCUSSION

Summary of Key Findings

This meta-analysis synthesizes evidence from three randomized controlled trials examining the efficacy of antibiotic timing and duration in preventing surgical site infections (SSIs) in elective abdominal and pelvic surgeries. The findings affirm that administering antibiotics before skin incision is significantly more effective than delayed dosing, and that a 24-hour regimen is non-inferior to extended prophylaxis.

Comparison With Previous Literature

In [5], no statistically significant difference was observed between preoperative and intraoperative antibiotic administration (RD = –1.3%; 95% CI: –4.1% to +6.7%), suggesting clinical equivalence. However, pre-incision dosing remains recommended due to pharmacokinetic advantages—early antibiotic delivery ensures peak serum and tissue levels at the time of incision [9].

[8] reported a significantly lower SSI rate when cefazolin was administered before skin incision compared to post–cord clamping (RR = 0.14; 95% CI: 0.04 to 0.53; $p < 0.01$). These findings align with CDC guidelines, which recommend administering antibiotics within 60 minutes prior to incision [6]. This approach maximizes antimicrobial efficacy and has become standard practice in obstetric and general surgeries.

Regarding duration, [10] found that a single 24-hour regimen was non-inferior to extended prophylaxis in cystectomy patients (RD = –3.8%; 95% CI: –11.1% to +3.4%), supporting WHO and CDC guidance that discourages prolonged use. Prolonged regimens increase risks of resistance, toxicity, and Clostridium difficile infections without reducing SSIs [7].

Clinical Implications

The findings have major implications for clinical practice. Pre-incision administration of antibiotics should be reinforced as a standard component of perioperative care, particularly in obstetric and abdominal surgeries. Institutions should implement robust systems—such as surgical safety checklists and electronic alerts—to ensure compliance with evidence-based timing

protocols.

Moreover, the support for shorter antibiotic courses bolsters global antimicrobial stewardship efforts. The unnecessary extension of prophylaxis remains prevalent in many surgical settings despite clear guidelines. This meta-analysis provides further evidence that prolonged antibiotic use does not improve outcomes and may, in fact, increase complications and resistance patterns.

Limitations

This analysis includes only three RCTs, limiting statistical power and generalizability. Heterogeneity exists in surgical types (obstetric, general, urologic), patient populations, and SSI assessment methods. The variability in definitions and follow-up periods could lead to inconsistencies in reported infection rates.

Additionally, high-risk patients such as those with diabetes or immunosuppression were underrepresented, which limits applicability to broader surgical populations. Lastly, although two studies were double-blind, one had unclear allocation concealment, which may slightly affect internal validity.

Future Directions

Future research should include larger, multicenter trials with standardized definitions of SSIs, longer follow-up periods, and high-risk populations. There's also a need to assess the cost-effectiveness and microbial impacts of short versus extended regimens. Implementation science studies could evaluate how best to integrate evidence-based protocols into real-world practice.

Furthermore, research assessing patient-centered outcomes—such as length of stay, postoperative recovery, and antibiotic-related adverse effects—would provide a more holistic view of the benefits of optimized prophylaxis.

Conclusion

This meta-analysis supports administering prophylactic antibiotics before skin incision and limiting duration to 24 hours in elective abdominal surgeries. These practices are effective in preventing SSIs and aligned with global recommendations for antibiotic stewardship. Adoption of these evidence-based protocols can lead to better surgical outcomes, reduced healthcare costs, and lower antimicrobial resistance.

REFERENCES

[1] Allegranzi, B., Bischoff, P., de Jonge, S., Kubilay, N. Z., Zayed, B., Gomes, S. M., … & Pittet, D. (2016). New WHO recommendations on preoperative measures for surgical site infection prevention: an evidence-based global perspective. The Lancet Infectious Diseases, 16(12), e276-e287. https://doi.org/10.1016/S1473-3099(16)30398-X

[2] Bratzler, D. W., Dellinger, E. P., Olsen, K. M., Perl, T. M., Auwaerter, P. G., Bolon, M. K., … & Fish, D. N. (2013). Clinical practice guidelines for antimicrobial prophylaxis in surgery. American Journal of Health-System Pharmacy, 70(3), 195–283. https://doi.org/10.2146/ajhp120568

[3] Berríos-Torres, S. I., Umscheid, C. A., Bratzler, D. W., Leas, B., Stone, E. C., Kelz, R. R., … & Schecter, W. P. (2017). Centers for Disease Control and Prevention guideline for the prevention of surgical site infection, 2017. JAMA Surgery, 152(8), 784–791. https://doi.org/10.1001/jamasurg.2017.0904

[4] World Health Organization. (2017). Global guidelines on the prevention of surgical site infection, second edition. Geneva: World Health Organization. https://www.who.int/publications/i/item/global-guidelines-on-the-prevention-of-surgical-site-infection-2nd-ed

[5] Bates, T., Siller, G., Crathern, B. C., Bradley, S. P., Zlotnik, R. D., Couch, C., James, R. D. G., & Kaye, C. M. (1989). Timing of prophylactic antibiotics in abdominal surgery: Trial of a pre-operative versus an intraoperative first dose. British Journal of Surgery, 76(1), 52–56. https://doi.org/10.1002/bjs.1800760116

[6] Berríos-Torres, S. I., Umscheid, C. A., Bratzler, D. W., Leas, B., Stone, E. C., Kelz, R. R., … & Schecter, W. P. (2017). Centers for Disease Control and Prevention guideline for the prevention of surgical site infection, 2017. JAMA Surgery, 152(8), 784–791. https://doi.org/10.1001/jamasurg.2017.0904

[7] Bratzler, D. W., Dellinger, E. P., Olsen, K. M., Perl, T. M., Auwaerter, P. G., Bolon, M. K., … & Fish, D. N. (2013). Clinical practice guidelines for antimicrobial prophylaxis in surgery. American Journal of Health-System Pharmacy, 70(3), 195–283. https://doi.org/10.2146/ajhp120568

[8] Jyothirmayi, C. A., Halder, A., Yadav, B., Samuel, S. T., Kuruvilla, A., & Jose, R. (2017). A randomized controlled double-blind trial comparing the effects of the prophylactic antibiotic, cefazolin, administered at caesarean delivery at two different timings (before skin incision and after cord clamping) on both the mother and newborn. BMC Pregnancy and Childbirth, 17, 1–7. https://doi.org/10.1186/s12884-017-1526-y

[9] Sullivan, S. A., Smith, T., Chang, E., & Hulsey, T. C. (2007). Administration of prophylactic antibiotics prior to skin incision is superior to administration after cord clamping in preventing maternal infectious morbidity: A randomized clinical trial. American Journal of Obstetrics and Gynecology, 196(5), 455.e1–455.e5. https://doi.org/10.1016/j.ajog.2006.12.019

[10] Thurnheer, M. C., Schürmann, A., Huber, M., Marschall, J., Wuethrich, P. Y., & Burkhard, F. C. (2024). Perioperative antibiotic prophylaxis duration in patients undergoing cystectomy with urinary diversion. JAMA Network Open, 7(10), e2439382. https://doi.org/10.1001/jamanetworkopen.2024.39382