Adherence to International Antimicrobial Prophylaxis Guidelines in Cardiac Surgery: A Jordanian Study Demonstrates Need for Quality Improvement

Nairooz H. Al-Momany, MSc; Amal G. Al-Bakri, PhD; Zeid M. Makahleh, MD, MRCS; and Mayyada M.B. Wazaify, PhD

ABSTRACT

BACKGROUND: Antimicrobial prophylaxis in cardiac surgery has been demonstrated to lower the incidence of surgical site infection (SSI). Inappropriate antimicrobial prophylaxis, such as inappropriate selection of the antimicrobial agent or inappropriate dosing regimen, can increase the prevalence of antibiotic resistant strains, prolong hospital stay, cause adverse reactions, and negatively affect an institution’s pharmacy budget for antibiotics. In developing countries such as Jordan, where the role of clinical pharmacists is still in its primary stages, the first step in establishing an organized clinical pharmacy service is the evaluation of current practice to determine the need for improvement.

OBJECTIVE: To assess the degree of adherence to international guidelines for antimicrobial prophylaxis practice in cardiac surgery performed at Queen Alia Heart Institute (Qahi) in Amman, Jordan, as part of an attempt to determine opportunities for clinical pharmacist intervention.

METHODS: For a total of 236 patients who were admitted for cardiac surgery to QAHI—the only official referral hospital for cardiac patients in Jordan—between November 19, 2006, and January 22, 2007, the antimicrobial prophylaxis indication, choice, duration, dose, dosing interval, and timing appropriateness were assessed against 3 international guidelines using a pre-tested, structured clinical data collection form that was completed by 2 of the authors who work at QAHI. The study design was prospective. All patients who were scheduled for surgery were monitored daily during their inpatient stay until discharge and then were tracked in the outpatient clinic for 2 months following surgery. Data regarding antimicrobial prophylaxis indication, choice, duration, dose, dosing interval, and timing appropriateness were collected during the patient's inpatient stay; data collection was performed periodically thereafter as data became available until the end of the 2-month follow-up. The 3 guidelines agreed on three criteria for antimicrobial prophylaxis: (a) antimicrobial prophylaxis should be given to all patients undergoing cardiac surgery; (b) the first- or second-generation cephalosporins (cefazolin or cefuroxime) are the antibiotics of choice, and vancomycin is reserved for cases of allergy to beta-lactams or if presumed or known methicillin-resistant Staphylococcus aureus (MRSA) colonization is present; (c) the timing of the first dose should be within 60 minutes prior to the skin incision; and (d) the duration of antimicrobial prophylaxis should not be longer than 48 hours.

RESULTS: Adherence to all antimicrobial prophylaxis guidelines was not achieved for any study patients. For the 6 evaluated criteria, (1) indication: in 100% of patients the appropriate decision was made to use antimicrobial prophylaxis in concordance with guidelines; (2) choice: only 1.7% of patients received the antibiotic of choice; (3) duration: 39.4% of patients received antimicrobial prophylaxis for a total duration of 48 hours or less in concordance with guidelines, and for 58.9% of patients, duration was longer than recommended; (4) dose: 27.9% of patients received an appropriate dose; (5) dosing interval: only 13.0% of patients received an appropriate dosing interval, and none of the doses of antimicrobial prophylaxis used at induction of anesthesia was repeated in operations that lasted longer than the half-life of the antibiotic used; and (6) timing: 99.1% of patients received antimicrobial prophylaxis dose within 60 minutes prior to skin incision as recommended by guidelines, but 97.0% of patients received an unnecessary midnight dose of intravenous antibiotic the night before surgery.

CONCLUSION: Study findings indicate that adherence to international guidelines for antimicrobial prophylaxis is far from optimal in QAHI, leading to the inappropriate administration of many antibiotics. Developing local hospital guidelines, as well as giving the clinical pharmacist a central role in the administration, monitoring, and intervention of antimicrobial prophylaxis may improve the current practice.

J Manag Care Pharm. 2009;15(3):262-71

What is already known about this subject:

- Several studies worldwide have described adherence to international guidelines in antimicrobial prophylaxis in different countries. Gorecki et al. (1999) found that in 74% of 211 patients undergoing elective or emergency surgery in a New York private teaching hospital, the antimicrobial prophylaxis administration was inappropriate according to Surgical Infection Society guidelines. Problems included excessive duration (66%), switch to inappropriate antibiotics (32%), spectrum (31%), and timing (i.e., no pre-operative dose, 22%).

- In a study of the application of guidelines on pre-operative antibiotic prophylaxis in León, Nicaragua, van Disseldorp et al. (2006) estimated that antibiotic choice was discordant with the hospital guidelines in 69% of the cases, dose in 20% of the cases, and both the timing of administration and duration in 78% of the cases. Overall adherence was achieved in 7% of patients.

What this study adds:

- This study represents the first attempt to assess the degree of adherence to antimicrobial prophylaxis practice standards in cardiac surgery performed in the only official referral hospital for cardiac patients in Jordan. This is an important step in developing strategies in Jordan and in other hospitals with similar conditions.

- Complete adherence to international antimicrobial prophylaxis guidelines was not achieved for any study patients. The lowest measured adherence rate (1.7%) was for antibiotic choice, and the highest (100%) was for appropriate decision making regarding use or nonuse of antimicrobial prophylaxis (indication), followed by timing of the first dose at a fixed time before incision (99%). Adherence rates in the other studied parameters were 39.4% for total duration of antimicrobial prophylaxis use, 27.9% for dose, and 13.0% for dosing interval.

- The study indicates the need for interventions to improve the rational use of antibiotic prophylaxis to prevent the complications of inappropriate administration of antimicrobials.
Although cardiac surgery is generally considered a clean procedure, antibiotic prophylaxis has been demonstrated to lower the incidence of surgical site infection (SSI). SSIs of the sternal wound and underlying mediastinum occur in 0.4%-4% of cardiac surgical procedures, with over 50% due to the coagulase-positive *Staphylococcus aureus* or the coagulase-negative *Staphylococcus epidermidis*. Patients who develop SSIs after coronary artery bypass graft (CABG) surgery have a mortality rate of 22% at 1 year compared with 0.6% for those who do not develop an SSI.

Practice guidelines are intended to assist physicians and other healthcare providers in clinical decision making by describing a range of generally acceptable approaches for the diagnosis, management, or prevention of specific diseases or conditions. The last decade has seen a proliferation of evidence-based clinical practice guidelines. Antibiotic guidelines and associated interventions have been demonstrated to be effective in improving antibiotic use. Organizations that have promulgated guidelines for antimicrobial prophylaxis in cardiac surgery include the National Surgical Infection Prevention Project (NSIPP), the Society of Thoracic Surgeons (STS), and the American College of Cardiology/American Heart Association (ACC/AHA).

The main recommendations of the 3 guidelines are as follows: (a) antimicrobial prophylaxis should be given to all patients undergoing cardiac surgeries; (b) the first- or second-generation cephalosporins (cefazolin or cefuroxime) are the antibiotics of choice, and vancomycin use is reserved for cases of allergy to beta-lactams or if presumed or known methicillin-resistant *Staphylococcus aureus* (MRSA) colonization is present; (c) the duration of antimicrobial prophylaxis use should not be longer than 48 hours; and (d) the timing of the first dose should be within 60 minutes prior to skin incision (Table 1). The practice of giving a midnight (on-call) dose of intravenous (IV) antibiotic the night prior to surgery as part of antimicrobial prophylaxis is inconsistent with guidelines; moreover, it has been frankly discouraged by the Centers for Disease Control (CDC).

Some countries have incorporated these guidelines into a national drug policy and provided government funding for a range of activities aimed at improving rational drug use. Health organizations have become interested in such policies because of concerns about inappropriate antibiotic prescribing and reported increase in the prevalence of antibiotic-resistant organisms. Antibiotic resistance has been described as a major threat to global public health by the World Health Organization (WHO) because there are now few and, in some cases, no antibiotics available to treat certain life-threatening infections.

Despite the availability of these guidelines, recent studies assessing the current practice of prophylaxis throughout the world have shown that inappropriate antibiotic choice, excessive duration of use, and inappropriate timing of antimicrobial drugs remains a problem in surgical prophylaxis. In an Italian teaching hospital, Motola et al. (1998) found that third-generation cephalosporins were the most frequently used antibiotics both in patients undergoing clean (74.1%) and clean-contaminated (73.0%) surgical procedures. The resulting costs were about 10-fold higher than estimated costs of antibiotic prophylaxis carried out according to international guidelines. In Belgium, Kurz et al. (1993) found that antimicrobial prophylaxis was given in 57% of the procedures for which prophylaxis is generally not recommended, was not used in 14% of procedures for which it is generally recommended and in 14% of contaminated procedures, and was prolonged by more than 2 days postoperatively after 23% of the procedures and by more than 4 days in 8%. In a Canadian survey of antimicrobial prophylaxis use among patients who underwent surgical repair of a fractured hip with insertion of prosthetic material, Zoutman et al. (1999) reported that 70% of cases did not receive a dose of antimicrobial prophylaxis within 2 hours pre-operatively; instead, antimicrobial prophylaxis was administered either too early or during the procedure. In 39% of cases receiving antibiotic prophylaxis, the first dose was not administered until the end of the procedure. Antimicrobial prophylaxis consisted of a parenteral first-generation cephalosporin for 94% of cases.

Monitoring and intervention can be effective in increasing the adherence to guidelines. In descriptive studies lacking a control group, stricter implementation of the existing antimicrobial prophylaxis protocols was associated with an increase in the appropriateness of antibiotic prophylaxis from approximately 50% to 95%-100%.

In Jordan in general and, specifically, in the Queen Alia Heart Institute (QAHI), in which the present study was conducted, antimicrobial prophylaxis in cardiac surgery is not governed either by national or by local guidelines. This problem is typical of other developing countries. Studies that assess the current clinical practice of antimicrobial prophylaxis in Jordan were lacking until the present study. Previous research in this topic area focused on the prevalence of antibiotic misuse among the Jordanian population. In light of this absence of local or institutional antimicrobial prophylaxis guidelines, the present study used the aforementioned 3 international guidelines—NSIPP, STS, and ACC/AHA—to assess the appropriateness and compliance of antibiotic prophylaxis practices in cardiac surgery within QAHI.

### Methods

#### Setting and Study Design

Patients enrolled in the present study were admitted to QAHI for cardiology services and cardiac surgery. QAHI is the only official referral hospital for cardiac patients in Jordan, performing an average of 30 cardiac surgeries per week. Eligible patients were enrolled in the study between November 19, 2006, and January 22, 2007. Generally, the study evaluated practitioner adherence to antibiotic prophylaxis guidelines using a clinical data collection form. The study was approved by the Career Ethics Committee.
Adherence to International Antimicrobial Prophylaxis Guidelines in Cardiac Surgery: A Jordanian Study Demonstrates Need for Quality Improvement

### TABLE 1
Summary of 3 International Guideline Recommendations for Antimicrobial Prophylaxis in Cardiotoracic Surgery

<table>
<thead>
<tr>
<th>Guideline</th>
<th>Antibiotic Choice</th>
<th>Dose and Route of Administration</th>
<th>Total Duration of AMP Use</th>
<th>Timing of First Dose at Fixed Time Before Incision; Dosing Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Antimicrobial Prophylaxis for Surgery: An Advisory Statement from the National Surgical Infection Prevention Project (NSIPP), 2005</strong></td>
<td>Cefazolin, cefuroxime, or cefamandole If the patient has a beta-lactam allergy, vancomycin or clindamycin</td>
<td>Cefazolin IV: 1-2 gm (20-30) mg per kg standard dose. If &lt; 80 kg, use 1 gm, if &gt; 80 kg, use 2 gm. End stage renal disease $t_{1/2}$ = 40-70 hours. Cefuroxime IV: 1.5 gm standard dose, 50 mg/kg adjusted dose. End stage renal disease $t_{1/2}$ = 15-22 hours. Cefamandole IV: 1 gm standard dose. End stage renal disease $t_{1/2}$ = 12.3-18 hours. Vancomycin IV infusion: 1 gm over 60 minute standard dose, 10-15 mg per kg (adult) adjusted. End stage renal disease $t_{1/2}$ = 44.1-406.4 hours. Clindamycin IV: 600-900 mg standard dose. If &lt; 10 kg, use at least 37.5 mg; if &gt; 10 kg, use 3-6 mg/kg. End stage renal disease $t_{1/2}$ = 3.5-5.0 hours.</td>
<td>24 hours or less</td>
<td>Within 60 minutes before incision. For vancomycin the infusion should begin within 120 minutes before incision. Doses should be repeated intraoperatively if the operation is still in progress 2 half-lives after the first dose.</td>
</tr>
<tr>
<td><strong>The Society of Thoracic Surgeons (STS) Practice Guideline Series: Antibiotic Prophylaxis In Cardiac Surgery, 2006-2007</strong></td>
<td>Cefazolin If presumed or known MRSA colonization, vancomycin (1-2 doses) + cefazolin In patients with beta-lactam allergy, vancomycin (up to 48 hours) + aminoglycoside (1 pre-operative and 1 post-operative dose).</td>
<td>Cefazolin IV: 1 gm pre-operative prophylactic dose; for a patient &gt; 60 kg, 2 gm is recommended. Vancomycin IV infusion over 1 hour: dose of 1-1.5 gm or a weight-adjusted dose of 15 mg per kg. Aminoglycoside IV; (usually gentamicin, 4 mg per kg) in addition to vancomycin prior to cardiac surgery.</td>
<td>48 hours or less</td>
<td>For cefazolin: administration within 60 minutes prior to the skin incision; second dose of 1 gram should be administered every 3-4 hours, if long procedure. For vancomycin: administration slowly over 1 hour, with completion within 1 hour of the skin incision. For aminoglycosides: the initial dose should be administered within 1 hour of the skin incision.</td>
</tr>
<tr>
<td><strong>American College of Cardiology/ American Heart Association (ACC/AHA) Guideline Update for Coronary Artery Bypass Surgery, 2004</strong></td>
<td>Cephalosporin class: cefuroxime (superior efficacy compared with the other cephalosporins), cefazolin or cefamandol. Vancomycin: reserved for penicillin-allergic and justified in periods of MRSA outbreaks.</td>
<td>Cefuroxime: 1.5 gm pre-operatively, 1.5 gm after cardiopulmonary bypass, 1.5 gm every 12 hours. Cefamandole, cefazolin: 1 gm pre-operatively, 1 gm at sternotomy, 1 gm after cardiopulmonary bypass, 1 gm every 6 hours. Vancomycin: 1 gm every 12 hours until lines/tubes are out. At least 2 doses.</td>
<td>48 hours or less</td>
<td>Initial dose to be given 30-60 minutes before skin incision. Vancomycin: 30- to 60-minute infusion timed to end before skin incision.</td>
</tr>
</tbody>
</table>


AMP = antimicrobial prophylaxis; gm = gram; IV = intravenous; kg = kilogram; mg = milligram; MRSA = methicillin-resistant Staphylococcus aureus; $t_{1/2}$ = elimination half-life.

the equivalent of an institutional review board in Jordan, in the Royal Medical Services.

**Patients**
Patients scheduled for any type of cardiac surgery were eligible for the study with a few exceptions. Patients diagnosed with human immunodeficiency virus (HIV) infection, tuberculosis, or cystic fibrosis were excluded from the study. To avoid difficulties in discriminating prolonged prophylaxis from post-operative therapy, patients with suspected or established infection during surgery were also excluded. Patients who died due to a cause other than SSI before the end of the follow up period were not included in the data analysis. Patients were enrolled in the study if informed consent was obtained from the patient or his/her representative.

**Data Collection**
Data were collected from patients’ verbal self-reports, files, medication sheets, and prescriptions using a clinical data collection form (summarized in Table 2). The form had been pre-tested on a small pilot scale (n=10) and subsequently modified to ensure that the data would provide valid information. The entire clinical data collection form is available from the authors upon request.
All parts of the form were completed by 2 of the authors (NM, a clinical pharmacist and ZM, a cardiac surgeon) who work at QAHI. All patients who were scheduled for surgery were monitored daily during their inpatient stay until discharge and then tracked in the outpatient clinic for 2 months following surgery. Data regarding antimicrobial use in the hospital were collected during the patient's inpatient stay; additional data collection was performed periodically thereafter as data became available, until the end of the 2-month follow-up period.

Analysis of Prophylactic Antibiotic Use

The compliance of current prophylactic antibiotic practices in cardiac surgery at QAHI with 3 published international guidelines was assessed. These guidelines were from the NSIPP (Antimicrobial prophylaxis for surgery: an advisory statement), the STS (Antibiotic prophylaxis in cardiac surgery, part I: duration, and part II: antibiotic choice), and the ACC/AHA (2004 guideline update for coronary artery bypass graft surgery). The following 6 aspects of antimicrobial prophylaxis were assessed: (1) indication—appropriate decision making regarding use or nonuse of antimicrobial prophylaxis; (2) choice—antibiotic choice for patients with and without allergy; (3) total duration of use; (4) dose; (5) dosing interval—includes both repeating of doses in procedures with durations longer than the half-life of the antibiotic used, and interval between doses; and (6) timing of dose given at a fixed time before incision (within 60 minutes prior to skin incision). The criteria for evaluation of adherence are summarized in Table 3.

If more than 1 drug was prescribed for a single procedure, all parameters were evaluated separately for each drug. Final assessment of the antibiotic course was composed by combining these separate drug evaluations. Any divergence from the guidelines in the prescription of 1 of the drugs led to a final assessment of the prophylactic course as discordant with the guidelines. If no antibiotic orders or prescriptions had been recorded, it was assumed that antibiotics were not given. If data on a certain parameter of the antibiotic prescription were lacking, the case was classified as missing data on this parameter only. We defined an antibiotic administered the day before surgery (e.g., in a midnight dose the night before surgery) as not indicated, and for these events, the parameters of antibiotic choice, duration, dose, dosing interval, and timing were not evaluated for that nonindicated drug; however, if the same patient received an antibiotic on the day of the surgery, all parameters were evaluated for that drug because it was indicated.

All data were coded, entered, and analyzed using SPSS for Windows, version 14.0 (SPSS Inc., Chicago, IL). Frequency and percentages were calculated and presented.
Adherence to International Antimicrobial Prophylaxis Guidelines in Cardiac Surgery: A Jordanian Study Demonstrates Need for Quality Improvement

### TABLE 3
Criteria to Assess Adherence and Compliance With Current Antimicrobial Prophylaxis Practices Within QAHI Compared With International Guidelines

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Concordant if</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Antibiotic indication</td>
<td>• Decision was made to use antimicrobial prophylaxis</td>
</tr>
<tr>
<td>2. Antibiotic choice</td>
<td>• Agent recommended by guidelines.</td>
</tr>
<tr>
<td></td>
<td>• Combination used only when indicated.</td>
</tr>
<tr>
<td></td>
<td>• No switch to another antibiotic in the absence of microbiologic or clinical indication</td>
</tr>
<tr>
<td>3. Total duration of prophylactic antimicrobial use</td>
<td>Duration as recommended by guidelines (48 hours or less).</td>
</tr>
<tr>
<td>4. Dose</td>
<td>Dose as recommended by guidelines. For pediatric patients, doses calculated according to body weight using Drug Information Handbook.</td>
</tr>
<tr>
<td>5. Dosing interval (a) during surgery</td>
<td>Additional dose was given in surgical procedure longer than the half-life of the prophylactic antibiotic used, and dosing interval did not exceed the guideline by more than 30 minutes. Dosing interval did not deviate from the guideline by more than 60 minutes.</td>
</tr>
<tr>
<td>(b) on the ward</td>
<td></td>
</tr>
<tr>
<td>6. Timing</td>
<td>Timing of dose did not deviate by more than 15 minutes from the recommended time (within 30-60 minutes prior to skin incision).</td>
</tr>
</tbody>
</table>

*aGuidelines used: National Surgical Infection Prevention Project; b The Society of Thoracic Surgeons; 1, 3 and American College of Cardiology/American Heart Association. 7

QAHI = Queen Alia Heart Institute.

### Results

Between November 19, 2006, and January 22, 2007, 252 cardiac surgeries were conducted in QAHI. After the application of inclusion and exclusion criteria, 236 patients were enrolled in the study (Figure 1). Patients’ characteristics and types of cardiac surgeries are presented in Table 4.

### Overall Assessment of All Parameters

Adherence to guidelines in antimicrobial prophylaxis for all parameters was not fulfilled in any of the 236 cardiac surgeries assessed in this study. Two common deviations from the guidelines were observed: (a) the unexplained switch from an appropriate or inappropriate agent(s) to an inappropriate agent(s) in the same patient in 230 (97.5%) patients; and (b) the practice of giving a midnight dose of IV antibiotic the night prior to surgery as part of antimicrobial prophylaxis in 229 (97.0%) patients.

### Assessment of Individual Parameters

Parameters were also evaluated separately, so that nonadherence to 1 parameter did not preclude assessment of the others. Rates of adherence to international guidelines for indication, choice, total duration, dose, dosing interval, and timing are presented in Table 5.

**Indication:** In concordance with the guidelines, antimicrobial prophylaxis was given for all of the 236 (100%) patients who underwent cardiac surgeries (Table 5). However, a midnight dose of IV antibiotic on the night before surgery was given to 229 (97.0%) of patients (third-generation cephalosporin in 85% of patients, second-generation in 10%, other antibiotics in 2%). As this antibiotic dose was given while not indicated, and because the midnight antibiotic might have differed from the antibiotic that was given later at induction of anesthesia, the parameters of antibiotic choice, dose, dosing interval and timing were not evaluated for the drug given at midnight; however, these parameters were evaluated for any antibiotics given to the patient on the surgery date.

**Antibiotic Choice:** Overall, antibiotic choice was concordant with guidelines for only 4 (1.7%) patients (Table 5), almost entirely because of post-operative treatment decisions. In the operating room and during induction of anesthesia, the antibiotic choice (cefuroxime) was concordant with guidelines in 226 (95.8%) patients and discordant in 10 patients. The reasons for discordance were the following:

- **Suspicion of beta-lactam allergy in 5 patients where cefuroxime was given.**
- **Use of a vancomycin and cefuroxime combination in 3 patients who did not have either beta-lactam allergy or presumed colonization with MRSA.**
- **Missing induction-antimicrobial prophylaxis dose in 2 patients to whom a third-generation cephalosporin was given 8 hours after the end of the operation.**

After surgery, for nearly all patients, there was an unexplained switch from an appropriate or inappropriate agent(s) to an inappropriate agent(s). Switches were made from a second-generation cephalosporin cefuroxime (or combination of cefuroxime with vancomycin) to (a) a combination of a third-generation cephalosporin with 1 of these antibiotics: vancomycin, amikacin, flucloxacillin, or imipenem in 145 (61.4%) patients; (b) a combination of vancomycin with amikacin or flucloxacillin or imipenem in 34 (14.4%) patients; (c) a third-generation
cephalosporin alone in 32 (13.6%) patients; or (d) vancomycin alone in 19 (8.1%) patients. Cefuroxime was maintained as a single prophylactic antibiotic in only 4 (1.7%) patients, and the third-generation cephalosporin ceftriaxone was maintained as a single prophylactic antibiotic in only 2 (0.8%) patients.

**Total Duration of Antimicrobial Prophylaxis Use:** In 93 of 236 patients (39.4%), total duration of all agents used as antimicrobial prophylaxis was discordant with the guidelines (48 hours or less). In 139 (58.9%) patients, duration was longer than recommended. In 4 cases (1.7%), duration could not be evaluated because medication charts were incomplete.

**Dose:** Only doses of antibiotics used in concordance with the guidelines were evaluated. The dose was discordant with the guidelines in only 63 (27.9%) of 226 evaluated doses. In all of the 163 (72.1%) discordant doses, the dose was lower than what is recommended, either because (a) a lower dose (e.g., 750 milligrams instead of 1.5 grams) was given to an adult patient; (b) no dose adjustment was made for an obese patient; or (c) the dose per kilogram calculated for a child was lower than recommended.

**Dosing Interval:** Only dosing intervals of agents used in concordance with the guidelines were evaluated (n=230, Table 5). Of these, only the dosing interval of antibiotics repeated during surgery or in the ward could be calculated. Of the 226 doses of antimicrobial prophylaxis used at induction of anesthesia, none was repeated, even though antimicrobial prophylaxis should have been repeated in 196 surgeries because the duration of the surgery was longer than the half-life of the antibiotic used. In the 4 patients for whom cefuroxime was maintained as a single prophylactic antibiotic in the ward after surgery (in compliance with the guidelines), the dosing interval was discordant with the guidelines (every 8 hours instead of every 12 hours). Thus, only 30 (13.0%) out of 230 evaluated agent dosing intervals were concordant with the guidelines.

**Timing of Doses Given on the Surgery Date:** For doses given on the day of the surgery, timing was concordant with the guidelines (at induction of anesthesia within 30 minutes before incision) in 224 of 226 (99.1%) of the evaluated cardiac surgeries. For the 2 surgeries in which antimicrobial prophylaxis timing was discordant with the guidelines, no antimicrobial prophylaxis was given in the hours prior to or during the surgery; instead, a third-generation cephalosporin was given 8 hours after the end of the operation.

### Discussion

**Adherence in Current Practice**

The present study demonstrates that adherence to the international guidelines for antimicrobial prophylaxis is disappointingly far from optimal. One of the most striking findings of this study was that no patient's care adhered to all guideline parameters. While this result is consistent with those of similar studies in Iran and Nicaragua, where rates of complete adherence to practice guidelines were 0.3%24 and 7%,28 respectively, higher percentages of adherence to antimicrobial prophylaxis guidelines have been reported in other studies. Gorecki et al. (1999, United States), van Kasteren et al. (2003, the Netherlands), Lallemand et al. (2002, France), and Voit et al. (2005, United States) found in their studies that overall adherence was achieved in 26%, 28%, 41.1%, and approximately 50% of surgical patients, respectively.17,20-31

Interestingly, although the present study reported lower adherence to all parameters than did earlier studies, the rate of adherence to timing of antimicrobial prophylaxis at a fixed time before incision (99.1%) is higher than that reported in most other studies. Paradiso-Hardy et al. (2002), Lallemand...
et al. (2002), van Kasteren et al. (2003), and van Disseldorp et al. (2006) reported in their studies that timing of the first dose was concordant with guidelines in 72%, 61.4%, 50%, and 22% of cases, respectively.²⁸⁻³⁰,³²

It is noteworthy that adherence in all of the previously mentioned studies, except ours and that of Askarian et al. (2006, Iran), was compared with local, rather than international, guidelines. The higher adherence rates in studies that used local guidelines (7%-50%) as opposed to studies that used international guidelines because of lack of national or local guidelines (0%-3%), suggest that adherence to local guidelines may be easier to achieve than adherence to international guidelines.¹⁷,²⁴⁻²⁸⁻³¹

One potential strategy to improve antimicrobial practice in hospitals is standardization, either by adopting an international guideline or by developing a local hospital guideline. Standardization efforts should be overseen by a committee that includes surgeons, anesthesiologists, microbiologists, pharmacists, and members of hospital epidemiology and infection control departments. Guidelines should be based on hospital-specific bacterial epidemiology patterns, the best literature evidence, and surgeon preference. Standardized protocols should then be provided to surgeons, in an effort to achieve consensus, before implementation.

The present study revealed several areas for improvement at the study hospital. At QAHI, the on-call surgeon (usually a junior surgeon) routinely prescribes a midnight antimicrobial prophylaxis dose the night before surgery and records it on the follow-up sheet in the patient’s file. The anesthesiologist gives the intraoperative antibiotic dose and records it only on the anesthesia chart. After surgery, the consultant, or senior surgeon, prescribes post-operative antimicrobial doses and records them on the follow-up sheet in the patient’s file. The absence of a standardized antimicrobial practice guideline creates a lack of communication between anesthesiologists, surgeons, and even among the members of the surgical team. This lack of communication produced poor monitoring, resulting in 2 main deviations that led to 100% nonadherence in this study. These deviations from the guidelines are as follows:

(a) *Unexplained switch to inappropriate antibiotic(s) without microbiological or clinical indication.* The most common antimicrobial prophylaxis agents used in this study were a combination of a third-generation cephalosporin with another antibiotic (vancomycin, amikacin, fluoc oxacillin, or imipenem); a combination of vancomycin with amikacin. fluocoxacillin, or imipenem; or a third-generation cephalosporin alone. Third-generation cephalosporins and broad spectrum combinations should not be used for SSI prophylaxis because they have less activity against *Staphylococcus* than does cefazolin. Such use induces the emergence of resistant organisms and is more costly.¹⁴,³³

(b) *Giving a midnight dose of IV antibiotic the night prior to surgery.* This practice should be strongly discouraged in group education and consensus meetings. One method of preventing this practice is to assign the prescription of antimicrobials to the anesthesiologist in charge only. Prevention could also be achieved by providing better staff training as to the benefits of adherence to standard international antimicrobial prophylaxis guidelines and the risks of unnecessarily dispensing antibiotics.

### TABLE 5 Adherence to International Guidelines in Antimicrobial Prophylaxis in Cardiac Surgery

<table>
<thead>
<tr>
<th>International Guideline</th>
<th>Recommendation Criteria</th>
<th>Number (%) Meeting Criteria (Concordant With any of A,B,C) (n = 236)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A = NSIPP 2005</td>
<td></td>
<td>236 (100.0)</td>
</tr>
<tr>
<td>B = STS 2006-2007</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C = ACC/AHA 2004</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any antimicrobial prophylaxis recommended by A,B,C</td>
<td>1. Appropriate decision making regarding use of antimicrobial prophylaxis (indication)</td>
<td>236 (100.0)</td>
</tr>
<tr>
<td>Any recommended duration by A,B,C</td>
<td>2. Appropriate antibiotic choice</td>
<td>4 (1.7)</td>
</tr>
<tr>
<td>Any recommended dose by A,B,C</td>
<td>3. Appropriate total duration of antimicrobial prophylaxis use</td>
<td>93 (39.4)</td>
</tr>
<tr>
<td>Any recommended dosing interval by A,B,C</td>
<td>4. Appropriate dose</td>
<td>63 (27.9)</td>
</tr>
<tr>
<td>Any recommended appropriate timing of first dose by A,B,C</td>
<td>5. Appropriate dosing interval</td>
<td>30 (13.0)</td>
</tr>
<tr>
<td>Any of the guidelines A,B,C</td>
<td>6. Appropriate timing of first dose at fixed time (within 30-60 minutes before incision)</td>
<td>224 (99.1)</td>
</tr>
<tr>
<td>Any of the guidelines A,B,C</td>
<td>Appropriate compliance with all recommendations</td>
<td>0 (0.0)</td>
</tr>
</tbody>
</table>

⁴NSIPP = National Surgical Infection Prevention Project; ⁶STS = The Society of Thoracic Surgeons; ¹³ACC/AHA = American College of Cardiology/American Heart Association.⁷

Number evaluated = 226.

Weight calculated according to Lacy et al. Drug Information Handbook, 2006.⁴¹

Number evaluated = 230.

Number evaluated = 226.
Potential solutions to avoid both of these mistakes include better organization of work and specification of tasks among individuals on the surgical team, introduction of special forms for ordering antimicrobial prophylaxis, and use of an antibiotic prophylaxis chart in the operating theaters. Another suggestion is to give a central role to the clinical pharmacists in antimicrobial prophylaxis administration. In a descriptive study without a control group, Prado et al. (2002) showed that when pharmacists were given a central role in the administration of prophylaxis, the appropriateness of the indication increased from 56% to 100%, while the costs decreased by 40%. Moreover, in a study of an intervention to reduce the prescribing of antibiotics for upper respiratory infections by general practitioners in Australia, Zwar et al. (2002) found that giving feedback on prescription behavior indicating that the surgical teams were aware of the importance of the timely administration of pre-operative antibiotics is well established and is broadly applicable to all procedures for which prophylactic antibiotics are administered. It has been suggested that antimicrobial selection is a moot point if the agent is not delivered during the optimal 30-60 minute window just before incision and that the beneficial effect is negated if the drug is given after incision. Investigation of the reasons for adherence to timing guidelines revealed that anesthesiologists were responsible for giving the intra-operative antimicrobial prophylaxis doses, providing further support for the suggestion to improve adherence by specifying tasks and distributing responsibilities among members of the surgical team.

Use of antibiotics for longer than the recommended period, especially in the absence of any evidence of secondary infection or SSI until the day of discharge in an attempt to prevent infection while patients were hospitalized, was observed in 58% of our study patients and has also been reported by some other researchers. Prolonged antibiotic prophylaxis is, at best, of no benefit and, at worst, potentially harmful to patients because of drug toxicity, the risk of super-infection, and the risk of inducing more bacterial resistance, both in surgical patients and throughout the hospital.

Doses and dosing intervals were discordant in 72% and 88% of patients, respectively. That is, no dose adjustment was done when it was needed and doses were not repeated intra-operatively in long-duration procedures. These findings are consistent with the work of Gupta et al. (2003), who found that prophylactic antibiotic administration in procedures lasting more than 4 hours was repeated in only 9 patients (3%) in 300 cases at the correct time for the entire duration of the surgery in complete compliance with the published guidelines.

Limitations
First, the exact timing of the intra-operative antimicrobial prophylaxis dose was assessed based on the anesthesiologists’ notes on the anesthesia chart, and it was recorded always at induction. However, we cannot guarantee the accuracy of recorded notes. In the future, one could consider a method to record the time of dose administration more precisely. Second, although anecdotal information suggests that most hospitals in Jordan share similar standards, our results may not be entirely applicable to other countries. However, our results can be generalized to hospitals in other developing countries, where not much attention is paid to international practice guidelines. Additionally, previous research has documented widespread nonadherence to antimicrobial practice guidelines in many countries, including the United States and Canada.

Conclusion
We found that adherence to international antimicrobial prophylaxis guidelines for cardiac surgery is far from optimal in the QAHI, which led to the inappropriate administration of many antibiotics. This pattern unnecessarily increases expenditures and likely plays a major role in the growing prevalence of antibiotic-resistant microbial strains. Strategies such as the development of local hospital guidelines may improve current antimicrobial prophylaxis practice in QAHI specifically and in other hospitals in general. There is a need to increase adherence to clinical guidelines for antimicrobial prophylaxis in cardiac surgery patients in QAHI, and other research has shown quality improvement using clinical pharmacists in a central role in the administration, monitoring, and intervention of antimicrobial prophylaxis. Additional effort should also be directed towards increasing the awareness of practitioners about the dangers of inappropriate use of antimicrobials before, during, and after surgeries.
Adherence to International Antimicrobial Prophylaxis Guidelines in Cardiac Surgery: A Jordanian Study Demonstrates Need for Quality Improvement

Authors

NAIROOZ H. AL-MOMANY, MSc, is Clinical Pharmacist in charge of the inpatient pharmacy, King Hussein Medical Center, Amman, Jordan; AMAL G. AL-BAKRI, PhD, is Associate Professor of Pharmaceutical Microbiology, Faculty of Pharmacy, The University of Jordan, Amman, Jordan; ZEID M. MAKAHLEH, MD, MRCS, is Specialist Cardiac Surgeon, Queen Alia Heart Institute, Amman, Jordan; and MAYYADA M.B. WAZAIFY, PhD, is Assistant Professor of Pharmacy Practice, Faculty of Pharmacy, The University of Jordan, Amman, Jordan.

AUTHOR CORRESPONDENCE: Mayyada M.B. Wazaify, PhD, Faculty of Pharmacy, University of Jordan, Amman, Amman 11942, Jordan. Tel.: 009626-5335000, ext. 23354; E-mail: m.wazaify@ju.edu.jo

DISCLOSURE AND ACKNOWLEDGEMENTS

This study was funded by the Deanship of Academic Research at The University of Jordan.

All authors contributed equally to concept and design, data collection and interpretation, and writing and revision of the manuscript.

The authors would like to thank all the physicians and nurses working at Queen Alia Heart Institute (QAHI) who helped us in patient recruitment and data collection.

REFERENCES


Adherence to International Antimicrobial Prophylaxis Guidelines in Cardiac Surgery:
A Jordanian Study Demonstrates Need for Quality Improvement


