Impact of a focused antimicrobial stewardship program in adherence to antibiotic prophylaxis and antimicrobial consumption in appendectomies

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\textbf{KEYWORDS}
Antimicrobial; Consumption; Compliance; Prophylaxis; Appendectomies; Qatar

\textbf{Summary} Antibiotic use in appendectomy constitutes a fundamental practice to achieve the clinical outcomes and the prevention of surgical site infection. A prospective interventional study was performed in a community hospital from January 2013 to December 2015 with the aim of determining the effect of a focused antimicrobial stewardship program in the compliance with antibiotic prophylaxis and the antimicrobial consumption in appendectomies. The compliance with the antibiotic prophylaxis was monitored for the timing of administration, the selection and dose and the discontinuation. The monitoring of antimicrobial consumption was performed by a pharmacist using ATC/DDD methodology. The stewardship program includes the education of the staff and the monitoring of the quality of antibiotic prophylaxis and consumption, and feedback. Comparison of the variables over the years was performed using student’s t-test or chi-square test as required. In 603 appendectomies performed the compliance with timely administration was achieved in 72.9%, 99.6% and 100% during 2013, 2014 and 2015 respectively and the compliance with the discontinuation had an increase from 86.4% (2013) to 96.7% in 2015. Consumption of antimicrobial was 355.1 DDD/100 procedures (DDD) in flemunous, 447.3 DDD in supplicative, 892.8 DDD in gangrenous and 1162.7 DDD in perforated

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Introduction

Antibiotic prophylaxis constitutes a fundamental practice for prevention of surgical site infections (SSI), representing the 30% of healthcare associated infections (HAI) and 40–60% could be preventable [1,2]. Umscheid et al. in a systematic review of US studies describe this as many as 55% of cases of SSI are preventable with current evidence-based practices, representing 75,526–156,862 annual cases [3].

Gouvea et al. described the significant variability observed in the adherence to guidelines for antibiotic prophylaxis in published papers, ranging from 0.3% to 84.5% the adequate practices [4]. Inappropriate use of antibiotic prophylaxis is related with adverse outcomes, including surgical site infections, selection of resistant organisms, increased cost, and others [5–7]. In appendectomies, the evidence recommend the use of single dose preoperative antibiotics in non-complicated appendicitis, and the use of postoperative antibiotics is associated with increased morbidity and prolonged length of stay [8–10].

Strategies for improving the compliance with antibiotic prophylaxis are focused on staff education regarding the best evidence-based guidelines and the local policies and the monitoring and feedback of compliance [11–13]. Others include actions addressed to the monitoring of antimicrobial prescription and consumption and the multidisciplinary involvement in the strategies for improvement [12–15].

The main outcomes for antibiotic prophylaxis are the choice, the timing, and the discontinuation. According to guidelines in appendectomies, a combination of cephalosporin plus metronidazole constitutes the first choice, which should be administered within 1 h before incision and re-dosing in specific conditions. Antibiotic prophylaxis should be limited to the 24 h after the surgical procedures, nevertheless, a single dose could be considered enough in most of the procedures [2,16].

The aim of this study was to determine the effect of a focused antimicrobial stewardship program in the compliance with the antibiotic prophylaxis and the antimicrobial consumption in appendectomies.

Methods

This prospective interventional study was performed in a community hospital from January 2013 to December 2015.

Of all consecutive appendectomies performed during the study period the following information was collected: age, sex, wound class (clean-contaminated, contaminated, dirty) and the appendicitis-type (flemonous, suppurative, gangrenous, perforated), being considered uncomplicated appendicitis the flemonous and suppurative and complicated the others.

The compliance with the antibiotic prophylaxis was monitored by an infection-control practitioner on an ongoing basis and according to the corporate policy recommending a single dose of cefuroxime plus metronidazole within 1 h before the surgical incision for all appendectomies or maximum up to 24 h if required. For gangrenous and perforated appendectomies full course of antimicrobial treatment is recommended. The compliance was calculated for the timing of administration, the selection and dose and the discontinuation, in all cases the number of compliant prescriptions was divided by the number of procedures (per 100 procedures). On monthly basis, feedback was provided to the surgical team and presented in the facility infection control committee for its analysis.

The monitoring of antimicrobial consumption was performed by a pharmacist from the pharmacy records and presented as defined as daily dose divided by the number of procedures and expressed by 100, as per the ATC/DDD methodology [16]. The consumption was presented according to the appendicitis types and to the antimicrobials used. This information was not given to the surgical team.
on a regular basis, nevertheless, an annual evaluation of the antimicrobial stewardship program was presented to the staff.

The stewardship program focused on appendectomies began in 2013 and it included the education of the staff and the monitoring and feedback. Education of staff about the local policy of antimicrobial prophylaxis and the best evidence-based guidelines was conducted for all staff, and reminding activities were continued on demanding basis. Besides, the education on the surgical bundle for all patients who required antibiotic prophylaxis was conducted on regular basis. The monthly analysis of departmental quality indicators constitutes an appropriate forum for analysis and learning.

The quality indicator used to monitor the program was the compliance with timing, selection and dose, and discontinuation of antibiotic prophylaxis as per the formula previously described.

Statistical analysis

Statistical analysis was performed using JMP 5.1 (SAS Institute, http://www.jmp.com/). Descriptive statistical methods were used. Comparison of the variables over the years was performed using student’s t-test or chi-square test as required. Significance was set at $p < .05$.

Results

During the study period 603 appendectomies were performed, with an increased number of procedures over the years. There were not observed differences in the demographics or procedures characteristics during the period (Table 1), mainly male patients (95.4%), clean contaminated (65.8%) and noncomplicated (73.5%) appendicitis.

The timely administration of the prophylactic antibiotic was achieved in 72.9% of the procedures during 2013, with a significant increase to 99.6% and 100% ($p < .001$) in 2014 and 2015 respectively. Similarly, the compliance with the discontinuation had an increase from 86.4% (2013) and 92.2% (2014) to 96.7% in 2015 ($p < .05$). The selection of the antimicrobial was not appropriate in relation to the policy in two cases. The antibiotics were prescribed as a single prophylaxis in 61.5% with the highest figure in 2015 ($p < .05$), while, the therapeutic schedule was prescribed in 38.5% with the lowest figure in 2015 ($p < .05$) (Table 2).

The consumption of antimicrobial was 355.1 DDD/100 procedures in flumenous, 447.3 DDD/100 procedures in suppurative, 892.8 DDD/100 procedures in gangrenous and 1162.7 DDD/100 procedures in perforated appendectomies. The most frequent antimicrobials were cefuroxime, metronidazole, and ceftriaxone that accounted for more than the 90% of the doses prescribed. A sustained reduction for cefuroxime use was observed over the years with 26.2% lower consumption in 2015 compared with 2013 ($p < .05$), while the variation for metronidazole (12.6% reduction) and ceftriaxone (18.1% reduction) in 2015 was mainly in comparison with 2014. Other antibiotics included were amoxicillin-clavulanic, meropenen, cefazoline, cefepime, clindamycin, piperacillin-tazobactam, ciprofloxacin, gentamycin, and ertapenem, with the most frequent use for the two first mentioned (Table 2). The consumption of antimicrobials in flumenous and suppurated appendectomies achieved the lowest figure in 2015, with reductions of 45.1% and 26.3% in comparison with 2014 respectively ($p < .05$). For gangrenous and perforated appendectomies, major differences were not observed during the study period, although in gangrenous ones, a light and

| Variables                  | 2013 $n=59$ | 2014 $n=244$ | 2015 $n=300$ | Total $n=603$
|---------------------------|------------|------------|-------------|---------
| Age                       | 32.8 (8.8) | 30.4 (8.6) | 30.6 (8.0)  | 30.7 (8.3)
| Gender                    |            |            |             |         
| Male                      | 55 (93.2%) | 235 (96.3%)| 285 (95.0%) | 575 (95.4%)
| Female                    | 4 (6.8%)   | 9 (3.7%)   | 15 (5.0%)   | 28 (4.6%)
| Wound class               |            |            |             |         
| Clean contaminated        | 42 (71.2%) | 163 (66.8%)| 192 (64.0%) | 397 (65.8%)
| Contaminated/Dirty        | 17 (28.8%) | 81 (33.2%) | 108 (36.0%) | 206 (34.2%)
| Appendicitis type         |            |            |             |         
| Non complicated           | 42 (71.2%) | 181 (74.2%)| 220 (73.3%) | 443 (73.5%)
| Complicated               | 17 (28.8%) | 63 (25.8%) | 80 (26.7%)  | 160 (26.5%)

*a Data are presented as mean (standard deviation).*

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sustained increase over the years was observed (Fig. 1).

**Discussion**

This study provides evidence of the improvement in the quality of antimicrobial prescription and in the reduction of antibiotic consumption in appendectomies in relation to the antimicrobial stewardship program. Our local program emphasizes on monitoring the compliance with antibiotic prescription and feedback to the staff involved in its analysis in a quality improvement environment. The education of the staff about the antimicrobial prophylaxis in surgery and the accurate implementation of the monitoring of the bundle constituted a fundamental strategy to improve the quality of prescription and the patient safety. Many published studies have shown the effectiveness of these measures [7,11,12,17].

Abdel-Aziz et al. described the adherence to prophylaxis in various procedures in a general hospital in Qatar, being the appendectomies the 24%, with adherence to prophylaxis guidelines in 53.5% and prolonged antibiotic use in 59.3% of the procedures [18]. Similar noncompliance with discontinuation was reported by Bozkurt et al. with a reduction of prolonged antibiotic from 77.0% to 44.7% [19]. In the appendectomies included in our study, especially when fluid in the peri-appendiceal area was observed, the physician decided the prolongation of antibiotic therapy for more than 24 h. even when there was no other clinical evidence of infectious complication in the surgical site. Additional clinical studies are required to identify measures to assist the decision making process of antimicrobial prescription in appendectomies.

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Annual compliance with antibiotic prophylaxis and antimicrobial consumption according to appendicitis type.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2013</td>
</tr>
<tr>
<td></td>
<td>n = 59</td>
</tr>
<tr>
<td>Compliance with antimicrobial prophylaxis [No. (%)]</td>
<td></td>
</tr>
<tr>
<td>Timing</td>
<td>43 (72.9%)</td>
</tr>
<tr>
<td>Selection and dose</td>
<td>59 (100%)</td>
</tr>
<tr>
<td>Discontinuation</td>
<td>51 (86.4%)</td>
</tr>
<tr>
<td>Type of prescription [No. (%)]</td>
<td></td>
</tr>
<tr>
<td>Only prophylactic</td>
<td>35 (59.3%)</td>
</tr>
<tr>
<td>Therapeutic schedule</td>
<td>24 (40.7%)</td>
</tr>
<tr>
<td>Antimicrobial consumption for selected antibiotics (DDD/100 procedures)</td>
<td></td>
</tr>
<tr>
<td>Cefuroxime</td>
<td>293.2</td>
</tr>
<tr>
<td>Metronidazole</td>
<td>217.1</td>
</tr>
<tr>
<td>Ceftriaxone</td>
<td>7.6</td>
</tr>
<tr>
<td>Others*</td>
<td>6.3</td>
</tr>
</tbody>
</table>

* Others include 10 antibiotics.
* * p < 0.001.
* ** p < 0.05.

Figure 1  Antimicrobial consumption according appendicitis type and year (DDD/100 procedures).
The measure of antimicrobial consumption is recommended for the antimicrobial stewardship programs [20]. The primary goal of this program is the focus on achieving optimal clinical outcomes and minimizing toxicity or other adverse effects. Also, an important goal is addressed to limit the antibiotic resistance. An important added benefit is the reduction of consumption related to overuse of antibiotics and consequently, the reduction of cost [7,12,21,22]. Our results are in line with these goals about the reduction of antimicrobial consumption mainly for non-complicated appendectomies. Nevertheless, there is evidence about the possibilities of additional reduction in consumptions, more significantly in suppurated appendectomies.

In conclusion, the focused antimicrobial stewardship program was effective to improve the timely administration and the proper discontinuation of prophylactic antibiotic, with an important reduction of antimicrobial consumption.

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**Competing interests**

None declared.

**Ethical approval**

Not required.

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**References**


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