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REVIEW

Antibiotic prophylaxis for open mesh repair of groin hernia: systematic review and meta-analysis

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Purpose

Abstract A meta-analysis was performed to asses whether antibiotic prophylaxis is effective in reducing the incidence of surgical site infection (SSI) after open mesh repair of groin hernia.

Methods A literature search for randomized controlled trials (RCT) evaluating the effectiveness of antibiotic prophylaxis in adult patients undergoing open mesh repair of groin hernia was performed in November 2015. Incidence of overall and deep SSI was considered as primary and secondary outcome measures, respectively. Only studies with a clear definition of SSI and a follow-up of at least 1 month were included. Effect size from each RCT was computed as odds ratio (OR) and 95 % confidence interval (CI) and then data were pooled using a random-effects model.

Results Sixteen RCTs with a total number of 5519 patients were included in the meta-analysis. Considering all the RCTs, antibiotic prophylaxis significantly reduced the overall incidence of SSI from 4.8 % to 3.2 % [OR 0.68, 95 % CI (0.51–0.91)]. However, after removal of two outlier studies, which were identified by evaluating the standardized residual, the result of the meta-analysis became non-significant [OR 0.76, 95 % CI (0.56–1.02)]. The incidence of deep SSI was very low (0–0.7 %) and the effect of antibiotic prophylaxis was not significant [OR 0.80, 95 % CI (0.32–1.99)].

Conclusions The results of this meta-analysis do not support the routine use of antibiotic prophylaxis for the open mesh repair of groin hernia. In clinical settings with unexpectedly high rates of SSIs, the appropriateness of surgical asepsis should be carefully checked.

Keywords Inguinal hernia repair · Antibiotic prophylaxis · Surgical site infection

Introduction

Groin hernia repair is traditionally considered a clean wound operation for which antibiotic prophylaxis is not indicated, since the estimated risk of surgical site infection (SSI) is very low (<1 %) [1–3]. However, the true incidence of SSI from groin hernia repair varies widely in the literature, reaching the worrisome rate of 10–13 % in some studies [4–6]. Given the proximity of the groin region to the genitals and perineum, this finding raises the question of whether it would be better to consider this operation as a clean-contaminated procedure, for which antibiotic prophylaxis is mandatory. The majority of the randomised controlled trials (RCT) published on this topic have failed to prove any benefit from the use of antibiotic prophylaxis, although most of them were limited by having small cohorts [4–19]. Conversely, a moderate trend in favour of antibiotic prophylaxis has emerged from the latest meta-analyses, but the data are not sufficiently strong to lead to definitive recommendations [20, 21]. As a result, current guidelines are discordant, some being in favour [22, 23] and others against [24–26] the routine use of antibiotic prophylaxis. Since groin hernia repair is one of the most common surgical procedures worldwide [27], both the inappropriate use of antibiotics and an excessively high

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rate of SSI are liable to have a major negative impact on health and social costs. Therefore, acquiring stronger evidence on this topic is even more essential. The latest update of the literature dates back to October 2011, and covered 6 and 11 RCTs on patients who underwent, respectively, traditional herniorraphy and mesh repair of groin hernia [21]. The purpose of our study was to perform a systematic review and meta-analysis including further RCTs, in order to gather more evidence on this topic. Since the use of prosthetic devices has become the rule nowadays [26], we focused our study only on mesh repair. An additional objective was to check for the presence of one or more outlier studies (studies whose results differ significantly from the others) and, if found, to verify their influence on the meta-analytic results. Finally, we investigated the extent to which several moderators, such as patient characteristics, surgical skill, duration of surgery, use of drainage and rate of SSI in patients not receiving antibiotics, could influence the correlation, if any, between antibiotic prophylaxis and SSI incidence.

Materials and methods

Eligibility criteria

Characteristics of primary studies

- *Participants* Adult patients undergoing elective open inguinal or femoral hernia repair with the use of prosthesis, regardless of the type of anaesthesia and hospital setting (inpatient/outpatient). Studies including patients less than 15 years old were excluded. Studies focused on laparoscopic hernia repair, herniorraphy without the use of prosthesis or emergency hernia repair were also excluded.
- *Intervention* any type of antibiotic administrated orally or intravenously before surgery to prevent post-operative wound infections. Studies using topical antibiotic administration were excluded;
- *Comparisons* placebo or no treatment;
- *Outcomes (dependent variables)* Overall incidence of post-operative SSI detected during a follow-up of at least 30 days. When data were available, incidence of deep post-operative SSI was also evaluated. Only studies with a clear definition of SSI were considered eligible;
- *Study design* RCT.

Characteristics of publications

The literature search focused solely on articles published in peer-reviewed journals, to enhance the methodological rigour of the studies examined and the reliability of the conclusions drawn regarding the efficacy of the intervention. No a priori exclusion based on language or year of publication was made.

Search strategy and selection of studies

The literature search was performed in November 2015, using several databases, including PubMed, Scopus, ISI-Web of Science and Google scholar.

For PubMed, the following search strategy was adopted: #1: antibiotic* OR antimicrob* OR anti-infect* OR anti infect*, #2: prophyla* OR prevent*, #3: #1 AND #2, #4: herni*, #5: #3 AND #4.

For Scopus and ISI-Web of Science, a similar strategy was used by entering the following terms in the field type TITLE-ABS-KEY: (antibiotic* OR antimicrob* OR anti-infect* OR anti infect*) AND (prophyla* OR prevent*) AND herni* AND (repair OR surgery OR tech* OR proced*) AND ((wound infection) OR SSI OR (surgical site infection)).

Google scholar was investigated by searching all the references that included the terms “hernia” AND (“prophyla” OR “prevent” OR “antibiotic” OR “infection”) in the title.

A further search was performed by checking articles in press in the index of journals which published more on this topic, in order to identify relevant studies not yet indexed in literature databases. Finally, a hand-search in the reference lists of the selected articles and of a previous similar review [21] was performed.

This study was performed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [28].

Coding

A coding protocol was prepared and used by the first and the last author to independently extract relevant information from the selected primary studies. Inter-rater reliability was very high (Choen’s kappa = 0.86) and disagreements were resolved through consensus. Six classes of information were coded:

1. *Characteristic of the publication* First author’s name, year, language and country of publication, number of centres involved, length of the study;
2. *Characteristics of the sample* Total sample size, male/female ratio, mean age, comorbidities, rate of recurrent hernias;
3. *Pre-operative management.* Type, dose, mode and timing of antibiotic administration;
4. *Characteristics of the operation* Type of anaesthesia, type of repair, use of drain, grade of the surgeon

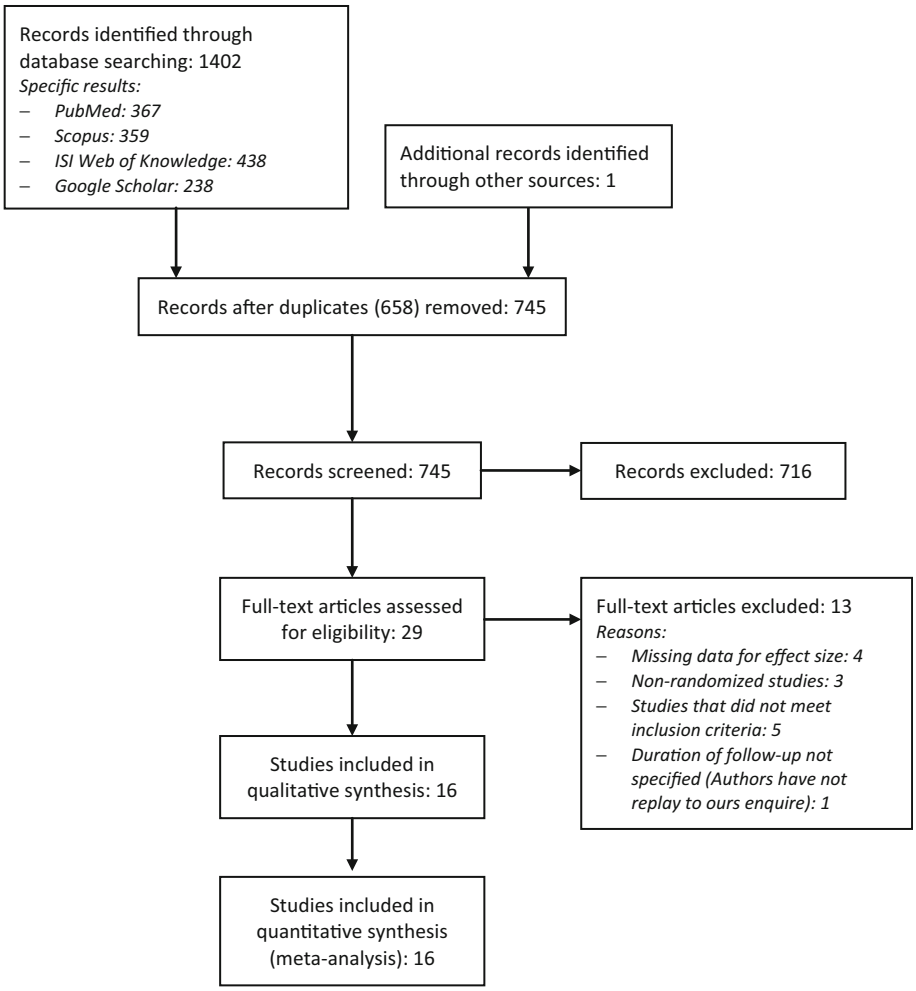

Fig. 1 Selection process of randomized controlled trials according to PRISMA statement

(consultant/resident), mean duration of the operation, hospital setting (inpatient/outpatient);

5. *Post-operative management* Duration and modality of follow-up, criteria used for diagnosis of SSI, management of SSI, rate of mesh removal;
6. *Data necessary for effect size computation* Number of patients and number of post-operative SSIs in the case and control groups, respectively. The number of deep SSIs was also evaluated when available.

Assessment of the methodological quality of each study was performed according to the criteria published in the Cochrane Handbook for Systematic Reviews of interventions (version 5.1.0) [29].

Statistical analysis

All statistical analyses were performed by means of the meta-analytic software ProMeta 2.0. Initially, we computed effect size as odds ratio (OR) and 95 % confidence interval (CI) from the data reported in each article. Then, data were pooled across studies to obtain an overall effect size using the inverse variance method.

The random-effects model was used as a conservative approach to account for different sources of variation among studies (i.e. within-study variance and between-studies variance). Further, the random-effects model allows for generalization of the meta-analytic findings beyond the studies included in this review [30]. OR was considered statistically significant at the 5 % level if the 95 % CI did not include the value 1. Numbers needed to treat (NNT) with 95 % CI were also calculated for the pooled results according to Altman [31].

To examine heterogeneity across studies, both Q and I^2 statistics were used. A significant Q value indicates the lack of homogeneity of results among studies. I^2 estimates the proportion of observed variance that reflects real differences in effect sizes, with values of 25, 50 and 75 % which might be considered as low, moderate and high, respectively [32].

To further evaluate heterogeneity across studies, an analysis of several moderators was performed. Five

continuous moderators, including rate of SSI in the control group, rate of operation performed by residents, duration of surgery, rate of women and mean age of the overall sample, were tested by means of meta-regression analysis, while one categorical moderator, the grade of the surgeon (consultant/resident), was tested through subgroups analysis.

A search for possible outlier studies was performed by evaluating the standardized residual and its statistical significance for each of the selected studies. If two or more outliers were detected, a further meta-analysis was performed after removing those studies, in order to appraise their influence on the overall effect size. Outlier studies were further analysed to detect any qualitative difference from the other studies.

Finally, publication bias analysis was performed. To do so, we initially evaluated the symmetry of the forest plot by ordering the results of primary studies according to sample size. An asymmetrical forest plot, where studies with small samples systematically report significant results, suggests the presence of publication bias. Then, we examined the funnel plot, which is a scatter plot of the effect sizes from selected studies against a measure of their standard error. In the absence of bias, the plot would be shaped as a symmetrical inverted funnel. Egger's linear regression analysis was employed to statistically test the symmetry of the funnel plot, with non-significant results indicative of absence of publication bias [33]. In addition, the trim and fill method, that is an iterative non-parametric statistical technique, was used to evaluate the effect of potential data censoring on the result of the meta-analysis. The absence of publication bias is indicated by zero trimmed studies or, in the presence of trimmed studies, by trivial differences between the observed and estimated effect sizes [34].

Results

Initial queries identified a total of 1403 articles from all databases and search methods. After duplicates were removed, the subsequent selection process resulted in 16 studies that meet the eligibility criteria of this meta-analysis [4–19] (Fig. 1). The assessment of the methodological quality of each RCT is reported in Fig. 2. As can be seen, only five studies had a low risk of bias in all the seven domains. An unclear risk of bias was found mainly in the domains of selection and performance bias, while high risk of bias was found in the other bias domains in four RCTs.

The main characteristics of the selected studies are reported in Tables 1, 2, 3, 4 and 5. All the articles were published in the period 2000–2015; most of them were written in English with only two published in Spanish [13, 14]. However, the contexts in which the studies had been conducted were heterogeneous, with five studies done in Europe [8, 9, 13, 14, 17] ten in Asia [4–6, 10–12, 15, 16, 18, 19] and one in Africa [7]. None of the articles had been published in North or South America. Most studies were conducted in a single centre and their duration varied from 12 to 55 months. Only three studies demonstrated the effectiveness of antibiotic prophylaxis

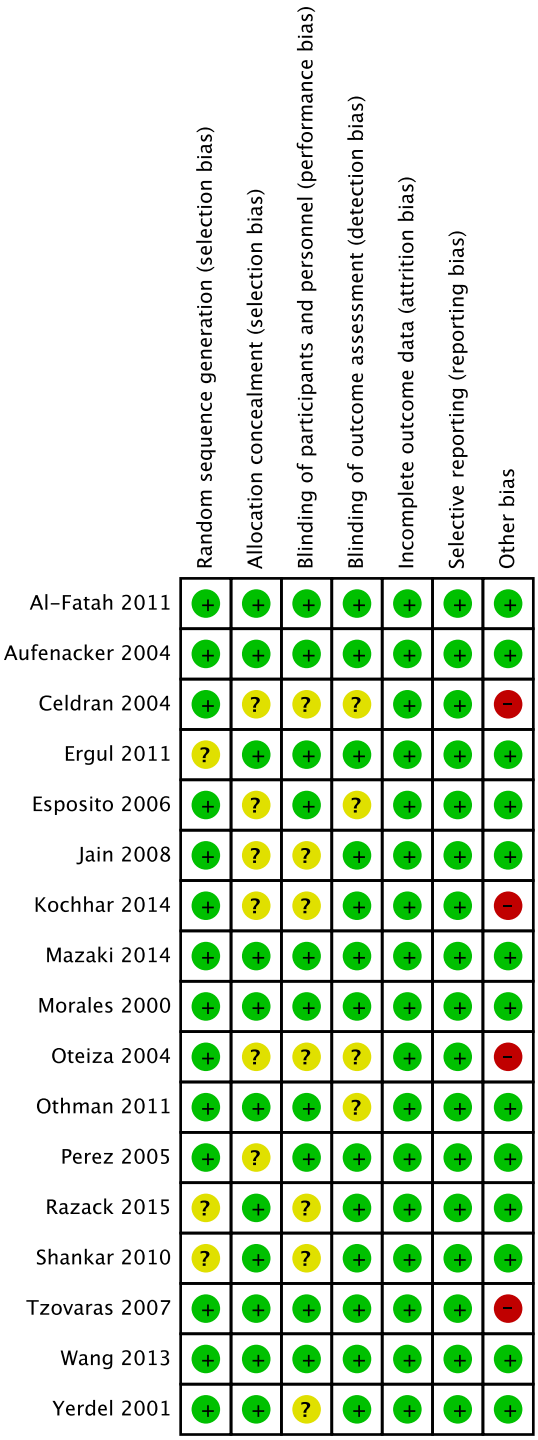

Fig. 2 Assessment of methodological quality of randomized controlled trials

Table Characteristics of the publications

	Year of publication	Language of publication	Country	Centers involved	Length of the study	Interruption for ethical reasons	Result of the study
Al-Fatah [7]	2011	English	Egypt	1	na	No	AP not indicated
Aufenacker [8]	2004	English	Netherlands	4	55 months	No	AP not indicated
Celdran [9]	2004	English	Spain	1	na	Yes	AP indicated
Ergul [10]	2012	English	Turkey	1	28 months	No	AP not indicated
Jain [11]	2008	English	India	1	12 month	No	AP not indicated
Kochhar [12]	2014	English	India	1	68 months	No	AP not indicated
Mazaky [4]	2014	English	Japan	1	54 months	Yes	AP indicated
Morales [13]	2000	Spanish	Spain	3	36 months	No	AP not indicated
Oteiza [14]	2004	Spanish	Spain	1	12 months	No	AP not indicated
Othman [5]	2011	English	Saudi Arabia	1	46 months	No	AP not indicated
Perez [15]	2005	English	Philippines	1	36 months	No	AP not indicated
Razack [16]	2015	English	India	1	20 months	No	AP not indicated
Shankar [6]	2010	English	India	1	20 months	No	AP not indicated
Tzovaras [17]	2007	English	Greece	1	54 months	No	AP not indicated
Wang [18]	2013	English	China	6	19 months	No	AP not indicated
Yerdel [19]	2001	English	Turkey	1	23 months	Yes	AP indicated

AP antibiotic prophylaxis, *na* not available

Table 2 Characteristics of the samples

	Total sample size	Mean age	Rate of women (%)	Diabetes	BMI	Rate of recurrent hernias
Al-Fatah [7]	200	63.0	0.5	13 (6.5 %)	26	na
Aufenacker [8]	947[a]	58.2	3.7	Excluded	na	Excluded
Celdran [9]	99	58.0	10.1	18 (18 %)	26.2	13 (13 %)
Ergul [10]	200	48.0	8.0	12 (6 %)	na	Excluded
Jain [11]	120	40.7	0.0	Excluded	na	Excluded
Kochhar [12]	212	37.4	4.2	Excluded	na	na
Mazaky [4]	200	70.5	8.5	13 (6.5 %)	22.85	Excluded
Morales [13]	524	54.2	10.1	na	na	39 (7.4 %)
Oteiza [14]	247	57.1	14.6	na	na	Excluded
Othman [5]	98	44.0	2.0	na	na	na
Perez [15]	350	60.7	2.0	na	na	Excluded
Razack [16]	180	44.9	0.5	Excluded	na	Excluded
Shankar [6]	334	45.0	1.2	Excluded	na	Excluded
Tzovaras [17]	379	63.0	5.8	13 (3.3 %)	26	na
Wang [18]	1160	54.3	9.8	na	na	Excluded
Yerdel [19]	269	55.7	7.4	Excluded	25	Excluded

na not available

[a] Sample size of the per-protocol analysis

and were stopped early for ethical reasons [4, 9, 19]. Sample size ranged widely from 98 to 1160, with mean age of participants varying from 37.4 to 70.5 years. The female gender was poorly represented with only 3 studies showing prevalence slightly above 10 % [9, 13, 14]. Patients affected by diabetes or recurrent hernias, which are potential risk factor for SSI, were not excluded in several studies [4, 7, 9, 10, 13, 17] while others did not specify this issue [5, 7, 12–15, 17, 18]. The method of pre-operative groin skin preparation (i.e. shaving and antisepsis) was clearly described in 10 studies [4–7, 9, 10, 15–17, 19], two of which were not in accordance with current recommendations (shaving was performed the day before surgery instead of just before) [6, 16]. No studies specified the

Table 3 Pre-operative management

	Pre-operative asepsis	Antibiotic	Placebo	Administration route	Timing of administration
Al-Fatah [7]	Standard	1 g Amoxicillin +200 mg clavoulanic acid	Sterile normal saline	IV	30 min before incision
Aufenacker [8]	Povidone-iodine (98 % of patients)	1.5 g Cefuroxim	Sterile normal saline	IV	At anaesthesia induction
Celdran [9]	Standard	1 gr Cefazolin	Yes (na which type)	IV	30 min before incision
Ergul [10]	Standard	1 g Cefazolin	Sterile normal saline	IV	At anaesthesia induction or when patient enter the operating room
Jain [11]	Povidone-iodine and alcohol	1 g Amoxicillin +200 mg clavoulanic acid	Sterile normal saline	IV	Before the incision (na how long before)
Kochhar [12]	na	1 g Amoxicillin +200 mg clavoulanic acid	Sterile normal saline	IV	Just before incision
Mazaky [4]	Standard	1 g Cefazolin	Sterile normal saline	IV	30 min before incision
Morales [13]	Povidone-iodine	2 g Cefazolin or 1 g Eritromicin in allergic patients	Sterile normal saline	IV	At anaesthesia induction
Oteiza [14]	na	2 g Amoxicilin + clavulanic acid	Not used	IV	15–30 min before surgery
Othman [5]	Standard	1 g Amoxicillin +200 mg clavoulanic acid	Sterile normal saline	IV	30 min before anaesthesia induction
Perez [15]	Standard	1 g Cefazolin	Sterile normal saline	IV	Before the incision (na how long before)
Razack [16]	Groin shaving the day before surgery; povidone-iodine	1 g Cefazolin	Sterile normal saline	IV	Just before the incision
Shankar [6]	Groin shaving the day before surgery; povidone-iodine	1 g Cefazolin	Sterile normal saline	IV	At anaesthesia induction
Tzovaras [17]	Standard	1 g Amoxicillin +200 mg clavoulanic acid	Sterile normal saline	IV	Before the incision (na how long before)
Wang [18]	Groin shaving (na how long before); povidone-iodine or chlorhexidine acetate	1 g Cefazolin or 200 mg levofloxacin	Sterile normal saline	IV	30–60 min before surgery
Yerdel [19]	Standard	1 g Ampicillin +500 mg sulbactam	Sterile normal saline	IV	Before the incision (ns how long before)

Standard pre-operative asepsis Skin shaved just before surgery and prepared by use of povidone-iodine, *na* not available, *IV* intravenous

methods used for skin shaving (razor/clipper). Antibiotics were always administered intravenously, with first-generation cephalosporin or a combination of beta-lactam/beta-lactamase inhibitors being the most used. Four studies did not clearly specify the timing of antibiotic administration [11, 15, 17, 19] and one did not use a placebo in the control group [14]. Hernia repair was always performed by means of polypropylene mesh, mainly through the Lichtenstein technique, under spinal or general anaesthesia. The use of drains was reported in four studies [7, 8, 17, 19] and was particularly frequent in Yerdel's study (22.3 %). In eight studies, residents performed a variable number of operations (24–100 %) under the supervision of a consultant surgeon [4, 6, 8–10, 15, 17, 19]. Mean duration of surgery ranged from 34 to 65.7 min. Seven studies reported the length of hospitalization, which varied from less than 24 h (i.e. Day Surgery) to more than 4 days [4, 6, 9, 10, 14, 16, 18]. Only 4 studies had a post-operative follow-up of more than 1 month (3–24 months) [4, 8, 9, 19] and all but one [9] described the follow-up method, which consisted in history-taking and clinical examination.

The overall rate of SSIs was 3.2 % in the case group (range 0–8 %) and 4.8 % in the control group (range 0–12.5 %). This difference was statistically significant, with no evidence of heterogeneity and publication bias

Table 4 Operative management and hospital setting

	Local anaesthesia	Repair Technique	Type of mesh	Use of drain	Surgical resident	Mean length of surgery	Mean length of hospital stay	Day surgery
Al-Fatah [7]	0 (0 %)	na	Polypropylene	7 (3.5 %)	Excluded	45 min	na	na
Aufenacker [8]	17 (1.7 %)	Lichtenstein	Polypropylene	15 (1.5 %)	437 (43.4 %)	40 min	na	463 (45.9 %)
Celdran [9]	99 (100 %)	Lichtenstein	Polypropylene	na	24 (24.0 %)	65 min	<24 h (100 %)	99 (100 %)
Ergul [10]	23 (11.5 %)	Lichtenstein	Polypropylene	Excluded	Yes (% na)	60 min	1 day (98 %)	0 (0 %)
Jain [11]	Yes (% n.a).	PHS	Polypropylene	0 (0 %)	Excluded	58 min	na	na
Kochhar [12]	na	Lichtenstein	Polypropylene	na	na	na	na	na
Mazaky [4]	na	Mesh-plug	Polypropylene	0 (0 %)	167 (83.5 %)[a]	65.7 min	3 days	Excluded
Morales [13]	na	na	Polypropylene	Excluded	Excluded	34.0 min	na	51 (9.7 %)
Oteiza [14]	226 (91.5 %)	Lichtenstein/ Plug/Mesh-plug	Polypropylene	na	Excluded	40.0 min	<24 h (100 %)	247 (100 %)
Othman [5]	0 (0 %)	Lichtenstein	Polypropylene	na	na	39.8 min	na	na
Perez [15]	0 (0 %)	Lichtenstein	Polypropylene	0 (0 %)	Yes (% na)	53.0 min	na	na
Razack [16]	na	Lichtenstein	Polypropylene	na	na	53.0 min	4.1 days[b]	na
Shankar [6]	26 (7.8 %)	na	Polypropylene	na	296 (88.6 %)	53.0 min	4.1 days[b]	na
Tzovaras [17]	329 (86.8 %)	na	Polypropylene	15 (3.9 %)	Yes (% na)	45.0 min	na	na
Wang [18]	238 (20.5 %)	Mesh-plug	Polypropylene	na	na	na	3.1 days	na
Yerdel [19]	111 (41.2 %)	Lichtenstein	Polypropylene	60 (22.3 %)	269 (100 %)	63.0 min	na	na

na not available, *PHS* prolene hernia system

[a] In this study, all SSIs occurred in patients operated by surgical residents

[b] Length of pre-operative hospital stay. In these studies, patients with wound infection had a significantly longer pre-operative hospital stay

(Fig. 3, Table 6). The number needed to treat was 61 (95 % CI 37.2–168.4). The analysis of categorical and continuous moderators showed no significant results (Tables 7, 8). However, meta-regression analysis showed a positive correlation between the incidence rate of SSI in the control group and the effectiveness of antibiotic prophylaxis in the case group, although this finding did not reach statistical significance.

The analysis of standardized residuals (s.r.) allowed the identification of two outlier studies: Mazaki et al. (s.r. = 2.11, $p = 0.035$) and Yerdel et al. (s.r. = −2.13, $p = 0.033$). Mazaki et al. considered an elderly population (mean age: 70.5 years) and included patients with diabetes (6.5 %). In this study, residents performed the majority of operations (83.5 %) and the mean length of surgery was the highest recorded among all RCTs (65.7 min). In the study by Yerdel et al., operations were always performed by residents (100 %), drains were frequently used (22.3 %) and mean length of surgery was among the highest reported (63 min). Both studies were discontinued for ethical reasons since the incidence of SSI in the control group was considered to be too high. The meta-analysis performed without these two studies shows no statistical difference between case and control groups in the incidence of post-operative SSI with an NNT of 108 (95 % CI −0.14 to 2.01) (Table 9).

Ten studies reported data about deep SSI [4–6, 8, 10, 11, 14, 15, 18, 19], with an incidence of 0.3 % (range 0–0.7 %) in the case group and 0.5 % in the control group (range 0–0.6 %). This difference was not significant and no heterogeneity or publication bias was found (Fig. 4; Table 6).

Management of SSI was conservative in the majority of cases. Mesh removal was performed in 0.27 % of all hernia repairs, 8.4 % of all SSIs and in 41 % of deep SSIs.

Discussion

The current meta-analysis examined the content of 16 RCTs addressing the use of antibiotic prophylaxis for the open mesh repair of groin hernia. Overall, this study added 5 RCTs and 2286 patients to the latest update published in 2012 [21].

Table 5 Incidence of SSI and post-operative management

	Length of follow-up (months)	Modality of follow-up	SSI criteria	Case		Control		Overall	N. of mesh removal (%)
				N. Events (%)	Total	N. Events (%)	Total	N. Events (%)	
Al-Fatah [7]	1	Clinical visit	ASEPSIS score	3 (3.0)	100	5 (5.0)	100	8 (4)	0 (0)
Aufenacker [8]	3	Clinical visit	CDC	8 (1.7)	475	8 (1.7)	472	16 (1.7)	2 (11.7)
Celdran [9]	24	na	CDC	0 (0.0)	50	4 (8.2)	49	4 (4)	0 (0)
Ergul [10]	1	Clinical visit	CDC	7 (7.0)	100	5 (5.0)	100	12 (6)	0 (0)
Jain [11]	1	Clinical visit	CDC	1 (1.7)	60	1 (1.7)	60	2 (1.7)	0 (0)
Kochhar [12]	1	Clinical visit	ASEPSIS score	4 (3.8)	106	5 (4.8)	106	9 (4.2)	0 (0)
Mazaky [4]	3	Clinical visit	CDC	2 (2.0)	100	13 (13)	100	15 (7.5)	0 (0)
Morales [13]	1	Clinical visit	ASEPSIS score	4 (1.7)	237	6 (2.1)	287	10 (1.9)	4 (40)
Oteiza [14]	1	Clinical visit	ASEPSIS score	1 (0.8)	124	0 (0.0)	123	1 (0.4)	0 (0)
Othman [5]	1	Clinical visit	CDC	4 (8.0)	50	6 (12.5)	48	10 (10.2)	0 (0)
Perez [15]	1	Clinical visit	CDC	4 (2.3)	174	7 (3.9)	176	11 (3.1)	2 (18.2)
Razack [16]	1	Clinical visit	ASEPSIS score	7 (7.4)	94	8 (9.3)	86	15 (8.3)	na
Shankar [6]	1	Clinical visit	CDC	12 (7)	172	17 (10.5)	162	29 (8.7)	na
Tzovaras [17]	1	Clinical visit	ASEPSIS score	5 (2.6)	190	9 (4.7)	189	19 (5)	0 (0)
Wang [18]	1	Clinical visit	CDC	32 (4.1)	768	20 (5.1)	392	52 (4.5)	na
Yerdel [19]	12	Clinical visit	CDC	1 (0.7)	136	12 (6)	133	13 (4.2)	3 (23)

N number, *na* not available, *CDC* Centers for Disease Control and Prevention

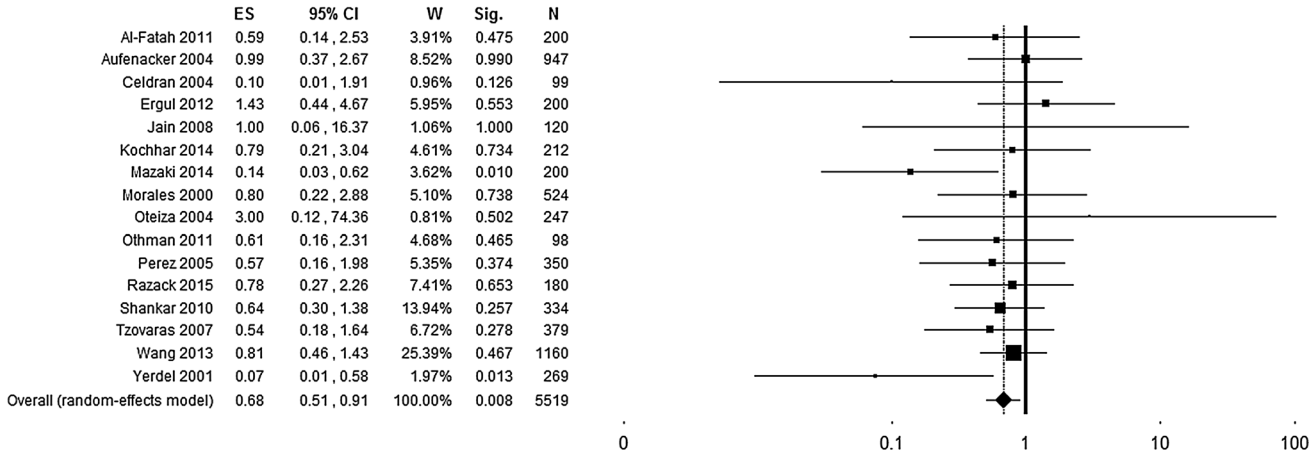

Fig. 3 Forest plot of effect sizes from meta-analysis on the effectiveness of antibiotic prophylaxis in reducing overall incidence of SSI (primary outcome)

Only 3 of 16 RCTs found significant benefits from the use of antibiotic prophylaxis and were interrupted prematurely due to the very high rate of SSIs in the control group, which varied from 6 % to 13 % [4, 9, 19]. However, the analysis of pooled data showed that prophylaxis significantly reduces the rate of post-operative SSI, from 4.8 % to 3.2 %, with an NNT of 61. These data are apparently stronger and more generalizable than that of the previous meta-analysis because it was obtained with a more conservative method of analysis. Nevertheless, we found several clinical and methodological limitations among the primary studies, which raise some doubts as to the full reliability of this result. Most studies were performed in Asia and Africa, only five in Europe and none in North America. This suggests that the occurrence of SSI after groin hernia repair is not perceived to be a major problem in Western countries. It should be noted that the incidence of SSIs reported in the control group exceeded 5 % in almost all RCTs from Asia and Africa (with 3 studies exceeding 10 %) but only in one study from Europe. Wide heterogeneity was found with regard to several well-recognized risk factors for SSI such as mean age of patients (range 37.4–70.5 years), duration of surgery (34–65.7 min), length of hospital stay (from some hours to

Table 6 Summary of meta-analytic results

	k	*N*	SSI/case (%)	SSI/control (%)	OR [95 % CI]	*Q*	I^2	Egger	Trim and fill
Overall SSI	16	5519	95/2936 (3.2)	126/2583 (4.8)	0.68 [0.51, 0.91]*	14.21	0.00	−0.80	0 (0.68 [0.51, 0.91])
Deep SSI	10	3986	8/2187 (0.3)	9/1799 (0.5)	0.80 [0.32, 1.99]**	1.19	0.00	0.51	0 (0.80 [0.32, 1.99])

K number of studies, *N* total number of participants, *OR* odds ratio, *CI* confidence interval, *Q* and I^2 heterogeneity statistics

* $p < .008$; ** not significant

Table 7 Continuous moderator analyses

Moderator	*k*	*N*	No. of case	No. of control	β (slope)	*p*
% of SSI in control group	16	5519	2936	2583	−0.07	0.095
% of operations performed by residents	10	4450	1628	1662	−0.01	0.209
% of women	16	5519	2936	2583	0.00	0.954
Mean age	16	5519	2936	2583	−0.03	0.165
Duration of surgery	14	4147	2062	2085	−0.03	0.111

K number of studies, *N* total number of participants, *No.* number

Table 8 Categorical moderator analysis

Moderator	*k*	*N*	OR [95 % CI]	*Q*	I^2	Contrast
Degree of surgeons (1st operator)						1.20*
Residents	6	2601	0.77 [0.49, 0.59]	1.12	0.00	
Consultant	7	2428	0.49 [0.24, 0.97]	12.13	50.55	

K number of studies, *N* total number of participants, *OR* odds ratio, *CI* confidence interval, *Q* and I^2 heterogeneity statistics

* $p = 0.273$

Table 9 Meta-analysis of overall SSI after removal of outlier studies

	k	*N*	SSI/case (%)	SSI/control (%)	OR [95 % CI]	*Q*	I^2	Egger	Trim and fill
Overall SSI	14	5050	92/2700 (3.4)	101/2350 (4.3)	0.76 [0.56, 1.02]*	4.98	0.00	−0.80	0 (0.76 [0.56, 1.02])

K number of studies, *N* total number of participants, *OR* odds ratio, *CI* confidence interval, *Q* and I^2 heterogeneity statistics

* $p = 0.065$

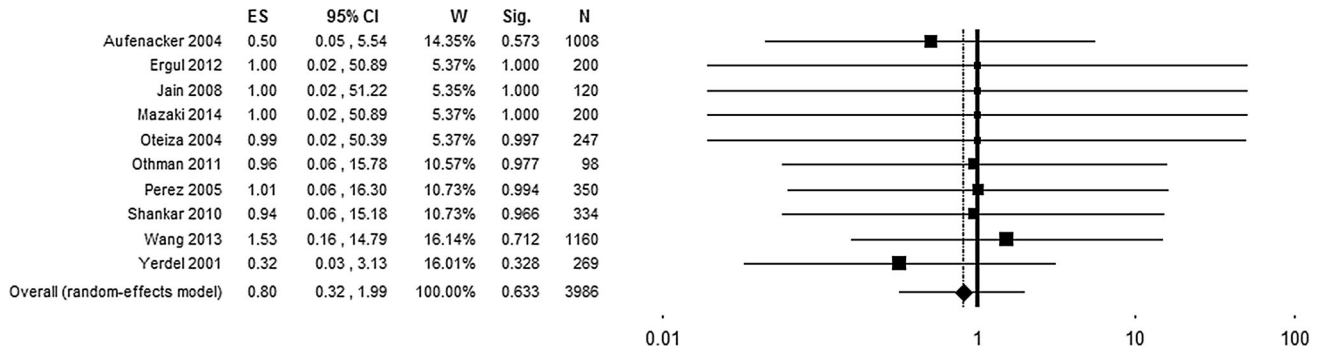

Fig. 4 Forest plot of effect sizes from meta-analysis on the effectiveness of antibiotic prophylaxis in reducing incidence of deep SSI (secondary outcome)

4 days), diabetes (0–18 %), use of drain (0–22.3 %), and repair of recurrent hernias (0–13 %). The description of pre-operative skin preparation was always incomplete and sometimes not in accordance with current recommendations. In some studies, data about the timing of antibiotic administration were missing or imprecise. Finally, the majority of RCTs were affected by one or more methodological bias.

Among all the RCTs included in the study, two were found to have an outlier effect size [4, 19], i.e. a result that differs considerably from the others. This finding could mean that such studies have distinctive characteristics, making them poorly comparable with the other RCTs. In both these studies, the rate of SSI was very high in the control group and several risk factors for post-operative infection, such as diabetes, advanced age, use of drain and long duration of the operation, were present. Although these features were not exclusive of the two studies, their combination might have played a role in determining such results. It is a fact that, when meta-analysis is performed excluding these two RCTs, the effect of antibiotic prophylaxis in reducing SSIs becomes non-significant. The analysis of several moderators did not show any significant correlation with the pooled effect size, although a trend towards positive correlation between effectiveness of antibiotic prophylaxis and the rate of SSIs in the control group was found (Tab.7). This could mean that the higher the rate of SSIs, the more evident is antibiotic effectiveness. Taken together, these findings suggest that antibiotic prophylaxis may be helpful in reducing SSIs, but it seems that this effect becomes evident only in the presence of risk factors or when the incidence of SSIs is high.

The indication for antibiotic prophylaxis depends essentially on two factors: the risk of SSI and the potential severity of the infection, which could have catastrophic outcomes for certain surgical procedures [1, 22, 24]. A survey conducted by the Centers for Disease Control and Prevention (CDC) in more than 1500 US hospitals in the period 2006–2008 found that the risk of SSI in groin hernia procedures is less than 1 %, but may exceed 5 % in the presence of generic risk factors, such as an ASA score greater than 2 and duration of surgery above the 75th percentile [3]. This study does not distinguish between herniorraphy and mesh hernioplasty, although the use of prosthetic devices has become the rule [26] and is a potential risk factor for SSI [1, 22, 24]. However, a meta-analysis of 20 RCTs comparing mesh with non-mesh methods of open groin hernia repair showed no significant difference in the rate of SSI between the groups [35]. In addition, the occurrence of SSI after inguinal hernia repair is not a dramatic event, even when a prosthetic device is used. In fact, antibiotic therapy alone or associated with drainage is adequate to resolve the vast majority of SSIs. We found that the incidence of deep SSI was very low in all the ten studies that provided data on this issue (0–0.7 %) and that the effect of antibiotic prophylaxis was not significant. The occurrence of deep SSI required mesh removal in 41 % of cases, but overall this procedure was performed in only 8.4 % of all SSIs and in 0.27 % of all hernia repairs. The RCTs included in our meta-analysis do not provide data on the incidence of hernia recurrence after mesh removal, but other studies showed that the rate is lower than 5 % and subsequent reoperation is rarely necessary [36, 37]. Based on these considerations, antibiotic prophylaxis should not be indicated for groin hernia repair but, since the incidence of SSI varies widely in the literature, it has been suggested to consider the routine use of antibiotic prophylaxis in those clinical settings that report a high rate of SSIs [20]. However, the effectiveness of this strategy has not been proven and, in the era of clinical governance, it would not seem to be very cost effective. The prevention of SSI requires several pre-, intra- and post-operative steps, among which antibiotic prophylaxis is the only optional one [22, 24]. Any violations while performing these steps can result in contamination and increased risk for SSI. Thus, when the rate of post-operative infections is higher than expected for a clean wound operation, it is best to analyse the appropriateness of all the steps of surgical asepsis before opting for routine antibiotic prophylaxis.

In conclusion, this meta-analysis has shown that antibiotic prophylaxis may be effective in reducing the overall incidence of SSIs after the open mesh hernia repair of groin hernias. However, this result cannot be generalized since it is conditioned by several clinical and methodological limitations of the primary studies and was not confirmed after the exclusion of outlier RCTs. Furthermore, the use of antibiotic prophylaxis is not useful in preventing deep SSI, which is a very uncommon event in groin hernia surgery. The wide heterogeneity in the incidence of SSI reported by the primary studies may be indicative of poor selection of patients or may be the consequence of different quality of surgical asepsis. Hospitals with unexpectedly high rates of SSIs should check for any shortfalls in their aseptic techniques and, where necessary, take corrective measures. Currently, there are no convincing arguments for recommending the routine use of antibiotic prophylaxis for groin hernia repair, especially in clinical settings with low incidence of SSI.

Compliance with ethical standards

Conflict of interest EE, FM, GP, AN, and PGC declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent For this type of study formal consent is not required.

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