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Abbreviations

CI: Confidence interval

NPV: Negative predictive value

OR: Odds ratio

PPV: Predictive positive value

SSI: Surgical site infections

Abstract

Background: Systematic cultures of drain tips or drainage fluids for the early detection of surgical site infections (SSI) are controversial.

Aim: To examine the association between the results of systematic drain tip or drainage fluid cultures and the occurrence of SSI in clean or clean-contaminated surgery.

Methods: We searched in the Pubmed, and Cat.inist databases for observational studies published before March 31st 2017. We included studies reporting results of drain tip or drainage fluid systematic cultures and SSI after clean or clean-contaminated surgeries, and we performed meta-analyses.

Findings: Seventeen studies, including 4,390 patients for drain tip cultures and 1,288 for drainage fluid cultures, were selected. The pooled negative predictive values were high (99%, 95% CI [98-100] for drain tip cultures and 98%, 95% CI [94-100] for drainage fluid cultures). The positive predictive values were low (11%, 95% CI [2-24] for drain tip cultures and 12%, 95% CI [3-24] for drainage fluid cultures). The sensitivities were low (41%, 95% CI [12-73] for drain tip cultures and 37%, 95% CI [16-60] for drainage fluid cultures). The specificities were high (93%, 95% CI [88-96]) for drain tip cultures and moderate (77%, 95% CI [54-94]) for drainage fluid cultures.

Conclusion: Systematic cultures of drain tips or drainage fluids appear not to be relevant, because their positive predictive values were low in the prediction of SSI.

Keywords:

Drain tip, drainage fluid, culture, prediction, surgical site infection.

INTRODUCTION

Surgical site infections (SSI) are still major surgical complications [1]. The contamination of the surgical site may occur during pre-operative, per-operative or post-operative periods. Surgical drainage can be used to prevent hematoma formation, and thus SSI, but can also be a risk factor for SSI [2]. Indeed, many studies have found an association between the presence of surgical drainage and SSI or between the drainage duration and the proportion of SSI [2-4]. Systematic cultures of drain tips or drainage fluids are commonly used by surgical teams for the early detection of SSI, even in the absence of clinical suspicion of infection. However, their prognostic values are controversial, and the collection and laboratory processing of these samples are costly and time-consuming [5].

We conducted meta-analyses of published comparative studies reporting on the association between results of systematic drain tip or drainage fluid cultures and the occurrence of SSI in clean or clean-contaminated surgery.

METHODS

The study was performed according to the recommendations of the *Preferred Reporting Items for a Systematic Review and Meta-analysis of Diagnostic Test Accuracy Studies (PRISMA-DTA)* [6].

We searched in the Pubmed, and Cat.inist databases for articles published before March 2017. First, we identified three MeSH (Medical Subject Headings) descriptors (1. Surgical wound infection; 2. Drainage; 3. Microbiological techniques) and linked the MeSH terms that corresponded to the descriptors by "OR" and each descriptor was associated by "AND" (Supplemental material 1). A second Pubmed search was performed using the following strategy: "*(surgical OR surgery) AND drain[title/abstract] AND culture AND infection[title/abstract]"*. The Cat.inist base was searched with the equation "*suction AND* *drain AND culture AND infection.”* Finally, a manual search from the bibliography of the selected articles was carried out.

Selection

Original articles about the use of systematic surgical drain tip or drainage fluid cultures to predict SSI were selected. We excluded studies in which cultures were performed only in cases of suspicion of SSI, as well as studies that only included contaminated or dirty/infected surgeries.

We also contacted five authors of studies that were potentially eligible for inclusion in the meta-analysis in order to obtain additional information or new results [7-11]. Two of them replied to us [7-8].

Quality

Two readers independently assessed the study limitations for each selected article employing the Newcastle-Ottawa Scale adapted to the specific design of the study [12]. Disagreements between the two reviewers were resolved by consensus.

Meta-analyses

Data about SSI and drain tip or drainage fluid cultures were extracted from the selected studies and analysed with Stata 11 [13] (metan add-on [14]). Positive predictive values (PPVs), negative predictive values (NPVs), sensitivities and specificities and their respective confidence intervals (CIs) were calculated to evaluate the performance of drain tip cultures and drainage fluids cultures to predict SSI. Odds ratios (ORs) were also calculated. Meta-analyses were also performed studying the concordance between microorganisms isolated in the drain tip or drainage fluid cultures and those isolated in SSI. We used double arcsine transformations to stabilize the variance of proportions [15] and a random effect model according to DerSimonian-Laird's method [16]. Heterogeneity was tested by the I^2 and Chi2 heterogeneity tests and was explored by subgroup analyses depending on the type of specialty. A potential publication bias was examined by means of funnel plots. We performed two sensitivity analyses. The first set of analyses included studies wherein data were available only in abstract form, but not in full-text form [10-11]. The second set included studies wherein data were available in full-text form, with a score of five or more.

RESULTS

One hundred and ninety studies were identified. The manual search revealed six new articles. The flow-chart is presented in Figure 1. Seventeen studies were selected (Tables I and II) [5,7,8,17-30].

Twelve studies were prospective and fourteen studies focused on orthopaedic surgery. Drain tip cultures were analysed in eleven articles, drainage fluids were analysed in three articles, and both were analysed in three other articles.

A total of 4,390 patients were included in drain tip culture studies and 1,288 were included in drainage fluid culture studies.

The studies' quality was moderate (Table III).

Between studies, the SSI proportion varied from 0% (95% CI [0-11]) to 20% (95% CI [10-34]), and the pooled proportions were 2% (95% CI [1-4]) for drain tip culture studies and 5% (95% CI [1-10] for drainage fluid culture studies) (Figure 2).

Figure 3 shows the results of PPV for each study. The pooled PPVs were low (11%, 95% CI [2-24] for drain tip cultures and 12%, 95% CI [3-24] for drainage fluid cultures).

Figure 4 shows the results of NPV for each study. The pooled NPVs were high (99%, 95% CI [98-100] for drain tip cultures and 98%, 95% CI [94-100] for drainage fluid cultures).

The sensitivities were low (41%, 95% CI [12-73] (I^2= 88.3%, p<0.001) for drain tip cultures and 37%, 95% CI [16-60] (I^2= 40.1%, p=0.154) for drainage fluid cultures).

The specificities were high (93%, 95% CI [88-96] (I^2= 95.4%, p<0.001)) for drain tip cultures and moderate (77%, 95% CI [54-94] (I^2= 97.9%, p<0.001)) for drainage fluid cultures.

The ORs showed an association between positive cultures and SSI, which was significant for drain tip cultures (OR=11.88, 95% CI [3.38-41.72]) but not for drainage fluid cultures (OR=3.42, 95% CI [0.70-16.63]). Subgroup analyses by specialty were performed in the presence of heterogeneity. Only the orthopedic surgery specialty saw more than two studies included. In the subgroup analysis including orthopedic studies only, heterogeneity was still high (I^2 =76.6%, p<0.001).

When studying the concordance between the drain tip or drainage fluid cultures and the SSI isolated bacteria, PPVs were very low (6%, 95% CI [0-23] for drain tip cultures and 7%, 95% CI [1-18] for drainage fluid cultures) (Supplemental material 2).

The funnel plot (Figure 5) did not suggest a publication bias.

Sensitivity analyses gave similar results (Supplemental material 3).

DISCUSSION

This study allowed us to determine the performances of systematic drain tip or drainage fluid cultures in the prediction of SSI and in the prediction of the microorganisms involved in SSI. Systematic drain tip or drainage fluid cultures seem to be of little value since the PPVs that represent the probability of SSI in the presence of a positive culture were low (11%, 95% CI [2-24] for drain tip cultures and 12%, 95% CI [3-24] for drainage fluid cultures). Moreover, the micro-organisms identified in the cultures did not systematically correspond to the micro-organisms involved in SSI (PPVs of 6%, 95% CI [0-23] for drain tip cultures and 7%, 95% CI [1-18] for drainage fluid cultures). Sensitivities were also poor; thus systematic drain tip or drainage fluid cultures are not reliable predictors of SSI in the absence of clinical signs. Therefore, due to the lack of benefit, the associated costs (24,30 euros for a drain tip or a drainage fluid culture in France) and the risk of unnecessary or inappropriate antibiotic treatment, use of these cultures has been discouraged in our facility. The microbiology examination that should be performed is culture of biopsies, or material collected during revision surgery [31].

The low relevance of systematic drain tip or drainage fluid cultures has been shown in several studies, particularly dealing with orthopedic surgery [25,26,29,30].

However, in the study conducted by Bernard *et al*. [20], drainage fluid cultures seemed to be promising in septic surgery with a PPV of 87%, being particularly useful in the follow-up of the efficacy of surgical and antibiotic treatments.

The NPVs were high in our meta-analysis (99%, 95% CI [98-100] for drain tip cultures and 98%, 95% CI [94-100] for drainage fluid cultures). However, the added value of this test is poor as the incidence of SSI is low in the literature (from 0.6 % in knee prosthesis surgery to 10.7% non-endoscopic colorectal surgery) [32] and in studies included in our meta-analysis. The heterogeneity was high (>50% and p<0.001). This heterogeneity was not explained by the type of surgical specialty, but might be explained by the differences in sampling methods or microbiological techniques. The sampling methods varied significantly between studies and were not sufficiently described in several studies. It was therefore not possible to take them into account in our meta-analysis.

To our knowledge, this is the first meta-analysis to explore the performances of systematic drain tip or drainage fluid cultures after clean or clean-contaminated surgery in the prediction of SSI. We included 17 studies involving 4,390 patients for drain tip cultures and 1,288 patients for drainage fluid cultures. Although an association between positive cultures and SSI was observed in several included studies, several of them did not show the performances in terms of NPV, PPV, sensitivity and specificity of these cultures [17,21,24,29]. Our meta-analysis allowed us to determine these performances in the prediction of SSI and to pool them.

The Newcastle-Ottawa scale was preferred to the QUADAS-2 [33] scale usually used for the assessment of diagnostic accuracy studies as the Newcastle-Ottawa scale allowed us to evaluate more items. Only the evaluation of the presence of SSI without knowledge of the culture was not assessed, but this information was never mentioned in selected studies [5,7,8,17-30].

This meta-analysis also has limitations, in particular the inclusion of studies with a medium quality and/or methods poorly described and retrospective studies. Only three had a score of six or more in the Newcastle-Ottawa quality assessment scale. Moreover, some confidence intervals were wide. Finally, the limited number of studies included, as well as the heterogeneity between studies should lead one to interpret results with caution.

Although a high NPV is not interesting in the context of systematic cultures, it could be interesting in cases of clinical suspicion or clinical diagnosis of SSI, or in contaminated or infected surgery. Some studies deal with cultures in this context but were not included in our meta-analyses [34]. Such meta-analyses could be conducted to determine the performance of drain tip or drainage fluid cultures in this context. If the PPV were high, this might allow one to confirm SSI or to adapt the antibiotic treatment. However, only early SSI would be identified since drains are usually removed a few days after surgery.

CONCLUSION

Our meta-analysis showed that the systematic cultures of drain tips or drainage fluids were of low relevance since the PPV were low in the prediction of SSI. Moreover, the associated costs and the risk of useless or inappropriate antibiotic treatment should lead one to discourage the performance of systematic cultures in asymptomatic patients.

It would be interesting to provide meta-analyses that include only studies in which cultures were performed for patients who are experiencing clinical signs or in contaminated or infected surgery.

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Figure legends

Figure 1. Flow chart for studies selection and inclusion

Figure 2. Meta-analysis of surgical site infections proportion in selected studies

Figure 3. Meta-analysis of positive predictive positive value of drain tip or drainage fluid cultures in the prediction of surgical site infections in selected studies

Figure 4. Meta-analysis of negative predictive value of drain tip or drainage fluid cultures in the prediction of surgical site infections in selected studies.

Figure 5. Funnel plot of selected studies

Tables

Table I. Characteristics of the included studies

Authors	Year	Country	Type of study	Type of surgery	Type of sample	Drainage duration	Prophylactic antibiotic treatment duration	Duration of follow-up	Inclusion criteria	Number of included patients
Ahn et al. [5]	2015	Corea	Retrospective	Orthopaedic	Drain tip	4.5 days	5 days	1 year	CDC criteria [35]	133
Aski et al. [17]	2015	India	Prospective	Orthopaedic	Drain tip	≤48 hours	3 days	6 months	Unspecified	338
Becker et al. [18]	1990	USA	Prospective	Ear, nose and throat	Drainage fluid	Unspecified	3 days	Unspecified	Presence of pus postoperatively	41
Becker et al. [19]	1985	USA	Prospective	Ear, nose and throat	Drainage fluid	Unspecified	During drainage	Unspecified	Presence of pus postoperatively	30
Bernard et al. [20]	2002	France	Prospective	Orthopaedic	Drainage fluid	Unspecified	Unspecified	1 month, 1 year if presence of implant	Unspecified	843
Degnim et al. [21]	2013	USA	Prospective	Breath	Drainage fluid and drain tip	4 to19 days (mean=7 days)	≤ 24 hours	30 days	CDC criteria ("purulent drainage, positive aseptically collected culture from the wound, signs of inflammation with opening of incision and	100

Authors	Year	Country	Type of study	Type of surgery	Type of sample	Drainage duration	Prophylactic antibiotic treatment duration	Duration of follow-up	Inclusion criteria	Number of included patients
									absence of a negative culture, or physician diagnosis of infection (which could include cellulitis)”)	
Girvent et al. [22]	1994	Spain	Prospective	Orthopaedic	Drain tip	Ablation if volume <20 mL/days (untill 6 days)	Variable	Unspecified	“any clinical signs of infection of the wound (redness, swelling, increase in the local temperature and exsudation)”	72
Gunterberg et al. [23]	1996	Sweden	Prospective	Orthopaedic	Drain tip	48 hours	48 hours	12 months	“purulent drainage, serous discharge from the wound with the growth of bacteria at reoperation”	105
Krishnan et al. [24]	2012	India	Retrospective	Orthopaedic	Drain tip	48 hours	3 days	Unspecified	Unspecified	156
Lindahl J. [8]	1993	Finland	Prospective	Orthopaedic	Drainage fluid and drain tip	3 groups: 12, 24 and 48 hours	None	1 month	Unspecified	60
Overgaard et al. [25]	1993	Denmark	Prospective	Orthopaedic	Drain tip	Ablation if volume <20 mL during 12hours mean = 1.8 days	During drainage	1 year	“purulent matter in the wound, or signs of infection including positive culture”	81
Petsatodis et al. [26]	2009	Greece	Prospective	Orthopaedic	Drain tip	48 hours	48 hours	2.8 years	Unspecified	110

Authors	**Year**	**Country**	**Type of study**	**Type of surgery**	**Type of sample**	**Drainage duration**	**Prophylactic antibiotic treatment duration**	**Duration of follow-up**	**Inclusion criteria**	**Number of included patients**
Sankar et al. [27]	2004	India	Prospective	Orthopaedic	Drainage fluid and drain tip	Ablation if volume < 100ml/24 hours (24- 48 hours)	16 hours	1 year	“purulent matter in the wound drained spontaneously or by incision, serous discharge from the wound with growth of bacteria, or signs of infection with growth of bacteria at reoperation ”	214
Takada et al. [28]	2015	Japan	Retrospective	Orthopaedic	Drain tip	12 to 72hours	48 hours	4.7 years	“ Any possible signs of SSI such as wound discharge or dehiscence, fever, pain, and an increase of level of C reactive protein or erythrocyte sedimentation rate ”	1,380
Weinrauch [29]	2005	Australia	Retrospective	Orthopaedic	Drain tip	24 hours	During drainage	8.9 months (3 months minimum)	Unspecified	393
Yamada et al. [7]	2016	Japan	Retrospective	Orthopaedic	Drain tip	48 hours	48 hours	3 years (0.5-5.5 years)	CDC criteria [36] – “the presence of SSI was confirmed by reoperation or by histopathologic or radiologic investigation"	1,240
Zamora et al. [30]	1999	Spain	Prospective	Orthopaedic	Drain tip	3 groups: 12, 24 and 48 hours	2 days	Unspecified	“ The evaluation of the healing of the wound was done taking into account the presence of purulent	32

Authors	Year	Country	Type of study	Type of surgery	Type of sample	Drainage duration	Prophylactic antibiotic treatment duration	Duration of follow-up	Inclusion criteria	Number of included patients
									matter coming from the wound, as well as other signs of infection or a positive culture"	

Table II. Description of microbiologic methods in the included studies

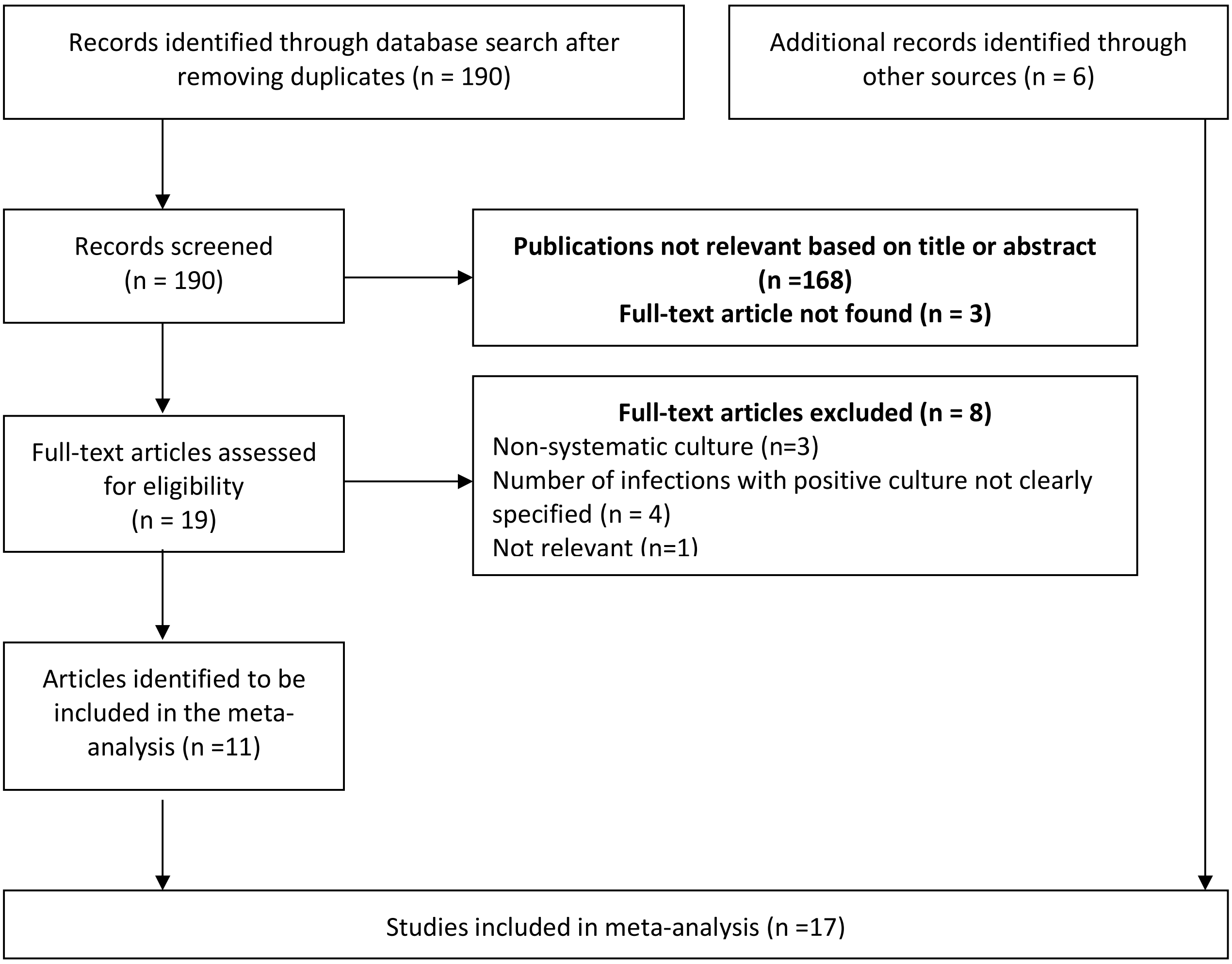
Authors	**Year**	**Type of sample**	**Incubation time**	**Culture medium**	**Analysis (qualitative or quantitative)**	**Transport medium (yes/no)**	**Sampling mode**	**Skin disinfection before drain removal**
Ahn et al.	2015	Drain tip	Unspecified	Unspecified	Unspecified	Unspecified	"The suction drain tip was cut off approximately 5 cm from its far end using single-use sterile scissors"	Yes (povidone iodine)
Aski et al.	2015	Drain tip	Unspecified	Unspecified	Unspecified	Unspecified	"aseptic"	Yes (povidone iodine)
Becker et al.	1990	Drainage fluid	Unspecified	Aerobic and Anaerobic blood agar plate, laked blood agar plate, *Fusobacterium* agar plate, phenyl ethyl alcohol agar plate, chocolate agar plate, McConkey agar plate	Quantitative	Yes	"on the second or third postoperative day, a sample of wound drainage was aspirated from the drain line into a syringe"	Unspecified
Becker et al.	1985	Drainage fluid	48 hours	Aerobic blood agar plate, McConkey agar plate, azide agar plate, chocolate agar plate, thioglycollate browth Anaerobic blood agar plate, kanamycin-vancomycin-laked blood agar plate, phenyl ethyl alcohol blood agar plate Chocolate agar plate incubated in 10% carbon dioxide	Qualitative	Yes	"on the second or third postoperative day, a sample of wound drainage was aspirated from the drain line into a syringe"	Unspecified

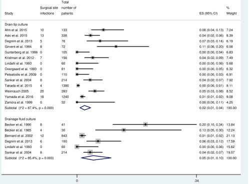
Authors	Year	Type of sample	Incubation time	Culture medium	Analysis (qualitative or quantitative)	Transport medium (yes/no)	Sampling mode	Skin disinfection before drain removal
Bernard et al.	2002	Drainage fluid	48 hours and day 7	Blood agar plates, aerobic and anaerobic	Qualitative	No	Unspecified	Unspecified
Degnim et al.	2013	Drainage fluid and drain tip	aerobic: 4 days anaerobic: 7 days	Blood agar plates aerobic and anaerobic, eosine methylene agar plates, colistin-nalidixic agar plates, thioglycolate broth	Quantitative	Unspecified	« At the one week visit, a 2 mL sample of drain fluid from the bulb was obtained aseptically" "Drains were removed in a sterile fashion after chlorhexidine preparation and sterile draping of the drain exit site. A 5 cm portion of the subcutaneous drain tubing was harvested, starting approximately 1–2 cm internal to the skin exit site"	Yes (chlorhexidine)
Girvent et al.	1994	Drain tip	Unspecified	Unspecified	Qualitative	Yes	Aseptic conditions	Unspecified
Gunterberg et al.	1996	Drain tip	120h	Aerobic and anaerobic blood agar plates	Quantitative	Yes	Aseptic conditions	Yes (ethanol)

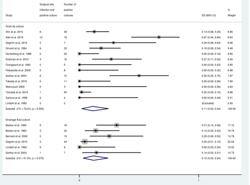
Authors	**Year**	**Type of sample**	**Incubation time**	**Culture medium**	**Analysis (qualitative or quantitative)**	**Transport medium (yes/no)**	**Sampling mode**	**Skin disinfection before drain removal**
Krishnan et al.	2012	Drain tip	Unspecified	Unspecified	Qualitative	Unspecified	Unspecified	Unspecified
Lindahl J.	1993	Drainage fluid and drain tip	Unspecified (méthode standard)	Unspecified (« standard methods »)	Qualitative	Yes	Unspecified	Yes (80% alcool)
Overgaard et al.	1993	Drain tip	48h	0.3% natrium-thiogluconate	Qualitative	Yes	" Under sterile conditions 2 cm from the end tip"	Yes
Petsatodis et al.	2009	Drain tip	48-72h	Unspecified	Qualitative	Unspecified	Aseptic conditions – "The drain tip was cut of approximately 5–10 cm from its far end utilising single-use sterile scissors. »	Yes (povidone iodine)
Sankar et al.	2004	Drainage fluid and drain tip	96h	Aerobic and anaerobic blood agar plates McConkey agar plate	Quantitative	Yes	5 cm - aseptic conditions	Yes (povidone iodine)
Takada et al.	2015	Drain tip	Unspecified	Unspecified	Unspecified	Unspecified	2 cm - aseptic conditions	Yes (povidone iodine)
Weinrauch	2005	Drain tip	3 days	Blood agar plate	Qualitative	Unspecified	1 cm - aseptic conditions	Unspecified
Yamada et al.	2016	Drain tip	48h	Aerobic and anaerobic blood agar plates	Quantitative	Unspecified	1 cm – aseptic conditions	Yes (povidone iodine)
Zamora et al.	1999	Drain tip	48h	Thioglycolate medium	Qualitative	Unspecified	1 cm – aseptic conditions	Unspecified

Table III. Quality of the included studies- A score of 1 is attributed if the answer is yes

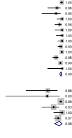
Study	Year	Representativeness of the exposed cohort	Selection of the non-exposed cohort	Ascertainement of Exposure(result of the culture)	Demonstration that outcome was not present at start	Comparability : confounders adjusted for in the analysis : -age/sex (/1) - additional factors (/1)	Assessement of outcome	Follow up enough for outcomes to occur	Adequacy of follow up	Total Score (/9)
Ahn	2015	1	1	1	1	0	1	1	0	6
Aski	2015	1	1	1	0	0	0	1	0	4
Becker	1990	1	1	1	0	0	1	0	0	4
Becker	1985	1	1	1	0	0	1	0	0	4
Bernard	2002	1	1	1	0	0	0	1	0	4
Degnim	2013	1	1	1	0	0	1	1	1	6
Girvent	1994	1	1	1	0	0	1	0	0	4
Gunterberg	1996	1	1	1	0	0	1	1	0	5
Krishnan	2014	1	1	1	0	0	0	0	0	3
Lindahl	1993	1	1	1	0	0	0	1	1	5
Overgaard	1993	1	1	1	0	0	1	0	1	5
Petsatodis	2009	1	1	1	1	0	1	1	1	7
Sankar	2004	1	1	1	0	0	1	0	1	5
Takada	2015	1	1	1	0	0	0	1	1	5
Weinrauch	2005	1	1	1	0	0	0	1	1	5
Yamada	2016	1	1	1	0	0	1	0	1	5
Zamora	1999	1	1	1	0	0	1	0	0	4


Records identified through database search after removing duplicates (n = 190)
Additional records identified through other sources (n = 6)
Records screened (n = 190)
Publications not relevant based on title or abstract (n =168)
Full-text article not found (n = 3)
Full-text articles assessed for eligibility (n = 19)
Full-text articles excluded (n = 8)
Non-systematic culture (n=3)
Number of infections with positive culture not clearly specified (n = 4)
Not relevant (n=1)
Articles identified to be included in the meta-analysis (n =11)
Studies included in meta-analysis (n =17)

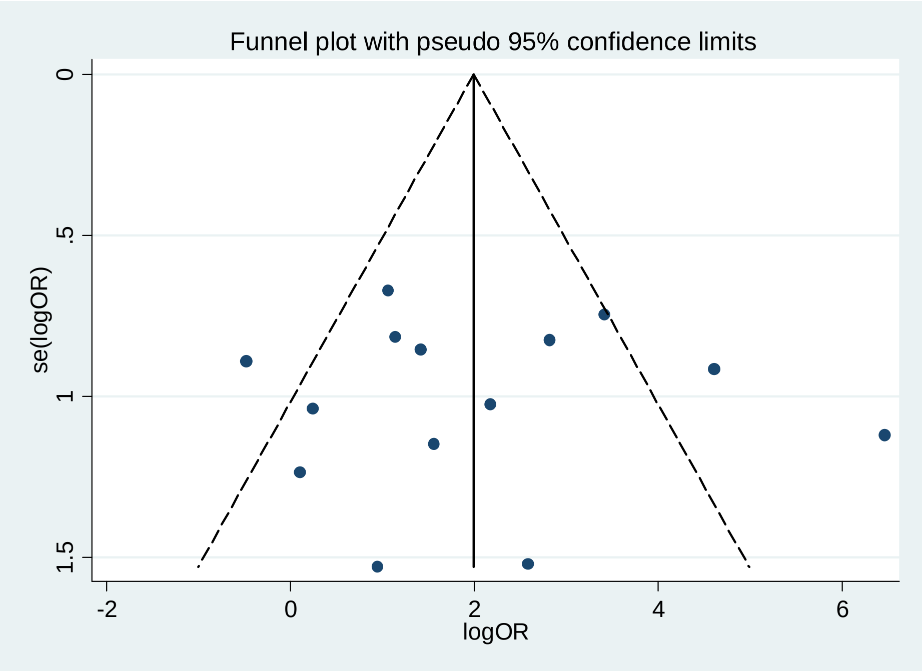

Study
Surgical site infections
Total number of patients
ES (95% CI)
% Weight
Drain tip culture
Ahn et al. 2015 10 133 0.08 (0.04, 0.13) 7.24
Aski et al. 2015 13 338 0.04 (0.02, 0.06) 8.39
Degnim et al. 2013 5 76 0.07 (0.03, 0.14) 6.19
Girvent et al. 1994 8 72 0.11 (0.06, 0.20) 6.08
Gunterberg et al. 1996 0 105 0.00 (0.00, 0.04) 6.83
Krishnan et al. 2012 7 156 0.04 (0.02, 0.09) 7.49
Lindahl et al. 1993 0 60 0.00 (0.00, 0.06) 5.68
Overgaard et al. 1993 0 81 0.00 (0.00, 0.05) 6.32
Petsatodis et al. 2009 0 110 0.00 (0.00, 0.03) 6.91
Sarkar et al. 2004 8 214 0.04 (0.02, 0.07) 7.92
Takada et al. 2015 4 1380 0.00 (0.00, 0.01) 9.11
Weinrauch 2005 20 393 0.05 (0.03, 0.08) 8.52
Yamada et al. 2016 18 1240 0.01 (0.01, 0.02) 9.08
Zamora et al. 1999 0 32 0.00 (0.00, 0.11) 4.25
Subtotal (I^2 = 87.4%, p = 0.000) 0.02 (0.01, 0.04) 100.00
Drainage fluid culture
Becker et al. 1990 8 41 0.20 (0.10, 0.34) 13.84
Becker et al. 1985 4 30 0.13 (0.05, 0.30) 12.24
Bernard et al. 2002 12 843 0.01 (0.01, 0.02) 21.13
Degnim et al. 2013 6 100 0.06 (0.03, 0.12) 17.59
Lindahl et al. 1993 0 60 0.00 (0.00, 0.06) 15.62
Sarkar et al. 2004 8 214 0.04 (0.02, 0.07) 19.57
Subtotal (I^2 = 85.4%, p = 0.000) 0.05 (0.01, 0.10) 100.00
0
.34



Study
Surgical site infection and positive culture
Number of positive cultures
ES (95% CI)
% Weight
Drain tip culture
Ahn et al. 2015 6 48 0.13 (0.06, 0.25) 9.85
Aski et al. 2015 12 18 0.67 (0.44, 0.84) 8.63
Degnim at al. 2013 2 7 0.29 (0.08, 0.64) 6.66
Girvent et al. 1994 6 33 0.18 (0.09, 0.34) 9.48
Gunterberg et al. 1996 0 20 0.00 (0.00, 0.16) 8.80
Krishnan et al. 2012 4 15 0.27 (0.11, 0.52) 8.30
Overgaard et al. 1993 0 5 0.00 (0.00, 0.43) 5.85
Petsatodis et al. 2009 0 8 0.00 (0.00, 0.32) 6.98
Sankar et al. 2004 6 12 0.50 (0.25, 0.75) 7.87
Takada et al. 2015 0 11 0.00 (0.00, 0.26) 7.69
Weinrauch 2005 0 3 0.00 (0.00, 0.56) 4.63
Yamada et al. 2016 1 55 0.02 (0.00, 0.10) 9.96
Zamora et al. 1999 0 4 0.00 (0.00, 0.49) 5.31
Lindahl et al. 1993 0 0 (Excluded) 0.00
Subtotal (I^2 = 79.2%, p = 0.000) 0.11 (0.02, 0.24) 100.00
Drainage fluid culture
Becker et al. 1990 5 16 0.31 (0.14, 0.56) 17.15
Becker et al. 1985 3 22 0.14 (0.05, 0.33) 19.79
Bernard et al. 2002 3 12 0.25 (0.09, 0.53) 14.78
Degnim et al. 2013 2 44 0.05 (0.01, 0.15) 25.03
Lindahl et al. 1993 0 9 0.00 (0.00, 0.30) 12.53
Sankar et al. 2004 1 7 0.14 (0.03, 0.51) 10.72
Subtotal (I^2 = 51.0%, p = 0.070) 0.12 (0.03, 0.24) 100.00
0
1



Study	Negative culture and no surgical site infection	Negative culture	ES (95% CI)	% Weight
Drain tip culture				
Ahn et al. 2015	81	85	0.95 (0.89, 0.98)	6.21
Aski et al. 2015	319	320	1.00 (0.98, 1.00)	9.37
Degnim et al. 2013	66	69	0.96 (0.88, 0.99)	5.61
Girvent et al. 1994	37	39	0.95 (0.83, 0.99)	4.04
Gunterberg et al. 1996	85	85	1.00 (0.96, 1.00)	6.21
Krishnan et al. 2012	138	141	0.98 (0.94, 0.99)	7.59
Lindahl et al. 1993	60	60	1.00 (0.94, 1.00)	5.22
Overgaard et al. 1993	76	76	1.00 (0.95, 1.00)	5.89
Petsatodis et al. 2009	102	102	1.00 (0.96, 1.00)	6.72
Sankar et al. 2004	200	202	0.99 (0.96, 1.00)	8.46
Takada et al. 2015	1365	1369	1.00 (0.99, 1.00)	10.92
Weinrauch 2005	370	390	0.95 (0.92, 0.97)	9.69
Yamada et al. 2016	1168	1185	0.99 (0.98, 0.99)	10.84
Zamora et al. 1999	28	28	1.00 (0.88, 1.00)	3.23
Subtotal (I^2 = 77.6%, p = 0.000)			0.99 (0.98, 1.00)	100.00
Drainage fluid culture				
Becker et al. 1990	22	25	0.88 (0.70, 0.96)	11.30
Becker et al. 1985	7	8	0.88 (0.53, 0.98)	5.15
Bernard et al. 2002	822	831	0.99 (0.98, 0.99)	26.83
Degnim et al. 2013	52	56	0.93 (0.83, 0.97)	16.81
Lindahl et al. 1993	51	51	1.00 (0.93, 1.00)	16.18
Sankar et al. 2004	200	207	0.97 (0.93, 0.98)	23.73
Subtotal (I^2 = 74.6%, p = 0.001)			0.98 (0.94, 1.00)	100.00


Funnel plot with pseudo 95% confidence limits
se(logOR)
0
.5
1
1.5
-2
0
2
4
6
logOR