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Review

Are systematic drain tip or drainage fluid cultures predictive of surgical site infections?

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SUMMARY

Systematic cultures of drain tips or drainage fluids for the early detection of surgical site infections (SSIs) are controversial. To examine the association between the results of systematic drain tip or drainage fluid cultures and the occurrence of SSIs in clean or clean-contaminated surgery. Searches were performed in the PubMed, and Cat.inist databases for observational studies published before 31st March 2017. Studies reporting results of drain tip or drainage fluid systematic cultures and SSIs after clean or clean-contaminated surgeries were included, and meta-analyses were performed. Seventeen studies, including 4390 patients for drain tip cultures and 1288 for drainage fluid cultures, were selected. The pooled negative predictive values were high (99%, 95% confidence interval (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. Systematic cultures of drain tips or drainage fluids appear not to be relevant, because their positive predictive values were low in the prediction of SSIs.

Introduction

Surgical site infections (SSIs) are still major surgical complications [1]. The contamination of the surgical site may occur during pre-operative, per-operative or postoperative periods.

Surgical drainage can be used to prevent haematoma formation, and thus SSIs, but can also be a risk factor for SSIs [2]. Indeed, many studies have found an association between the presence of surgical drainage and SSIs or between the drainage duration and the proportion of SSIs [2–4]. Systematic cultures of drain tips or drainage fluids are commonly used by surgical teams for the early detection of SSIs, 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].

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Meta-analyses were conducted of published comparative studies reporting on the association between results of systematic drain tip or drainage fluid cultures and the occurrence of SSIs 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].

PubMed and Cat.inist databases were searched for articles published before March 2017. First, three Medical Subject Headings (MeSH) descriptors (1. surgical wound infection; 2. drainage; 3. microbiological techniques) were identified and the MeSH terms that corresponded to the descriptors were linked by 'OR' and each descriptor was associated by 'AND' (Supplementary 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 SSIs were selected. Studies in which cultures were performed only in cases of suspicion of SSIs were excluded, as well as studies that only included contaminated or dirty/infected surgeries.

Five authors of studies that were potentially eligible for inclusion in the meta-analysis were also contacted 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.

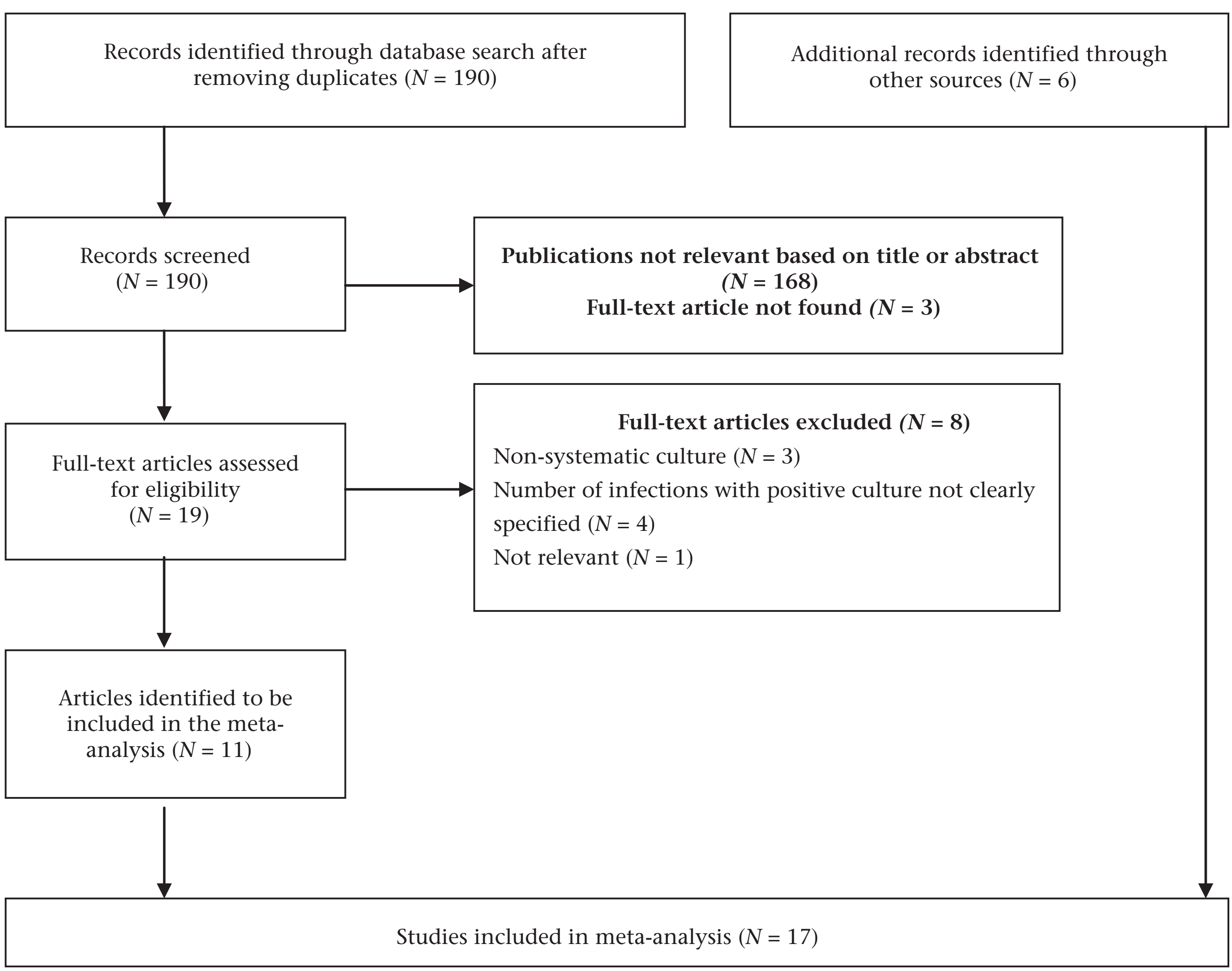

Figure 1. Flow chart for studies selection and inclusion.

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	Korea	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 h	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	4–19 days (mean = 7 days)	≤24 h	30 days	CDC criteria ('purulent drainage, positive aseptically collected culture from the wound, signs of inflammation with opening of incision and absence of a negative culture, or physician diagnosis of infection (which could include cellulitis)')	100
Girvent *et al.* [22]	1994	Spain	Prospective	Orthopaedic	Drain tip	Ablation if volume <20 mL/day (until 6 days)	Variable	Unspecified	'any clinical signs of infection of the wound (redness, swelling, increase in the local temperature and exudation)'	72
Gunterberg *et al.* [23]	1996	Sweden	Prospective	Orthopaedic	Drain tip	48 h	48 h	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 h	3 days	Unspecified	Unspecified	156
Lindahl J. [8]	1993	Finland	Prospective	Orthopaedic	Drainage fluid and drain tip	3 groups: 12, 24 and 48 h	None	1 month	Unspecified	60
Overgaard *et al.* [25]	1993	Denmark	Prospective	Orthopaedic	Drain tip	Ablation if volume <20 mL during 12 h mean = 1.8 days	During drainage	1 year	'purulent matter in the wound, or signs of infection including positive culture'	81

(*continued on next page*)

Table I (*continued*)

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
Petsatodis *et al.* [26]	2009	Greece	Prospective	Orthopaedic	Drain tip	48 h	48 h	2.8 years	Unspecified	110
Sankar *et al.* [27]	2004	India	Prospective	Orthopaedic	Drainage fluid and drain tip	Ablation if volume <100 ml/24 h (24–48 h)	16 h	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	12–72 h	48 h	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.	1380
Weinrauch [29]	2005	Australia	Retrospective	Orthopaedic	Drain tip	24 h	During drainage	8.9 months (3 months minimum)	Unspecified	393
Yamada *et al.* [7]	2016	Japan	Retrospective	Orthopaedic	Drain tip	48 h	48 h	3 years (0.5–5.5 years)	CDC criteria [36] – 'the presence of SSI was confirmed by reoperation or by histopathologic or radiologic investigation'	1240
Zamora *et al.* [30]	1999	Spain	Prospective	Orthopaedic	Drain tip	3 groups: 12, 24 and 48 h	2 days	Unspecified	'The evaluation of the healing of the wound was done taking into account the presence of purulent matter coming from the wound, as well as other signs of infection or a positive culture'	32

CDC, centers for disease control and prevention; SSI, surgical site infection.

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 h	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
Bernard *et al.*	2002	Drainage fluid	48 h 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	120 h	Aerobic and anaerobic blood agar plates	Quantitative	Yes	Aseptic conditions	Yes (ethanol)
Krishnan *et al.*	2012	Drain tip	Unspecified	Unspecified	Qualitative	Unspecified	Unspecified	Unspecified

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Table II (*continued*)

Authors	Year	Type of sample	Incubation time	Culture medium	Analysis (qualitative or quantitative)	Transport medium (yes/no)	Sampling mode	Skin disinfection before drain removal
Lindahl J.	1993	Drainage fluid and drain tip	Unspecified (standard method)	Unspecified ('standard methods')	Qualitative	Yes	Unspecified	Yes (80% alcool)
Overgaard *et al.*	1993	Drain tip	48 h	0.3% natrium-thiogluconate	Qualitative	Yes	'Under sterile conditions 2 cm from the end tip'	Yes
Petsatodis *et al.*	2009	Drain tip	48–72 h	Unspecified	Qualitative	Unspecified	Aseptic conditions – 'The drain tip was cut off 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	96 h	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	48 h	Aerobic and anaerobic blood agar plates	Quantitative	Unspecified	1 cm – aseptic conditions	Yes (povidone iodine)
Zamora *et al.*	1999	Drain tip	48 h	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

Meta-analyses

Data about SSIs 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 SSIs. 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 SSIs. Double arcsine transformations were used 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 χ^2 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. Two sensitivity analyses were performed. 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 14 studies focused on orthopaedic surgery. Drain tip cultures were analysed in 11 articles, drainage fluids were analysed in three articles, and both were analysed in three other articles.

A total of 4390 patients were included in drain tip culture studies and 1288 were included in drainage fluid culture studies.

The quality of the studies 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).

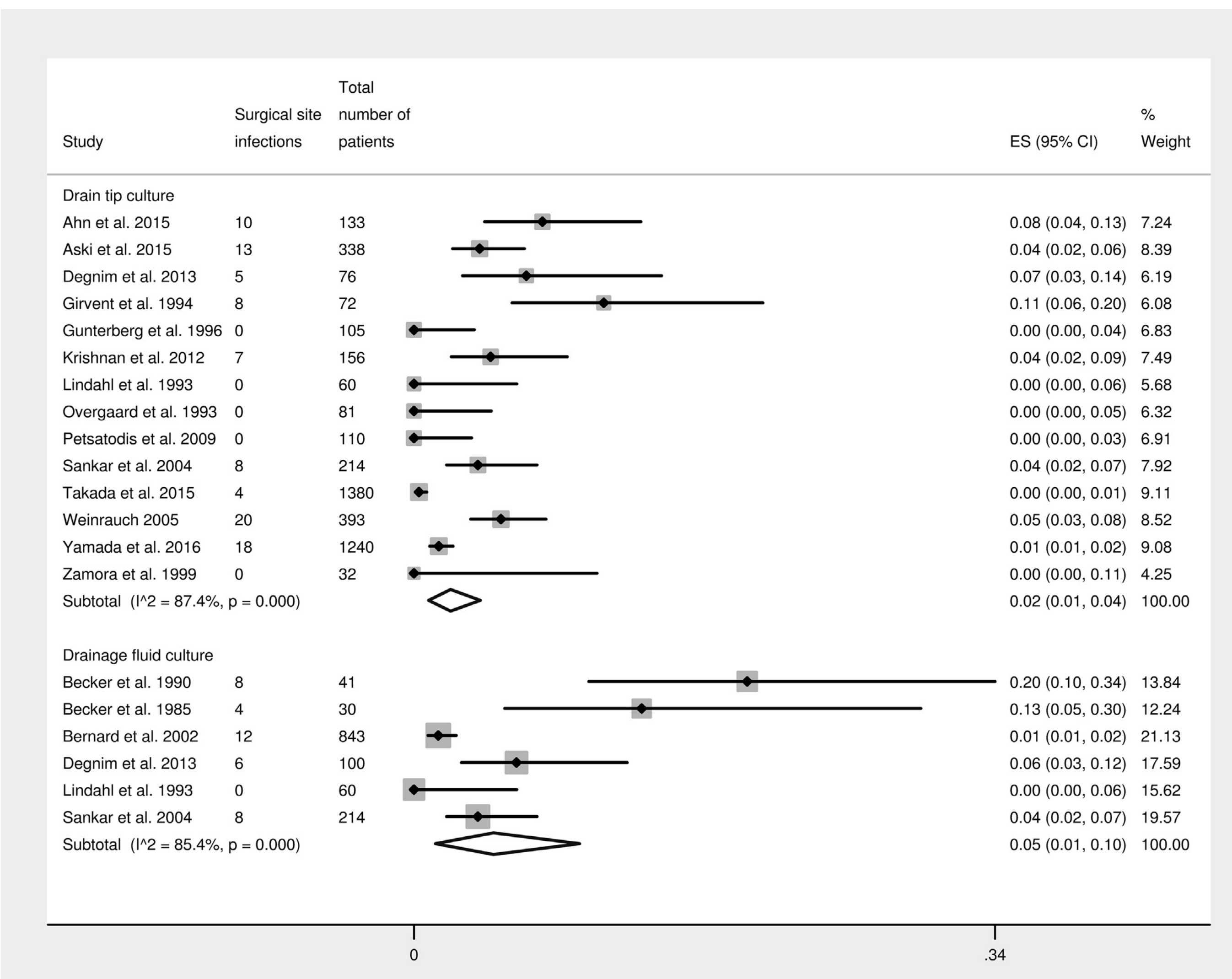

Figure 2. Meta-analysis of surgical site infections proportions in selected studies. CI, confidence interval; ES, effect size

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 SSIs, 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 orthopaedic surgery specialty saw more than two studies included. In the subgroup analysis including orthopaedic 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) (Supplementary Material 2).

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

Sensitivity analyses gave similar results (Supplementary Material 3).

Discussion

This study allowed us to determine the performances of systematic drain tip or drainage fluid cultures in the prediction of SSIs and in the prediction of the microorganisms involved in SSIs. Systematic drain tip or drainage fluid cultures seem to be of little value since the PPVs that represent the probability of SSIs 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

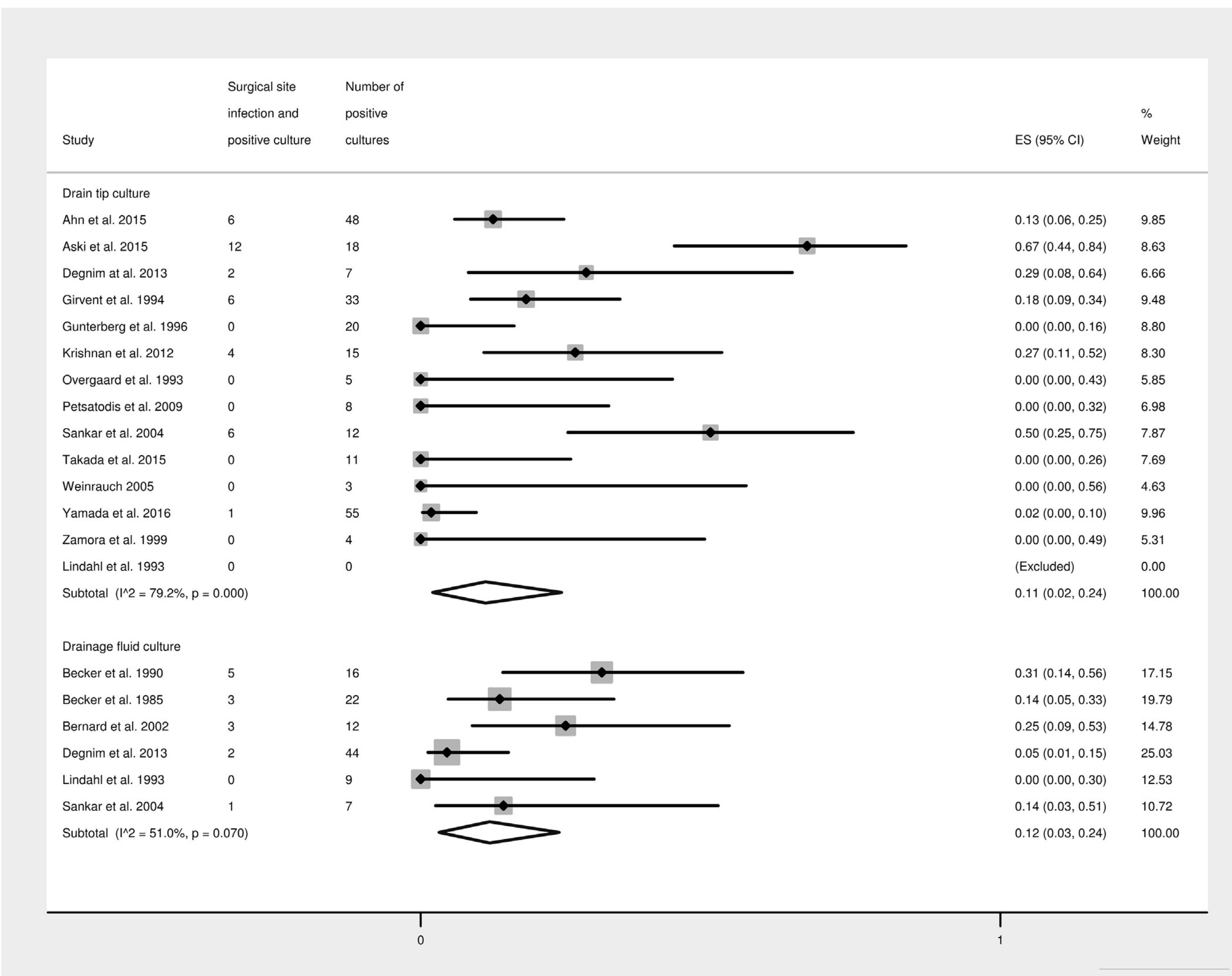

Figure 3. Meta-analysis of positive predictive positive value of drain tip or drainage fluid cultures in the prediction of surgical site infections in selected studies. CI, confidence interval; ES, effect size

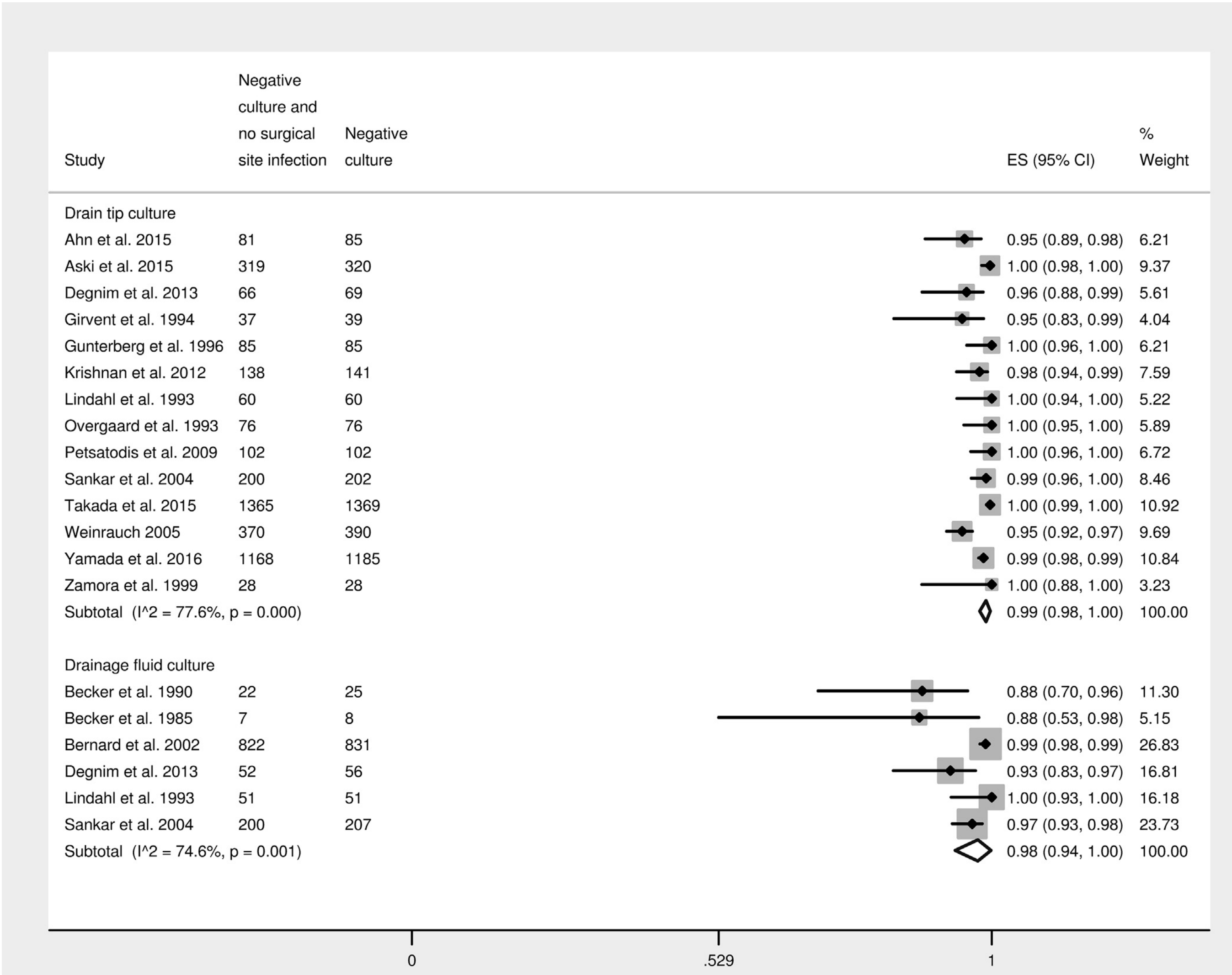

Figure 4. Meta-analysis of negative predictive value of drain tip or drainage fluid cultures in the prediction of surgical site infections in selected studies. CI, confidence interval; ES, effect size

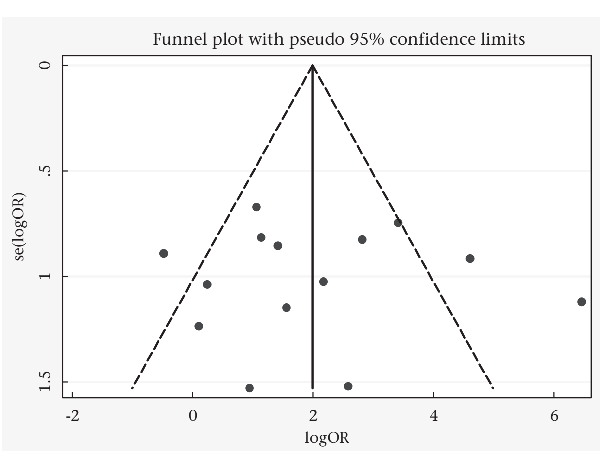

Figure 5. Funnel plot of selected studies. OR, odds ratio.

fluid cultures). Moreover, the micro-organisms identified in the cultures did not systematically correspond to the micro-organisms involved in SSIs (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 SSIs in the absence of clinical signs. Therefore, due to the lack of benefit, the associated costs (€24.30 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 orthopaedic 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 SSIs 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 SSIs. We included 17 studies involving 4390 patients for drain tip cultures and 1288 patients for drainage fluid cultures. Although an association between positive cultures and SSIs 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 SSIs 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 SSIs 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 SSIs, 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 PPVs were high, this might allow one to confirm SSIs or to adapt the antibiotic treatment. However, only early SSIs would be identified because 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 PPVs were low in the prediction of SSIs. 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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Conflict of interest statement
None to declare.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jhin.2018.11.013.

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