

REVIEW ARTICLE

Contamination level of transvaginal ultrasound probes in standard setting: A meta-analysis

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ABSTRACT

Gynecologist should be aware of cross infection using transvaginal ultrasonography. In fact, the contamination was usually being underestimated. Disinfection and probe cover in transvaginal ultrasound remained controversial. This study was planned with the objective to review the pooled proportion of contamination and types of microbes contaminated after the standard procedure at transvaginal probe and characterize the methods of disinfection and type of cover probe used in transvaginal ultrasound. Comprehensive literature search was done in Medline (1966-2015), SCOPUS (2004-2015), EMBASE, and Cochrane Central Register of Controlled Trials along with reference lists of electronically retrieved studies. We considered all published English language articles. The author used search strategy with words such as transvaginal, ultrasound, probe, contamination, and infect. Full-text journals are more preferred, but the abstract only journal is considered based on if the data are provided in the abstract. Data of study design, contamination rate, ultrasound disinfection technique, and probe cover were being reviewed. The pooled proportion of microbes contamination and difference of disinfection and probe cover were determined using Stata 12 and Review Manager 5.4. From 110 studies, 13 studies were potentially eligible for systematic review. Pooled proportion of total microbes contamination was 31% (95% CI: 1-56%, I²: 99.14%, P = 0.00). This rate was found 50% in bacteria contamination and only 4% in virus contamination. The most prevalence bacteria were coagulase-negative *Staphylococci*. A similar contamination rate was found either using condom or specific cover as probe cover (both 3%, risk difference -0.04). Interestingly, some studies showed advantage of using gloves as probe covers and automated disinfectant machine as disinfection methods. Contamination rate, especially bacteria contamination, is still high even after using the standard disinfection procedure. Further research is needed to find new disinfection procedures to reduce the contamination rate.


KEY WORDS: Contamination; Transvaginal; Probe

INTRODUCTION

Ultrasound is a high-frequency sound waves imaging of body organs. Not only safe and effective, ultrasound can be done in

bedside setting.^[1] Many improvisation of ultrasound had been made, especially ultrasound in obstetrics and gynecology, transabdominally and transvaginally. Although women may prefer transabdominal to transvaginal ultrasound, doing transvaginal scan can bring more accurate results.^[2]

Transvaginal ultrasound, nowadays, has become a common procedure in the gynecologic even obstetric field.^[3] Differs from transabdominal ultrasound, inserting probe into genitalia will allow very close view of the pelvic organs, uterus, cervix, endometrium, fallopian tubes, ovaries, bladder, and pelvic cavity.^[4] This procedure will allow probe to make contact

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with skin or mucous membranes. Bacterial contamination can adhere to the probe through blood or genital secretion which will be transmitted if the probe is being used in another patient. This can be aggravated if there were incidental perforation of probe cover which causes leakage of blood or mucous secretion.^[5]

Gynecologist should be aware of this cross infection.^[6] Many studies had reported various levels of vaginal ultrasound probes contamination by bacteria, viruses, and fungi.^[7] In fact, the rate of contamination usually being underestimated. Many centers did not aware of the risk and fail to carry out proper disinfection of the probes.^[8] However, until now, there is no standard guideline for probe disinfection.^[7] Almost all centers recommend to cover the probes. Methods of disinfection and cover remained controversial.^[9,10] This systematic review will review the risk of probe contamination after the standard procedure and review the methods of disinfection and type of cover probe that is being used in worldwide.

Objective

To review the pooled proportion of contamination and type of microbes contaminated after the standard procedure at transvaginal probe and characterize the methods of disinfection and type of cover probe used in transvaginal ultrasound.

MATERIALS AND METHODS

Study Design

This study provided systematic review that discusses contamination proportion of transvaginal ultrasound contamination. The study design followed the rules in the preferred reporting items for systematic reviews and meta-analyses guidelines.^[11,12] The steps of the systematic review followed guidelines for systematic reviews, the Cochrane Handbook for Systematic Reviews of Interventions.^[13]

Data Sources

Comprehensive literature search was done by the author on 10th November 2015. Relevant citations were obtained from Medline (1966-2015), SCOPUS (2004-2015), EMBASE, and Cochrane Central Register of Controlled Trials. The references of all retrieved study were reviewed to identify relevant additional studies. The search terms (available from the authors) were then applied (with small modifications) to all electronic databases. The author used search strategy with words (Transvaginal ultrasound [all fields] or transvaginal [all fields] and ultrasound [all fields], contamination [all fields] or infect [all fields] or transmission [all fields]; transvaginal probe [all fields] or transvaginal [all fields] and probe [all fields], contamination [all fields] or infect [all

fields] or transmission [all fields]; transvaginal transducer [all fields] or transvaginal [all fields] and transducer [all fields], contamination [all fields] or infect [all fields] or transmission [all fields]; vaginal ultrasound [all fields] or vaginal [all fields] and ultrasound [all fields], contamination [all fields] or infect [all fields] or transmission [all fields]).

Studies Assessment

The author assessed the methodological quality of all included studies using Jadad score (Table 1).

Data Selection

Duplicates of journals were managed using endnote software. A systematic review of these papers was performed after removal of repeated articles from the study searches. Titles and abstracts of the search results were reviewed. Full-text was analyzed in the case of doubtful eligibility.

We considered all published studies that assessed. All articles were assessed using inclusion and exclusion criteria that determined by the author. The articles were included if they contained original data from a cohort, clinical trial, case series, of patients for whom contamination of transvaginal ultrasound were reported. Only English language journal was included in this study. Full-text journals are more preferred, but the abstract only journal is considered based on if the data are provided in the abstract.

Data Extraction

Selected journals were evaluated for eligibility. Data were extracted from included studies using a data extraction form. The scope of the data collection is regarding the study design, contamination rate, ultrasound disinfection technique, and probe cover.

Parameters of Review

The primary parameter of this study is calculating the pooled proportion of contamination. The secondary parameters of this study are type of microbes contaminated after the standard procedure at transvaginal probe, methods of disinfection, and type of cover probe used in transvaginal ultrasound.

Statistical Analysis

This review will calculate the pooled proportion of microbes contamination in the transvaginal ultrasound. We used Metaprop in Stata 12/SE software (StataCorp LP, Texas) with 95% confidence interval (CI).^[13] This method incorporates, the Freeman-Tukey arcsine transformation to normalize the variances^[14] and pooling the estimated proportion using DerSimonian and Laird method under random effects model.^[15] Further systematic review was done in review

Table 1: Jadad score of included studies

| Jadad score | Buescher et al. (2015) | Ngu et al. (2015) | M'Zali et al. (2014) | Velvizhi et al. (2013) | Casalegno, et al. (2012) | Ma et al. (2012) | Kac et al. (2010) | Sykes et al. (2006) | Amis et al. (2000) | Storment et al. (1997) | Rooks et al. (1996) | Jimenez et al. (1993) | Milki AA. (1988) |
|--|------------------------|-------------------|----------------------|------------------------|--------------------------|------------------|-------------------|---------------------|--------------------|------------------------|---------------------|-----------------------|------------------|
| Was the study describe as random? | - | + | - | - | - | - | - | + | - | - | - | - | - |
| Was the randomization scheme describe and appropriate? | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Was the study describe as double-blind? | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Was the method of double binding appropriate? | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Was there a description of dropouts and withdrawals? | + | + | + | + | + | + | + | + | + | + | + | + | + |
| Overall Jadad score | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 |

manager 5.4 (The Nordic Cochrane Center, The Cochrane Collaboration, Copenhagen, Denmark) software.

RESULTS

The last electronic search was performed of MEDLINE on 10 November 2015. The literature search identified 110 potentially eligible studies (3 additional articles were added through the analysis of the found articles references). 27 duplicates articles were removed (Figure 1). After examined articles, on the basis of abstract and title, the articles were excluded because they did not meet eligibility criteria. In remaining 83 articles yielded, we excluded two nonEnglish-based articles, one systematic review, one letter to the editor, and four abstract only articles. Five abstract only articles were included because there was statistical data information provided in the abstract (Table 2).

Pooled Proportion of Microbes Contamination in Transvaginal Ultrasound after Standard Procedure

About 10 studies^[5-6,10,16-22] were analyzed to determine the pooled proportion of microbes contamination in transvaginal ultrasound after using both probe cover and disinfection procedure. Not all studies analyzed both bacteria and viruses contamination.^[6,10,16-19,21-22] There were only two studies which analyzed both microbes.^[5,20] In this study, the contamination will be analyzed regardless how many microbes that analyzed in each study. Separate analysis was performed.

There were several conditions that carried out. To determine the bacteria contamination, the author included both pathogenic and commensal bacteria, assumed that normal flora can also become pathogenic. In Buescher et al. (2015)^[16] and Ngu et al. (2015)^[17] studies, contamination rates were taken in the group that undergoing standard disinfection procedures.

The pooled proportion of bacterial and viral contaminations (Table 3) was 31% (95% CI: 1-56%, I²: 99.14%, $P = 0.00$, Figure 2a). Bacterial and virus contamination analysis performed on six^[10,16-18,21-22] and two studies,^[6,19] respectively, that specifically analyzed the bacteria or virus alone. The pooled proportion of bacterial contamination was 50% (95% CI: 14-86%, I²: 98.83%, $P = 0.00$, Figure 2b). The pooled proportion of virus contamination 4% (95% CI: 2-5%, I²: 0%, $P = 0.00$, Figure 2c).

Figure 2a Forest plot of the pooled proportion of microbes contamination in transvaginal ultrasound after standard disinfection procedure. The pooled proportion of bacterial and viral contaminations was 31% (95% CI: 1-56%, I²: 99.14%, $P = 0.00$); (b) forest plot of pooled proportion of bacterial contamination in transvaginal ultrasound after standard disinfection procedure. The pooled proportion of bacterial contamination was 50% (95% CI: 14-86%, I²: 98.83%, $P = 0.00$); (c) forest plot of pooled proportion of virus contamination in transvaginal ultrasound after standard disinfection procedure. The pooled proportion

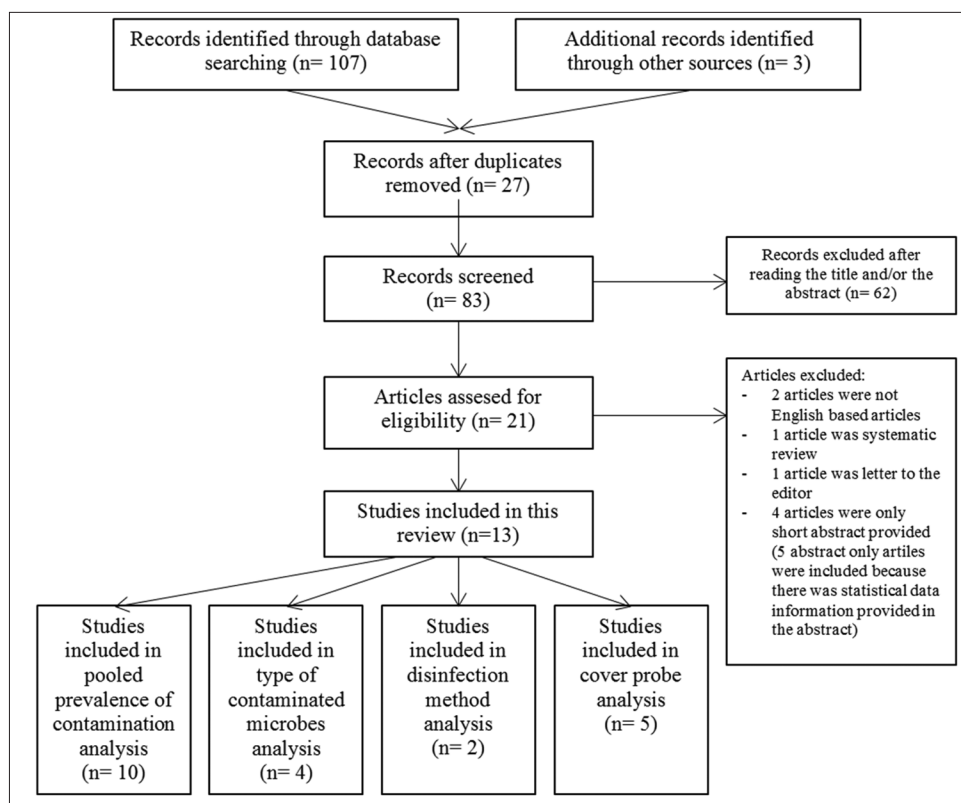


Figure 1: PRISMA flow chart showing trial selection methodology

Table 2: Studies included in this systematic review

| Author, year, country | Type of study | Samples | Type of infection studied | Study design | Results | Disinfection | Probe cover |
|--------------------------|--------------------|------------|---|--|--|--|--|
| Buescher et al. (2015) | Cohort prospective | 120 | Bacteria (culture) | Analyze difference of disinfection using manual (113 samples) and automated (116 samples) disinfection | 93 of 113 (78.8%) by manual disinfection and 106 of 116 (91.4%) by automated machine ($P=0.009$), mostly <i>S. aureus</i> , <i>Enterobacteriaceae</i> , <i>Pseudomonas</i> sp. | Manual disinfected (Mikrozid) on or automated method | Not clear (only mentioned standard procedures) |
| Ngu et al. (2015) | Cohort prospective | 152 | Bacteria (culture) | Analysis difference between 77 using glutaraldehyde disinfection and 72 using automated disinfection machine | Contamination: 62 of 75 (80.5%) by GDHH, mostly <i>Micrococcaceae</i> (2), <i>Acinetobacter</i> (1), <i>Bacillus</i> sp. (1); 4 of 77 (5.3%) by ADHH ($P<0.0001$), mostly <i>Staphylococci</i> coagulase negative (30), <i>S. aureus</i> (1), <i>Micrococcaceae</i> (6) | Probe disinfected by detergent and water then disinfected whether with paper towel+2.4% glutaraldehyde or 20 min automated disinfection system | Not mentioned |
| M'Zali et al. (2014) | Cohort prospective | 300 | HPV, C. trachomatis, mycoplasma (PCR), Bacteria (culture) | 100 samples for each HPV, C. Trachomatis/ Mycoplasma, and Bacteria | HPV in 13 of 100 (13%, 95% CI: 6-20%). <i>C. trachomatis</i> and <i>Mycoplasma</i> in 20 of 100 (20%, 95% CI: 3-13) Commensal bacterial flora in 86 of 100 (86%, 95% CI: 79-93) at 10-3000 CFU/probe); with the most common <i>Staphylococci</i> coagulase negative (73%), <i>Micrococcus</i> (20%), and <i>S. Aureus</i> (4%) | Low level disinfect with alcohol, quaternary ammonium, and chlorhexidine | Disposable probe cover (medical CE mark) |
| Velvizhi et al. (2013) | Cohort prospective | 50 samples | Bacteria (culture) | Analysis probes after disinfection without using probe cover | Bacteria contamination in 36 of 50 (72%), mostly Gram-negative Bacillie (<i>K. pneumonia</i>) (32), Gram-positive cocci (5) Risk is 6.71 for the probes cleaned by single paper wipe and 0.76 for the probes cleaned by double paper wipe ($P<0.001$) | Low level disinfection using single or double paper wipe | No cover |
| Casalegno, et al. (2012) | Cohort prospective | 414 | HPV (PCR) | 1 st : 198 swab taken after the probe was disinfected 2 nd : 216 swab taken before the next examination | 1 st : 7 of 198 (3.5%) were HPV positive, with 1 is low risk HPV and 7 are high risk HPV. 2 st (control): 6 of 216 (2.8%) were HPV positive, with 4 is low risk HPV and 2 are high risk HPV. No break of probe covers in all samples | Low level disinfection wipes (quaternary ammonium compounds (Sani-Cloth Active) performed by nurse | Disposable probe cover (93/42/EEC CE mark) |

(Contd...)

Table 2: Continued...

| Author, year, country | Type of study | Samples | Type of infection studied | Study design | Results | Disinfection | Probe cover |
|------------------------|--------------------|---------|--|---|---|--|--------------------------------------|
| Ma et al. (2012) | Cross sectional | 120 | HPV (PCR) | 1 st : HPV detection on probe used by surveillance samples 2 nd : HPV detection on probe used by patients with early pregnancy complications | Contamination of HPV in 9 of 120 (7.5%) | Low level disinfection (quaternary ammonia, T-spray) | Condom |
| Kac et al. (2010) | Cohort prospective | 440 | All microbes (Culture) Virus: EBV, HPV, CMV (PCR) | 440 samples for bacterial analysis, only 336 samples for viral analysis 267 samples using condoms and 173 using specific cover | Contamination: Bacterial flora in 301 of 440 (68.4%) with 1–1,000 CFU/plate; pathogenic flora in 15 of 440 (3.4%) with 3–1,000 CFU/plate, mostly <i>Enterobacter</i> (8), <i>Acinetobacter</i> (3), <i>Pseudomonas</i> (2). Virus in 5 of 56 (8.9%; 95% CI: 3.5-19.7%), the most common virus are HPV (3), EBV (2). After chemical and UVC disinfection, no microbial found. Probe covers: Bacterial and virus contamination 3 of 173 (1.7%) and 1 of 68 (1.5%) with specific probe; 12 of 267 (4.5%) and 4 of 268 (1.5%) with condom ($P=0.2$). | Low level disinfection (quaternary ammonium, alcohol (Aniospray) followed by High level disinfection (5-minute disinfection UVC chamber) | Condoms and specificcover (Microtec) |
| Sykes et al. (2006) | Cohort prospective | 62 | Bacteria (culture) | Analysis of transvaginal ultrasound probe | Bacterial contamination in 50 of 62 (83%) while 6.7% is potential pathogens | Low level disinfection (alcohol, chlorhexidine) | Not mentioned |
| Amis et al. (2000) | Cohort prospective | 217 | Herpes virus (culture) Bacteria (culture) | 46 samples for bacteria assessment, 26 samples for herpes virus assessment Condom defects were detected by adding hydrogen peroxide and filling 500 ml water | Contamination: Bacteria in 1 of 46 (2.2%), <i>Acinetobacter</i> spp.; No herpes virus contamination. Probe covers: 3 of 217 condoms broke, 2 of remaining 214 condoms perforate, none of remaining 212 condoms leaked | Low level disinfection with alcohol | Condom |
| Storment et al. (1997) | Cohort prospective | 173 | - | Condoms were filled with 10 ml of hydrogen peroxide, bubbling are considered positive | 8 of 173 (5%) had a positive H ₂ O ₂ test for contamination. In only 3 of 8 gross contamination was seen | Not mentioned | Condom |
| Rooks et al. (1996) | Cohort prospective | 180 | - | Remaining non perforated sheaths filled with water to determine potential contamination | Perforation in 15 of 180 (8.3%) by specific cover and 3 of 180 (1.7%) by condom ($P<0.05$) Contamination in 9 of 174 by specific cover and 1 of 178 by condom ($P<0.05$) | Not mentioned | Specific cover and condom |

(Contd...)

Table 2: Continued...

| Author, year, country | Type of study | Samples | Type of infection studied | Study design | Results | Disinfection | Probe cover |
|-----------------------|--------------------|---------|---------------------------|---|---|-----------------------------|-------------------------------------|
| Jimenez et al. (1993) | Cohort prospective | 230 | None | Comparing gloves (2.5 x 8.5 cm) and condoms (diameter 3.7, stretched to 5 cm stretched) | Gloves: contamination 1 of 128 (0.78%, 95% CI: 0.1-1.6%), perforation 4 of 128 (3.1%, 95% CI: 1.6-4.6%) Condoms: Contamination 8 of 102 (7.8%, 95% CI: 5.2-10.4%), perforation 7 of 102 (6.9%, 95% CI: 4.4-9.4%) | Not mentioned | Gloves (128 samples), condoms (102) |
| Milki AA. (1988) | Cohort prospective | 840 | - | Condoms were filled with water to determine leakage | 17 of 840 (2%) condom leaked, 65% of leaks were <=10 cm from the tip, that potential for contamination | Germicidal disposable cloth | Condom |

S. aureus: *Staphylococcus aureus*, *K. pneumonia*: *Klebsiella pneumonia*, *C. trachomatis*: *Chlamydia trachomatis*

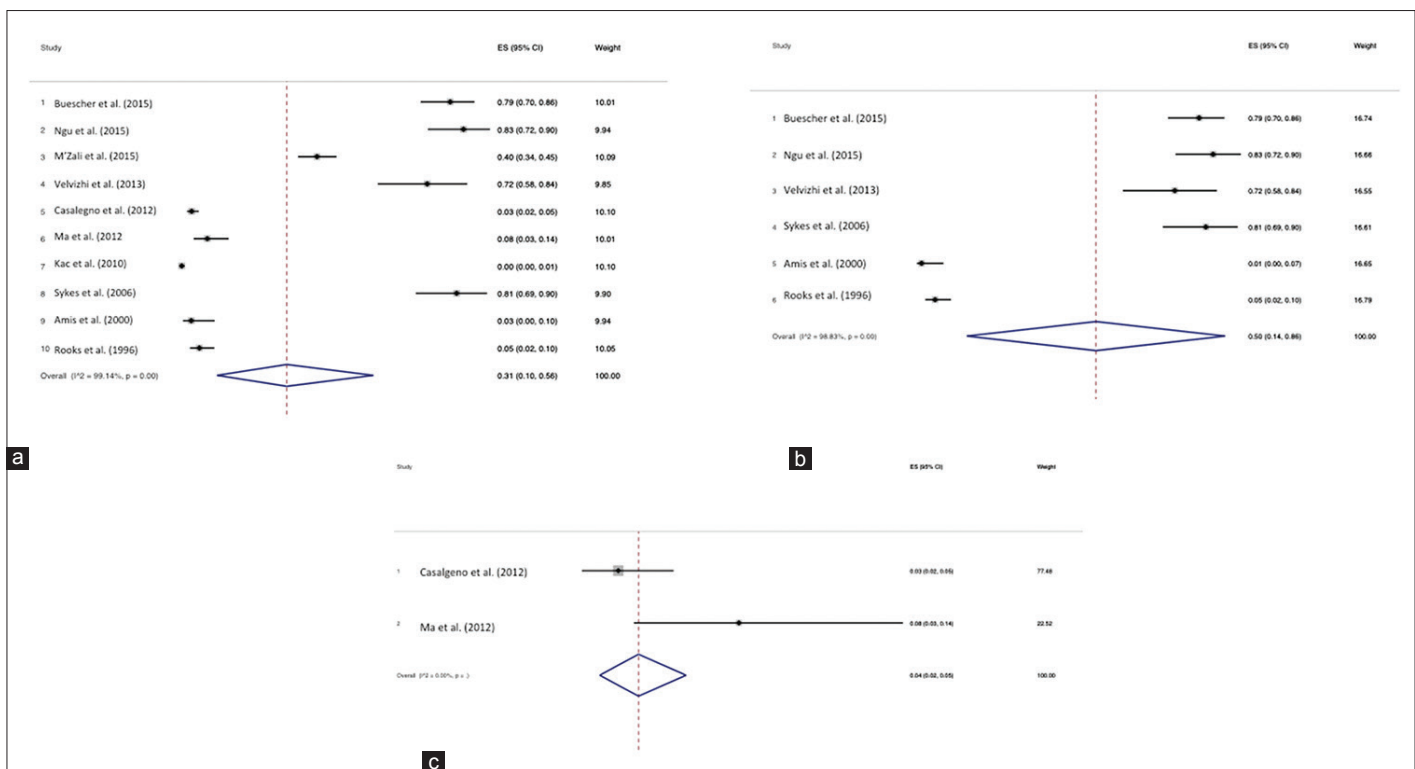


Figure 2: (a) Forest plot of pooled proportion of microbes contamination in transvaginal ultrasound after standard disinfection procedure. Pooled proportion of bacterial and viral contaminations was 31% (95% CI: 1-56%, I²: 99.14%, P=0.00), (b) Forest plot of pooled proportion of bacterial contamination in transvaginal ultrasound after standard disinfection procedure. Pooled proportion of bacterial contamination was 50% (95% CI: 14-86%, I²: 98.83%, P=0.00), (c) Forest plot of pooled proportion of virus contamination in transvaginal ultrasound after standard disinfection procedure. Pooled proportion of virus contamination 4% (95% CI: 2-5%, I²: 0%, P=0.00)

of virus contamination 4% (95% CI: 2-5%, I²: 0%, P = 0.00).

Type of Contaminated Bacteria and Virus

Five studies provided the data of bacteria types that contaminated on probes.^[5,10,17-18,20] The author took only three

most common infected bacteria from each study (Table 2). In cumulative data, it was shown eight most common bacteria that can contaminate the probe even after standard cleaning procedure (Figure 3).

Four studies identified type and number of virus contaminated (Table 4).^[5-6,10,16] Only one study identified

various viruses.^[20] No herpes virus^[10] and CMV^[20] contamination were identified in studies.

Transvaginal Ultrasound Probe Cover Analysis

There were different probe covers being used in various centers. Five studies were tabulated to assess the pooled risk proportion of contamination using either condoms or specific covers, while two studies were analyzed to assess the difference between using condoms and covers.^[20,22-25] Milki et al. (1988) showed 17 of 840 condoms were defective, but they mentioned only 65% were contaminated because only that 65% presented with leaking distance <10 cm to intravaginal.^[24] Contamination of bacteria and viruses in Kac et al. (2015) study were summed up.^[20]

The pooled contamination proportion using whether condoms or specific probe covers were almost the same, yielding 3%

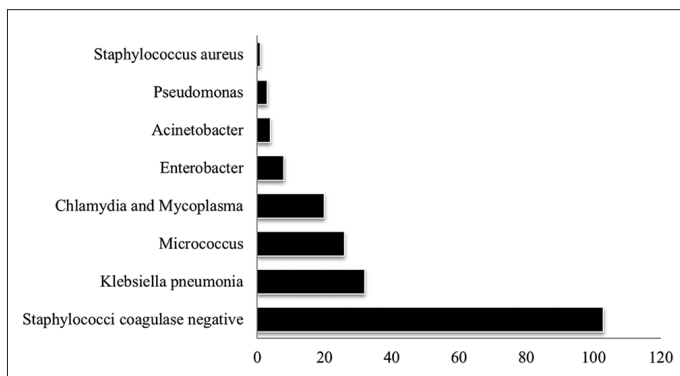


Figure 3: Types of contaminated bacteria in transvaginal ultrasound

(95% CI: 1-7%, I²: 85.83%, P = 0.00, Figure 4a) and 3% (95% CI: 1-4%, I²: 0%, P = 0.00, Figure 4b), respectively. The risk difference between both covers also showed slightly low contamination using probe cover (Risk difference -0.04, -0.02 -0.07- 95% CI, I²: 0%, P = 0.001, Figure 4c). Thus, it was shown that using both condom and probe cover had the same risk of contamination. On the other hand, Jimenez et al. (1998) showed that only one out of 128 samples using gloves were contamination.^[23]

Figure 4a Forest plot of pooled proportion of microbes contamination using condoms, (b) forest plot of pooled proportion of microbes contamination using specific probe covers, and (c) forest plot of risk contamination difference using condoms versus probe covers.

New Methods of Disinfection

In recent years, researchers have developed a new tool for disinfection called ADHH. Pooling the data from Buescher et al. (2015)^[16] and Ngu et al. (2015)^[17] studies, risk difference between both methods was -0.22 using ADHH (95% CI: -0.29-0.15, I²: 99%, P < 0,00,001, Figure 5). This result could not be taken because both studies showed quite different results.

DISCUSSION

Ultrasound probe is classified as the semicritical items that should be free from all microorganisms, while small numbers of bacterial spores are permissible.^[7] Mechanism of probe

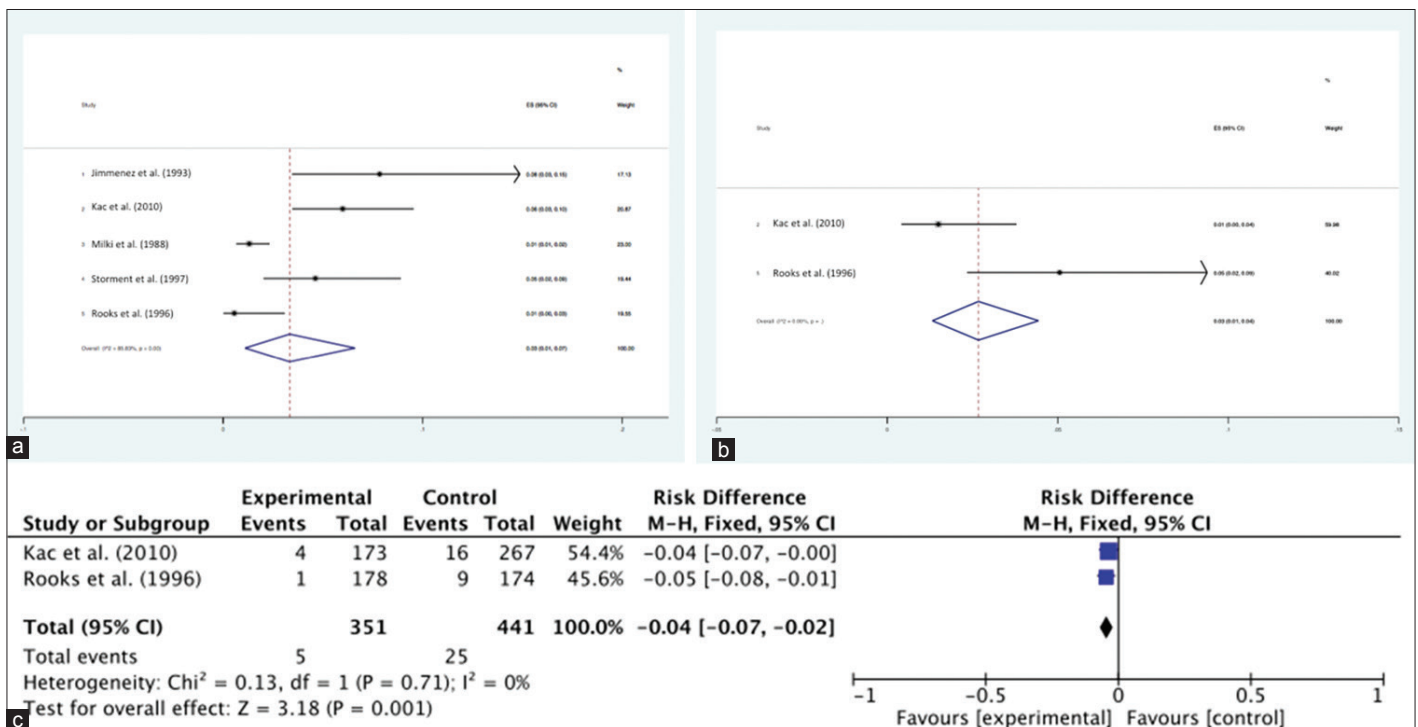


Figure 4: (a) Forest plot of pooled proportion of microbes contamination using condoms, (b) Forest plot of pooled proportion of microbes contamination using specific probe covers, (c) forest plot of risk contamination difference using condoms versus probe covers

contamination is still unclear. If there was macroscopic broke of probe cover, contamination can be understood logically.^[23] In fact, we should understand that there was possibility of microscopic damage of the covers, which brought the risk of contamination probes.^[5] Therefore, the examiner should carried out proper disinfection of the probes.^[8]

Until now, there transvaginal probe disinfections, either using low-level disinfection (quaternary ammonium compounds or phenolics or chlorhexidine) or high-level disinfection (immersion in glutaraldehyde, hydrogen peroxide or peracetic acid, and then rinsing and drying), were still controversial.^[26] The US preferred using high-level disinfection while some

countries, such as France, used low-level disinfection, as high-level disinfection can harm either the transducer and vaginal mucosa.^[9,27]

In this study, author showed 31% of pooled proportion of microbes contamination (95% CI: 1-56%, I²: 99.14%, P = 0.00). Differences in disinfection methods and probe covers used in each study might play an important role in this study bias. For cases of HIV infection, this would result in approximately 60 patients infected a year. Mathematical computer simulation by Leroy et al. (2014) showed that the probability of infection from a contaminated probe ranged from 1% to 6%.^[28]

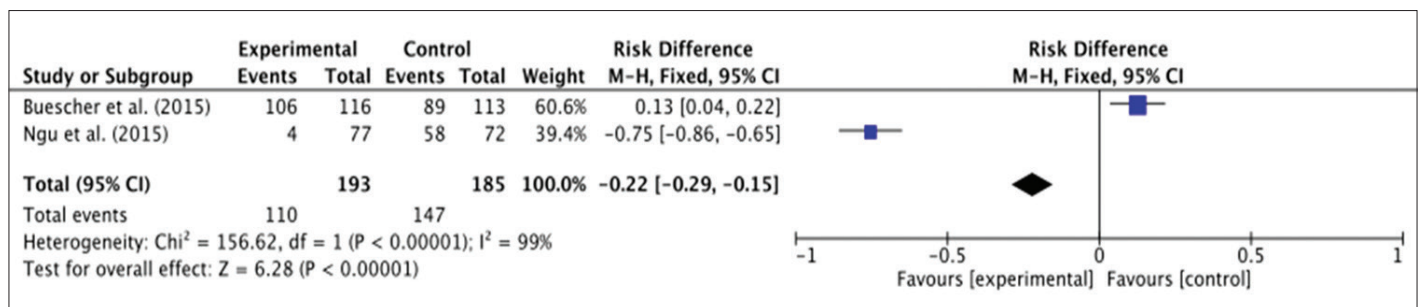


Figure 5: Forest plot of ADHH versus GDHO probe disinfection

Table 3: Manual and computerized calculated of pooled proportion of microbes contamination in transvaginal ultrasound after standard procedure

| Contamination | Number of studies analyzed | Number of cases | Total samples | Manual calculated proportion | Computerized metaprop calculated pooled proportion (%) |
|----------------|----------------------------|-----------------|---------------|------------------------------|--|
| Bacteria+virus | 10 | 388 | 1820 | 21 | 31 (95% CI:1-56) |
| Only bacteria | 6 | 248 | 546 | 45 | 50 (95% CI:14-86) |
| Only virus | 2 | 21 | 534 | 4 | 4 (95% CI:2-5) |

*This table showed number of studies analyzed to obtain the pooled proportion of microbes contamination, whether bacteria or virus or combined. Manual calculated proportion was also shown compared to pooled proportion that is calculated in STATA using metaprop

Table 4: Type and number of bacteria and viruses identified on transvaginal probes

| Study | Bacteria identified | Virus identified |
|----------------------------------|---|------------------|
| M'Zali et al. (2014), France | 73 <i>Staphylococci</i> coagulase negative 20 <i>Micrococcus</i> 20 <i>C. trachomatis</i> and <i>Mycoplasma</i> | 13 HPV |
| Ngu et al. (2015), UK | 30 <i>Staphylococci</i> coagulase negative 6 <i>Micrococcus</i> 1 <i>S. aureus</i> | |
| Velvizhi et al. (2013), India | 32 <i>K. pneumonia</i> 5 Gram-negative cocci | |
| Casalegno, et al. (2012), France | | 12 HPV |
| Ma et al. (2012), Hong Kong | | 9 HPV |
| Kac et al. (2010), France | 8 <i>Enterobacter</i> 3 <i>Acinetobacter</i> 2 <i>Pseudomonas</i> | 3 HPV 2 EBV |
| Amis et al. (2000), UK | 1 <i>Acinetobacter</i> | |

S. aureus: *Staphylococcus aureus*, *K. pneumonia*: *Klebsiella pneumonia*

The lowest contamination rates were found in M'Zali et al. (2014) and Amis et al. (2000) study (0.03% rates of contamination). In M'Zali et al.' study, flocked swabs were swabbed directly to universal transport medium that did not enable any contamination with another thing, while in Amis et al. (2000) study, low contamination rates might be due to the relatively small sample size ($n = 72$).^[5,10]

The highest contamination rates were found in Buesher et al. (2015) and Ngu et al. (2015) studies. Buesher et al. (2015) used alcohol swab as the method of disinfection. However, Velvizhi et al. (2015) that only use non-sterile disinfectant showed lower contamination levels (72%). Interestingly, Ngu et al. (2015) showed high rates of contamination even they used glutaraldehyde, a high-level disinfectant. Further research is needed to assess this.^[16,17]

None of the low-level disinfectant chemicals that were superior to others. Studies showed various results. Casalegno et al. (2012) and Ma et al. (2012), which both used quaternary ammonium compound, showed contamination levels of 79% and 3%.^[6,19] Only M'Zali et al. (2014), which used a combination of three chemicals, showed lower contamination rates.^[5] The used of high-level disinfectant as recommended the American Disinfection seemed promising.^[29] Kac et al. (2010) found contamination zero after low level followed by UV-B disinfection. However, the result could not be considered as a generalization.^[20]

The pooled proportion of bacterial contamination showed a fairly high rates as 50% (95% CI: 14-86%, I^2 : 98.83%, $P = 0.00$). The pooled proportion virus showed 4% (95% CI: 2-5%, I : 2.0%, $P = 0.00$), quite low because mostly study only examined HPV.^[20]

HPV is a physically stable and resistant viruses with long durability, which increase of its chance to be transmitted even after a long time interval of the probes using. A recent *in vitro* study demonstrated that it can survive on a wet surface for at least 7 days and carries an infection ratio of 30%.^[30] About 3% of HPV was high-risk types. Furthermore and apparently, the same HR-HPV on an endovaginal probe persisted even after three disinfection procedures.^[6] M'Zali et al. (2014) showed that 3/14 samples collected from HPV colonized patients were contaminated by HPV DNA that emphasized the importance of HPV transmission through transvaginal ultrasound.^[5]

A recent systematic review and meta-analysis estimated pooled prevalence of 12.9% (95% CI: 1.7-24.3%) for pathogenic bacteria remaining on the probe after cleaning and low level disinfection even when a disposable cover is used, and 1.0% (95% CI: 0-10%) for frequently occurring viruses (HPV, HSV, and CMV).^[7]

In formal settings, the probes were used by covering it with covers and chemical disinfection immediately after each

examination.^[8,9] Kac et al. (2010) showed advantage of using probe, which reduced contamination from 8.2% to 0.9% (Absolute risk reduction = 7.3%). Analysis of the ultrasound cover showed that HPV was detected in 28 samples and only 5 patients were infected.^[20]

Control Disease and Prevention^[31] and the American Institute of Ultrasound in Medicine⁹ recommend the use of condoms rather than specific cover probes because they are less prone to perforations (1-9% and up to 81% in one study). However, the protective efficacy of condoms in preventing contamination are still doubted.^[24] Even Storment et al. (1997) stated that the latex condom did not adequate to prevent contamination of the probe.^[25]

In this study, it was demonstrated that using both condoms and specific cover showed similar risks of contamination (pooled proportion of 3%, risk difference -0.04). On the other hand, Jimenez et al. (1998) recommended using gloves that only 1/128 samples were contaminated. Gloves were best suited to be probe cover because it was longer and bigger which can cover the entire probe. Velvizhi et al. (2013) also showed a signification reduction of contamination risk using double instead of single paper wipe ($P < 0.001$). However, author could not take a conclusion based on the single study.^[23]

In recent years, some researchers have developed a new disinfection tool.^[16] The idea of finding this machine based on the high contamination regardless of using chemical disinfectant and the risk of reducing the utility of the probe.^[10] However, the automated disinfection machine remains controversial because the studies showed various results.^[16,17]

It is our belief that both disinfection procedure and probe covers remain a matter of debate. The methodological heterogeneity of the included studies can subject to potential bias. Differences in examined population and hygiene practice can contribute to difference of the study results. The confounding factors, such as ultrasound gel, can also contribute to contamination.^[32] Abdullah (1998) found a 23.5% incidence of *Staphylococcus epidermidis* in the ultrasound gel.^[33] It cannot be forgotten that ultrasound equipment comes into direct contact with patients and practitioners during scanning procedures, enabling it to be a potential vehicle for the spread of nosocomial infections. This could be explained by the high copied of human DNA detected on transvaginal probe, 63/216 (29.2%) and 39/198 (19.7%) samples, before and after the probe use.^[6]

Strength of this study was that the author included all the studies associated with transvaginal probe contamination. This study also showed which type of bacteria dominated the contamination. Limitations of this study were some of the

studies analyzed only based on their abstracts. This study was also included only English language articles.

CONCLUSION

In conclusion, contamination rate, especially bacteria contamination, is still high even after using the standard disinfection procedure. However, definitive results are precluded because methodological heterogeneity of the included studies can subject to potential bias. Further research is needed to find new disinfection procedures to reduce the contamination morbidity rates.

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