Risk of Infection Associated with Transesophageal Echocardiography and Prevention Measures: Literature Review

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Abstract

Background: Transesophageal echocardiography is an exam widely used in clinical practice for investigation and diagnosis of cardiac and noncardiac diseases. Although safe, it is a semi-invasive and non-risk-free examination. Cases of infection associated with transesophageal echocardiography were described and, due to the potential risk of transmission of infection during its implementation, the objective of this work was to review literature data regarding the transmission of infection during the examination, as well as prevention methods. Methods: Review of literature on the subject between December 2017 and January 2018, through research in public domain scientific portals, in the different health science databases, including original articles, guidelines, simple and systematic reviews, case reports, published in periodicals indexed in the last 20 years. Results: Thirteen articles fulfilled the established criteria: a systematic review of transesophageal echocardiography-related complications, six articles describing transesophageal echocardiography-related bacterial outbreaks, the British guideline on cleaning and disinfection for transesophageal echocardiography probes, four articles on adverse reactions to orthophthaldehyde residues in transesophageal echocardiography probes and an article regarding the use of protective covers for the probes. Conclusion: The risk of infection associated with transesophageal echocardiography exists, although poorly described in the literature. It is recommended to establish specific protocols for disinfection of transesophageal echocardiography probes and routine inspection of probes. The strengthening of infection control teams is also essential for the detection and resolution of transesophageal echocardiography-related outbreaks.

Introduction

Transesophageal Echocardiography (TEE) is an ultrasound scan of the heart and large vessels via the esophagus. This requires intubation of the esophagus using a probe provided with a transducer at its tip.[1] This scan is widely used in clinical practice for the investigation of cardiac and non-cardiac diseases. Since its introduction in 1976, up to these days, the technique has been progressing, especially with the development of biplane and three-dimensional transducers, as well as improved quality and definition of images, which enabled more accurate diagnoses and made TEE a complementary option and, sometimes essential to Transthoracic Echocardiography (TTE).[2,3]

Although TEE is considered a safe diagnosis and monitoring tool, it is a non-risk-free test, as sedation is used to perform it, and the insertion and handling of the probe can cause oropharyngeal, esophageal and gastric trauma.[3-5] Studies show that the incidence of complications related to TEE ranges from 0.2 to 1.2% and mortality below 0.01%.[4] The main complications reported are related to the gastrointestinal, respiratory and cardiovascular systems, such as dysphagia, gastroesophageal perforation and bleeding, accidental intubation of the trachea, laryngospasm, bronchospasm, bronchoaspiration, cardiac arrhythmias (atrial fibrillation and ventricular tachycardia) and transient hypotension. Complications related to sedation, reaction to the anesthetic drug, meta-hemoglobinemia, ultrasound cavitation, lesions related to probe contamination and infection are also described.[2,4,6-8]

Although the cases of infection associated with TEE are rare, they have been described in the literature. Because it is a semi-invasive test, there is potential for transmission of pathogens among sequential patients, with implications for the protection of patients and the healthcare team.[9] The TEE probe, as it is semi-critical equipment, must undergo high-level disinfection procedures, following institutional protocols and the guidelines from the local health authority.[10]

Given the increasing number of TEE tests performed and the potential risk of infection during its execution, as well as the scarcity of specific disinfection guidelines for TEE probes in the national and international literature, the objective of this study is to review literature data concerning infection during the test, as well as methods of prevention, in particular the cleaning and disinfection of TEE probes.

Objective

To search the scientific literature and look for information on the transmission of infection related to transesophageal echocardiography, as well as to investigate prevention methods such as disinfection and protective covers for transesophageal echocardiography probes.

Methods

Search for manuscripts

The search in the literature was conducted between December 2017 and January 2018 on public domain portals, such as the Latin American and Caribbean Center for Health

Keywords

Transesophageal Echocardiography; Disinfection; Diagnosis.

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Sciences Information (BIREME), with searches on the databases Latin American and Caribbean Literature (LILACS), *Índice Bibliográfico Espanol en Ciencias de la Salud* (IBECS), MEDLINE® of the National Library of Medicine (NLM), Scientific Electronic Library Online (SciELO), The Cochrane Library, PubMed of the NLM and AskMEDLINE. Due to the scarcity of published manuscripts addressing this subject, the search included manuscripts published over the last 20 years.

The following descriptors were used with the help of Boolean connectors: "ecocardiografia transesofagiana" *AND* "complicação" *OR* "sonda" *OR* "desinfecção" *OR* "infecção". For the English-language searches, Medical Subject Heading (MeSH) terms were used: "*transesophageal echocardiogram*" *AND* "*probe*" *AND* "*disinfection*". At askMEDLINE, the following sentence was formulated: "contamination in transesophageal echocardiogram."

Criteria for inclusion of manuscripts

Original manuscripts, guidelines, simple or systematic literature reviews and case reports written in Portuguese, English and Spanish were included in the study and published in journals indexed in the databases searched on the topic proposed in the study. This included studies on the incidence of scan-related infections, technical standards with disinfection guidelines and methods of prevention of TEE-related infections, as well as manuscripts reporting complications secondary to the disinfection methods.

Results

The search identified 13 manuscripts that met the established criteria and were published between 2003 and 2016. Six manuscripts described bacterial outbreaks associated with TEE in 143 patients. Regarding the disinfection process of the TEE probe, in 2011, the British Society of Echocardiography (BSE) published a guideline on cleaning and disinfection for TEE probes. Also related to the disinfection process, four manuscripts described mouth, tongue, pharynx and esophagus injuries in five patients undergoing TEE due to orthophthaldehyde residues found in the probe, and one manuscript, published in 1993, was related to the use of TEE probe covers. We also found a systematic review published in 2008 that evaluated 207 manuscripts and covered 44,005 patients, on all complications associated with TEE, and described 35 complications related to the scan, including cases of infection.

Cleaning and disinfection of transesophageal echocardiography probes

The process of cleaning and disinfecting flexible endoscopes is well documented in the literature, but regarding the disinfection of TEE probes, there is only the BSE guideline, published in 2011. This document was used as a basis for the subsequent paragraphs.

According to Spaulding's criteria,[11] the TEE probe is considered a semicritical equipment since, during its use, there is contact with intact mucous membranes and potential contact with non-intact mucous membranes and must undergo high-level disinfection.[9,10] Although the TEE probe is similar to that of gastrointestinal endoscopy, has no internal channels, which reduces the risk of contamination and makes the cleaning process easier. On the other hand, the TEE probe cannot be completely immersed in any liquid for cleaning and disinfection, which makes it harder to disinfect the parts that cannot be immersed in the disinfectant solution.

The TEE test should be performed in a suitable area, preferably with two rooms, one for its execution and another separate room for the disinfection of the probe. The procedure room must feature an area for hand washing, waste disposal and safe storage of the probe. The disinfection room should have a sink for cleaning the probe, a hand-washing sink, a countertop and containers for disinfecting the probe. The workflow in this room should be clear, with distinction between dirty and clean areas. In health facilities where test and disinfection take place in the same room, areas pre-designated "dirty" (pre-disinfection) and "clean" (post-disinfection) should be in place to ensure that disinfected probes are not mixed up with probes not yet decontaminated. For storage of disinfected probes, there must be a clearly identified location in the "clean" area of the room. If the test and processing of the probes occur in two rooms, it is recommended to provide a rigid box to transport the probes.[9]

The process of cleaning and disinfecting the probes should be preceded by a pre-evaluation phase, which includes the adoption of precautionary measures for all patients and evaluation of patients with the greatest potential for transmission of infectious microorganisms, placing them at the end of the list of scans to reduce the risk of cross-contamination. The probe must be cleaned immediately after its removal from the patient, using wipes soaked in detergent solution. The non-immersible parts should also be preferably cleaned with proper cleaning wipes soaked in detergent solution.[9] After immediate cleaning, the probe should be immersed in detergent solution for a period of time recommended by the manufacturer in order to remove all organic matter which may inhibit the action of the disinfectant. Afterwards, the probe must be thoroughly rinsed with potable water to remove any residual detergent, as it is incompatible with the disinfectant.

The choice of the disinfectant should involve microbicidal range, safety and compatibility with the TEE probe. The most commonly used agents include aldehydes, hydrogen peroxide, peracetic acid, chlorine dioxide, superoxidized water and alcohols. It is not advisable to use alcohols and aldehydes as disinfectants because of their fixing properties, resulting in retention of proteins (including prion proteins) in the probe.[9]

Disinfection can be manual or automated. Some automated endoscope reprocessors allow immersion of the TEE probe and protect the non-immersible parts of the probe, which require manual disinfection.[9]

After the time of exposure to the disinfectant, the probe should be rinsed with sterile, filtered or high-quality drinking water.[11] This process is essential for the removal of potentially toxic waste from disinfectants.

The probe must be dried after rinsing in order to reduce the chance of recontamination by microorganisms, which

may be present in the water.[11] Ideally, the probes should be hung up in a locked cabinet. An alternative would be storing it on a rigid tray for 2 days at the most, since longer storage times may cause the probe axis to twist. Using tray liners and covers can be beneficial in the transport of the probes.[9]

National standards

In Brazil, there is no specific guideline on cleaning and disinfecting TEE probes. In addition to Resolution RE 2606, which provides for the reprocessing of health products, Brazil's Health Authority (ANVISA), in partnership with the Brazilian Society of Nursing in Gastrointestinal Endoscopy (SOBEEG), published the Guidebook on Cleaning and Disinfection of Endoscopes, both in 2006. Regarding the use of disinfectants, the main ones used for flexible endoscopes in Brazil are: 2% glutaraldehyde, peracetic acid, hydrogen peroxide, 0.55% orthophthalaldehyde and electrolytic acid water (it requires a device that performs the electrolysis of sodium chloride). Using these substances requires periodic training and personal protective equipment (gloves, apron, goggles and mask) preferably following institutional protocols. Besides that, the products should be used according to the probe manufacturer's guidelines and recommendations.[12-15]

Protective covers

Only one study on protective covers for TEE probes was found in this review. The manuscript was published in 1993 and analyzed a latex device. Despite few publications, this apparatus is commonly used in daily practice. These covers are characterized by physical barriers in addition to contamination and protection against damage, but using these covers does not rule out the need for disinfection, since it does not cover the entire probe and is prone to perforations, thereby causing cross contamination.[9-16]

Adverse effects of orthophthalaldehyde

Adverse effects of orthophthalaldehyde, a disinfectant widely used on flexible endoscopes and TEE probes, have been reported in the literature. A manuscript from 2003 reports the case of a man undergoing intraoperative TEE without a protective cover on the probe, which progressed with denaturation lesions on the tongue and lips. In the immediate postoperative period, the patient presented odynophagia with progressive worsening. The lesions became ulcerated and, after 3 days from the onset of symptoms, an Upper Gastrointestinal Endoscopy (UGIE) revealed ulceration near the upper esophageal sphincter and stomach. Despite the proposed therapy, the patient needed an enteral diet and hospital stay for 20 days, when he presented improvement of the symptoms and was discharged.[17]

Another article reports the case of a 5-year-old child, who underwent intraoperative TEE, without the use of a TEE probe cover. The child presented black lesions due to lip, tongue and esophagus denaturation. The child developed esophageal stenosis and underwent monthly esophageal dilatation procedures for more than one year after the injury.[18]

In 2011, a manuscript reported the case of two patients who underwent TEE and developed lesions due to lip, tongue and pharynx denaturation. In both cases, the probes were fitted with protective covers, which were not damaged. The patients evolved with intense pharynx pain, preventing the intake of liquids and foods orally, and intravenous nutritional therapy was required. Remission of symptoms occurred within one week and the patients were discharged without sequelae. Orthophthalaldehyde residues were evaluated by means of chromatography on the equipment used in the TEE and were found in all of the samples collected. From the location of the lesions, it was concluded that the contact of the mucosa with the proximal part of the probe/transducer contaminated with orthophthalaldehyde residues, which is not covered by the protective cover, was responsible for the lesions.[8]

In a report published in 2003, researchers from the Massachusetts General Hospital, Harvard Medical School, reported that after adopting orthophthalaldehyde for disinfecting the TEE probes, found dark spots in the oral cavities of patients undergoing the test, despite thoroughly rinsing the probes, especially in patients undergoing cardiac surgeries, in which the probe remains for long periods in the patient. According to the report, although the labial spots were difficult to remove, they disappeared in a few hours, without any apparent sequelae. The authors concluded that regardless of thorough rinsing with water, small orthophthalaldehyde residues remain in the probe. When these probes treated with orthophthalaldehyde are gently cleaned with 3% hydrogen peroxide solution, after disinfection, these residues are not found.[19]

A study evaluating orthophthalaldehyde rinsing concluded that the disinfectant adsorbs polymer materials from flexible endoscopes and other medical devices and cannot be thoroughly rinsed. Any material disinfected with orthophthalaldehyde can induce an allergic reaction or mucosal injury regardless of serial rinsing procedures, so the use of protective covers is recommended.[20]

Bacterial outbreaks involving transesophageal echocardiography

Even though bacterial outbreaks involving TEE are rare, they have been described in the literature. In a French manuscript published in 2003, a case-control study involving three cases of *Legionella pneumophila* was described, in which TEE was identified as a risk factor. The patients underwent TEE while in hospital and developed pneumonia after the procedure. After environmental, process and molecular biology analyses (pulsed field gel electrophoresis), it was found that the rinsing water used on the TEE probes was contaminated with *L. pneumophila*, which reinforces the importance of high-quality water to rinse the probes.[21]

In 2007, a case-control study involving 17 patients, conducted at a large Japanese university hospital, found, from routine supervision procedures, a significant increase in the incidence of Enterobacter cloacae, isolated from sputum and oropharyngeal cultures in the hospital's cardiovascular ward. An investigation measured exposure to intubation, history of stay at the Intensive Care Unit (ICU) and oral care among patients positive and negative for E. cloacae. The odds ratio suggested cross-contamination through the

TEE probe at the ICU prior to transfer to the cardiovascular ward and this information was corroborated by pulsed field gel electrophoresis and antibiogram patterns. An intervention was carried out, in which disinfection of the probes was standardized, using 0.55% orthophthalaldehyde as a disinfectant and protective cover on the probes in order to avoid recontamination. After the intervention, the incidence rate returned to previous levels.[22]

In a manuscript published in 2013, an outbreak of multiresistant *Pseudomonas aeruginosa* occurred between May and June 2004 at a university hospital in Osaka, Japan. Sputum and pharyngeal culture showed that eight ICU patients were infected with a strain of *P. aeruginosa*, one developing severe pneumonia and evolving to death, two with less severe pneumonia and five with no infection. All patients had been monitored with the same TEE probe during their cardiac surgeries and the probe in question was found to have a 5-mm diameter crack. Pulsed field gel electrophoresis showed that the strain isolated from the patients and the probe were genetically the same. There were no flaws in the probe disinfection process, but the use of protective cover for the probes was not standardized. Once the faulty probe was withdrawn from operation and the use of a protective cover during the test was adopted, no further test-related outbreaks were observed in the subsequent eight years.[23]

A *P. aeruginosa* outbreak was also been reported in an American article published in 2013, related to the contamination of an ultrasound transmission gel during a TEE scan. In December 2011, the infection control commission of a large tertiary hospital in Beaumont, Michigan, noticed an abnormal increase in patients with *P. aeruginosa*-positive respiratory tract cultures, all from the same ICU. All the patients concerned had undergone cardiac surgeries and all of the isolated patients had the same sensitivity profile. The cases were defined as patients undergoing cardiac surgery with respiratory tract cultures positive for *P. aeruginosa* with similar antibiotic susceptibility, after December 1, 2011. Epidemiological investigation found that the only common aspect of cardiovascular surgeries was the intraoperative use of TEE. All of the probes were inspected and the cultures were collected from the probes, from the environment and from the ultrasound transmission gel. From December 9, 2011 to January 20, 2010, 16 cases were found. Of these, two developed pneumonia, five developed tracheobronchitis and nine had colonization of the respiratory tract. There was a significant increase in hospital stay among the cases, compared to controls ($p<0.0001$). During the outbreak investigation, ultrasound transmission gel bottles used in the TEE were collected and cultured. Growth of *P. aeruginosa* was detected in one of them. Molecular typing evidenced more than 95% similarity between the *P. aeruginosa* of the ultrasound gel bottle, and ten very similar cases and strains between two cases and the gel bottle. To determine if the ultrasound gel was intrinsically contaminated or if there was contamination after opening, two closed and sealed bottles were cultured, and P. aeruginosa growth was found. With this result, the brand of the contaminated gel was recalled. The local and state health authorities, the Center for Disease Control and Prevention (CDC) and the Food and Drug Administration (FDA) were notified, which generated national safety alert by the FDA for the recall of contaminated lots. After the outbreak, sterile single-use ultrasound gel was used for TEE scans and no further outbreaks were reported.[24]

An *Escherichia coli* outbreak related to TEE was described in an American manuscript published in 2013. A community hospital reported to the Los Angeles health authority a group of patients with *E. coli* positive blood and sputum cultures 1 to 4 days after undergoing cardiac surgery. Extensive epidemiological investigation was carried out with revision of processes and procedures in the cardiovascular surgery room and TEE scans, as well as collection of environmental cultures (surgical room and ICU), staff, TEE probe and ultrasound gel. Eight patients had positive *E. coli* and TEE probe cultures. All other environmental cultures were negative. Molecular typing of five samples isolated from *E. coli* patients was performed. In three samples, the genetic profile was the same as that of the sample isolated in the TEE probe; in one sample, there was only one band of difference; and another one had more than seven bands of difference. There were flaws in the probe cleaning and disinfection process, such as no visual inspection prior to cleaning, the probe was washed very close to the waste basket and was stored in a container (a briefcase) on top of the refrigerator, where the temperature is generally high. On inspection, cracks were noticed in the probe. Once the probe was withdrawn from operation and the cleaning, disinfection and storage process was improved, there were no more cases of *E. coli* in sputum cultures of cardiac surgery patients.[25]

Finally, a Swiss manuscript reported an outbreak of *Serratia marcescens* in 2012 in an educational hospital. The outbreak lasted 12 months and involved 91 patients. The onset of the outbreak occurred with three patients with infection or colonization of *S. marcescens* in the respiratory tract, at the ICU of cardiac surgery. Epidemiological investigation and surveillance cultures for *S. marcescens* were started in cardiac surgery patients. Molecular typing showed two different groups of *S. marcescens* involved in the outbreak. The first group included 74 patients with different epidemiological profiles and the second one included 17 patients with respiratory tract cultures positive for *S. marcescens* after intraoperative TEE, presenting the same molecular profile as the one isolated in the TEE probe. Analysis of the probe revealed a crack, so the probe was withdrawn from operation. During the investigation period, it was also found that the disinfectant solution was contaminated. After revising the whole process of diluting and storing the disinfectant solution at the hospital, it was chosen to purchase diluted solution and store it in disposable containers. With the implementation of corrective measures, such as improvement of disinfection procedures and preparation of TEE probes and taking samples from the probe as a routine conducted by the infection control team, no similar outbreak was found in the institution until the manuscript was published in 2016.[26]

Regarding the transmission of Hepatitis B (HBV) and C (HCV) virus, although there are cases described during gastrointestinal endoscopy, there are no literature reports of

transmission during TEE scans. Regarding the HIV virus, it seems to be sensitive to the disinfection process, and no cases of transmission during endoscopic tests, such as TEE, have been found in the literature.[2,27]

Discussion

Although the TEE is widely used in clinical practice, with major importance in cardiac surgery, the literature review evidenced that the risk of infection associated with the test is mainly related to flaws in the cleaning and disinfection of the probes and equipment maintenance.

There is a lack of studies related to the risk of TEE infection, as well as in the disinfection of the probes, considering that only BSE has produced a specific guideline on the disinfection process of TEE probes, which is not observed in other countries, where gastrointestinal endoscope disinfection protocols are used as a reference, without considering the specificities of the TEE probe, such as not fully immersing it in disinfectant solutions.[9]

The studies showed that small flaws in the probe, such as cracks, may be responsible for biofilm formation, preventing penetration of the disinfectant and compromising the whole disinfection process, also causing outbreaks related to the scan. This reinforces the importance of periodic inspection of probes and withdrawal of damaged probes from operation. As the device is very expensive, many institutions do not replace probes with minor faults, which may expose patients to higher risk of infection.

Flaws in the disinfection process, such as improper disinfection areas, contaminated rinsing water, untrained personnel and improper storage, were also responsible for the outbreaks described, which reinforces the importance of paying close attention to this process, including institutional protocols specific to the TEE scan, as well as appropriate areas for the disinfection and storage of the probes. Echocardiography societies should develop specific protocols for cleaning and disinfecting the probes, as BSE did.

Regarding the use of probe covers during the TEE scans, although there is no recent study on the use of such covers, it was recommended by most authors as an additional measure of protection against infections, as well as protection against the potential adverse effects of orthophthalaldehyde residues adsorbed by the probes.

The work done by the infection control teams in the identification of outbreaks related to TEE scans is of paramount importance. In all published manuscripts, epidemiological investigation and the adoption of surveillance cultures as a routine for patients staying at critical units were key to the identification and resolution of the outbreaks. Unfortunately, it is known that most health institutions from developing countries, such as Brazil, do not have the necessary structure to carry out surveillance cultures and molecular typing, which greatly limits the identification and resolution of the outbreaks, which possibly means that the number of unidentified TEE outbreaks is exponentially higher. Raising the awareness of echocardiographic teams on the subject and empowering the infection control teams, as well as the means for the investigation and detection of outbreaks, are indispensable for the improvement of the care provided to patients undergoing TEE scans.

Conclusion

The risk of infection related to transesophageal echocardiography exists, although there are few cases described in the literature. The establishment of specific protocols for disinfection and storage of the probes is recommended for the improvement of the procedure and reduction of the risk of infection related to the scan, as well as routine and careful inspection of the probes. Raising the awareness of echocardiographic teams and empowering the infection control teams are also essential for the detection and resolution of transesophageal echocardiographic outbreaks.

Authors' contributions

Research creation and design: Becker JB; Data acquisition: Becker JB; Data analysis and interpretation: Becker JB, Moisés VA; Manuscript writing: Becker JB; Critical revision of the manuscript for important intellectual content: Parreira FP, Fischer CH, Moisés VA.

Potential conflict of interest

The authors declare that there is no relevant conflict of interest.

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