

# Bacterial contamination and cleanliness of emergency department ultrasound probes

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## ABSTRACT

**Objectives:** As ultrasonography is increasingly used in the emergency department (ED), ultrasound equipment has become a potential threat to infection control. Improperly cleaned ultrasound probes may serve as a vector for pathogens such as methicillin-resistant *Staphylococcus aureus* (MRSA). The primary objective of this study was to determine the prevalence of MRSA colonization on ultrasound probes used in a busy, urban ED. It was hypothesized that cultures of our ED ultrasound probes would yield a significant number of positive results for MRSA.

**Methods:** In this observational study, 11 ED ultrasound probes were randomly sampled on 10 different occasions. Samples were taken using a RODAC plate method and were cultured for MRSA and methicillin-sensitive *Staphylococcus aureus* (MSSA). On half of the randomly assigned sampling occasions, a visual inspection of each ultrasound probe for general cleanliness was conducted and recorded. Data were stratified by ultrasound location in the ED and analyzed using the Fisher exact test, with  $p < 0.05$  deemed to be statistically significant.

**Results:** Of 110 samples, no isolates of MRSA were cultured. One probe yielded a positive culture for MSSA. Probes in the medicine, trauma, and pediatrics areas were found to be clean 65%, 33%, and 70% of the time, respectively. This variability in probe cleanliness by ED location was found to be statistically significant ( $p < 0.01$ ).

**Conclusions:** Contrary to our hypothesis, MRSA contamination of ultrasound probes was not found. This finding suggests that the spread of MRSA by ED ultrasound machines in a high-volume urban ED is unlikely. Further research at different centres with larger sample sizes is required before these results can be generalized.

## RÉSUMÉ

**Objectifs :** Les services des urgences (SU) utilisent de plus en plus l'échographie; or, ces appareils sont devenus des menaces potentielles dans la lutte contre l'infection. Des sondes échographiques mal nettoyées peuvent en effet servir de vecteurs aux pathogènes comme le *Staphylococcus aureus* résistant à la méthicilline (SARM). Cette étude avait donc comme principal objectif de déterminer la prévalence de colonisation par le SARM des sondes échographiques utilisées dans un SU en milieu urbain à grande affluence. On a émis l'hypothèse que des cultures des sondes échographiques du SU donneraient un nombre important de résultats positifs quant au SARM.

**Méthodes :** Dans cette étude par observation, onze sondes échographiques ont été échantillonnées au hasard en dix occasions différentes. Les échantillons ont été prélevés au moyen de la méthode en boîte Rodac et cultivés afin d'y détecter la présence de SARM et de SASM (*Staphylococcus aureus* sensibles à la méthicilline). Lors de la moitié des échantillonnages au hasard, une inspection visuelle de la propreté globale de chaque sonde échographique a été menée et consignée. Les données ont été stratifiées par site d'échographie au SU et analysées au moyen de la méthode exacte de Fisher, où  $p < 0,05$  était considéré comme significatif sur le plan statistique.

**Résultats :** Aucun des 110 échantillons n'a produit d'isolats de SARM. La culture de SASM s'est avérée positive pour une sonde. Les sondes en médecine, traumatologie et pédiatrie se sont avérées propres dans une proportion de 65%, 33% et de 70% respectivement. La variabilité de la propreté des sondes par site au SU s'est avérée significative sur le plan statistique ( $p < 0,01$ ).

**Conclusions :** Contrairement à l'hypothèse émise, on n'a pas observé de contamination par le SARM. Ce résultat permet

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de présumer que la propagation du SARM par les appareils d'échographie d'un SU à grande affluence en milieu urbain est improbable. Il faudra toutefois d'autres recherches, menées dans différents centres et sur de plus vastes échantillons, pour généraliser ces résultats.

As the clinical role of sonography continues to grow, ultrasound equipment is increasingly found in emergency departments (EDs) worldwide, particularly those in North America. Like other noninvasive medical devices, such as electrocardiogram machines, portable x-ray equipment, and stethoscopes, proper cleaning techniques and protocols remain vaguely defined. To our knowledge, there are no widely applied, evidence-based cleaning protocols for ED ultrasound machines and probes. Rather, it is up to the users of such equipment, primarily physicians, to ensure that the machines are properly cleaned before and after each use. Undoubtedly, this situation results in variability in the technique and frequency of equipment cleaning, making ultrasound machines a possible vector for a range of pathogens, including methicillin-resistant *Staphylococcus aureus* (MRSA).

It is known that bacterial colonization of radiology suite ultrasound equipment can occur,<sup>1</sup> as can colonization of mobile non-ED ultrasound machines for bedside use.<sup>2,3</sup> A previous study evaluating MRSA colonization of inanimate objects in the ED failed to show the presence of this pathogen on two samples taken from ED ultrasound probes<sup>4</sup>; however, this study was limited by the small number of ED ultrasound machine probes sampled.

This study expands on prior research by focusing specifically on ED ultrasound probes. The primary objective was to identify the frequency of MRSA colonization of ultrasound probes used in a busy, urban ED. Given the absence of a formal ultrasound cleaning protocol at the study location, along with a high patient volume and frequent use of ED ultrasonography, we hypothesized that MRSA would be found in a significant number of cultures of our ED ultrasound probes.

## METHODS

### Study design

This was an observational study designed to evaluate the prevalence of bacterial contamination and cleanliness

**Keywords:** contamination, methicillin-resistant *Staphylococcus aureus*, MRSA, ultrasound, contamination

of ED ultrasound probes. The research protocol was approved by our institutional review board.

### Setting

The study took place at Denver Health, a level 1 trauma center with an annual ED census of approximately 75,000 patients (50,000 adult and 25,000 pediatric patients). Three ultrasound machines are used full time in the study ED: two GE LOGIQ e machines and one GE LOGIQ P6 machine (GE, Wauwatosa, WI). Although the machines are not always kept in one area of the ED, they do have assigned areas in which they are primarily used. The LOGIQ P6 is assigned to the medicine area and is equipped with four probes (phased, linear, curvilinear, and endocavitary). One LOGIQ e is assigned to the trauma area and is equipped with three probes (phased, linear, and curvilinear). The second LOGIQ e is assigned to the pediatrics area and is equipped with four probes (phased, linear, curvilinear, and endocavitary).

In our ED, the phased probe is typically used for focused assessment by sonography in trauma (FAST) and bedside echocardiography. The linear probe is typically used for ultrasound-guided vascular access, deep vein thrombosis studies, and soft tissue studies, including evaluation of potential abscesses. The curvilinear probe is typically used for studies of the right upper quadrant of the abdomen, FAST, kidneys, abdominal aorta, and early first-trimester pregnancy. The endocavitary probe is typically used for endovaginal studies in early first-trimester pregnancy.

The study centre has a significant rate of MRSA positivity among cultures collected in the ED. Of all 219 cultures from the ED that grew *Staphylococcus aureus*, 47% (103) were found to be MRSA in 2009. This rate is similar to that of the hospital as a whole, which was 45% (560 of 1,241) during the same year.

No formal cleaning protocol exists in the study ED ultrasound machines and probes. Machine and probe cleaning is carried out by the sonographers, primarily ED attending physicians, fellows, and residents, who clean this equipment between uses with Super Sani-Cloth (Professional Disposables International Inc.,

Orangeburg, NY) antimicrobial wipes. In addition to this, endocavitary probes are placed in Cidex (CIVCO Worldwide, Kalona, IA) solution for at least 10 minutes following each use. All ED attending physicians are credentialed to perform bedside ultrasonography. Attending physicians typically supervise ED bedside ultrasound studies performed by resident physicians. Appropriate methods for cleaning are discussed with the residents at the beginning of each academic year and during their second-year, 2-week ultrasound rotation.

### **Data collection and processing**

Ultrasound probes were sampled on 10 different occasions using a direct inoculation technique on RODAC plates (BD, Franklin Lakes, NJ). This medium is specifically designed for inanimate object sampling. Given that 11 transducers are in active use in our ED, 11 RODAC plates were used on each sampling occasion (one plate for each transducer sampled). A total of 110 samples were taken over the 8-week study period. Power calculations were not done owing to a paucity of previous studies on MRSA prevalence on ED ultrasound probes. Thus, sample size was the result of the maximum in-kind departmental funding available for culture media and microbiology laboratory technician costs.

Owing to the wide variability in probe cleanliness, all probes were wiped with Super Sani-Cloth antimicrobial wipes after sampling. This measure was taken to ensure a universally clean state of the probes before they were returned for clinical use.

The laboratory methodology after sampling was designed to isolate *Staphylococcus aureus*. If *S. aureus* was isolated, further plating to CHROMagar (BD, Franklin Lakes, NJ) was carried out to differentiate MRSA from methicillin-sensitive *Staphylococcus aureus* (MSSA). We did not attempt to differentiate community-acquired MRSA from hospital-acquired MRSA.

The microbiology laboratory was able to accept study samples only between midnight Sunday mornings and midnight Wednesday mornings. Thus, sampling times were randomized within this 72-hour period. A random whole number was generated between 1 and 72 to dictate the hour at which sampling would occur; zero corresponded to a study sampling time of midnight Sunday morning and 72 corresponded to midnight Wednesday morning. Sampling times were scheduled twice per week, and

it was established a priori that each sampling could not occur within 12 hours of a prior sample. This was done to ensure that the limited number of available RODAC plates were used in a manner that would accurately represent patterns of typical use. If randomized times were generated within the same 12-hour period within the week, the process was repeated until sampling times greater than 12 hours apart were established. Samples were obtained strictly within the hour dictated by randomization, unless the primary investigator was working clinically in the ED. When this happened, the sampling was conducted either during the hour before or after the primary investigator's shift, whichever was closer to the assigned randomized time. If a sampling time could not be adhered to owing to machine maintenance, the sampling time was deferred to the next week at the same time and day.

Initially, the cleanliness of the probes was not recorded. However, during the course of data collection, a wide variability in probe cleanliness was noted, and it was decided to record the state of cleanliness of each probe sampled for the remainder of the study. This resulted in half of the samples (55) having a recorded state of cleanliness. Gross visual inspection of each probe was undertaken prior to RODAC plate sampling. Specifically, the probe was inspected for the presence of dry or wet ultrasound coupling gel, blood, or dust. The amount of material soiling the probe was not noted. Probe cleanliness results were analyzed for statistical significance using the Fisher exact test ( $p < 0.05$ ). Statistics were calculated using SAS software (SAS Institute Inc., Cary, NC).

The entire ED staff, with the exception of the primary investigator, were blinded to the times of data collection. The four ultrasound fellows and two attending physicians had knowledge of the purpose of the study. The remainder of the ED staff were initially unaware of the nature of the study. However, sampling of the probes was often visible to persons in the immediate vicinity at the time of data collection; therefore, ongoing blinding could not be ensured.

All samples were taken by the same operator using a consistent technique. One RODAC plate was used for each ultrasound probe. The entire surface that would contact patients was sampled. This included the surface of the piezoelectric crystal array as well as all of the plastic housing within 5 cm of it. After sampling was complete, the probes were cleaned using standard

cleaning procedures. The inoculated plates were immediately placed in an incubator in the microbiology laboratory for subsequent analysis by trained laboratory staff.

## RESULTS

On 10 randomly generated sample times, 11 probes from three ED ultrasound machines were sampled. One sampling episode was moved to the beginning of the primary investigator's ED shift and one was moved to the end of an ED shift. Two sampling episodes were deferred by one week because of machine unavailability owing to maintenance. A total of 110 samples were taken during the 10 sampling episodes, of which 4 were not strictly done at the randomized time. Two endocavitary probes, three phased array probes, three curvilinear probes, and three linear probes were sampled on each occasion.

As illustrated in Table 1, 32 of 55 probes were found to be clean by gross visual inspection (58%). The remainder of the probes (42%) were soiled with either wet ultrasound coupling gel, dry ultrasound coupling gel, blood, or dust. The linear and endocavitary probes tended to be clean a larger proportion of the time (73% and 80%, respectively) compared to the phased and curvilinear probes (47% and 40%, respectively). The variations in probe cleanliness by probe type were not statistically significant ( $p = 0.11$ ).

When the cleanliness of the probes was stratified by the ED location in which the ultrasound machine resided, it was found that 70% and 65% of the probes were clean in the pediatrics and medicine areas, respectively. In contrast, only 33% of ultrasound probes inspected in the trauma area were found to be clean by visual inspection. The difference in probe cleanliness by probe area was statistically significant ( $p = 0.01$ ). Cleanliness results by probe location are shown in Table 2.

None of the 110 samples were positive for MRSA. In a single instance, MSSA was grown. This positive sample was from an endocavitary probe found to be uncharacteristically dusty at the time of sampling.

## LIMITATIONS

Our study had a number of limitations that should be considered. First, although RODAC plates are currently the preferred medium for the detection of MRSA from environmental surfaces, there is no gold standard to compare this technique to, so the true sensitivity and specificity of this test are not known. In an ideal design, multiple sampling techniques would have been used to optimize the potential yield of MRSA detection. It is unclear how this may have impacted our results.

Next, the entirety of the ED staff were not blinded to the nature of the study. Notably, the four ultrasound fellows were aware of the study and are frequent users of the ultrasound machines. Furthermore, owing to space and time constraints, the physical sampling of the ultrasound probes was visible to some ED staff during sampling episodes. It is thus possible that some ED staff changed their normal cleaning behaviour during the study period.

Third, there was incomplete randomization of the study sampling episodes. Owing to the logistical constraints of the microbiology laboratory, RODAC plate samples could be submitted only for a specific 72-hour period each week, from midnight Sunday morning to midnight Wednesday morning. It is possible that the exclusion of the remainder of the week introduced a selection bias; however, it is felt that this potential was mitigated by our consistently large patient volume and regular use of ultrasonography on a daily basis.

Given that postsampling cleaning of the probes was part of the methodology and that a limited number of

**Table 1. Visual appearance of ultrasound probes by probe type prior to culturing**

Ultrasound probe type	Visual appearance of ultrasound probe, <i>n</i> (%)					Total
	Clean	Dried gel	Wet gel	Blood	Dust	
Phased	7 (47)	5 (33)	3 (20)	0 (0)	0 (0)	15
Curvilinear	6 (40)	4 (27)	4 (27)	1 (7)	0 (0)	15
Linear	11 (73)	1 (7)	2 (13)	1 (7)	0 (0)	15
Endocavitary	8 (80)	0 (0)	0 (0)	1 (10)	1 (10)	10
Total	32 (58)	10 (18)	9 (16)	3 (5)	1 (2)	55

**Table 2. Visual appearance of ultrasound probes by emergency department ultrasound machine location prior to culturing**

ED location	Visual appearance of ultrasound probe, n (%)					Total
	Clean	Dried gel	Wet gel	Blood	Dust	
Medicine	13 (65)	1 (5)	5 (25)	1 (5)	0 (0)	20
Trauma	5 (33)	4 (27)	4 (27)	2 (13)	0 (0)	15
Pediatrics	14 (70)	5 (25)	0 (0)	0 (0)	1 (5)	20

RODAC plates were available for the study, it was determined that sampling occurring less than 12 hours apart would not accurately represent the usual state of probe cleanliness. Postsampling probe cleaning was done primarily to avoid bias toward an artificially high MRSA or MSSA prevalence from repeated sampling of a MRSA-positive probe. Alternatively, this cleaning of the probes could potentially lower the detected prevalence of MRSA and MSSA. To minimize any effect of the latter bias, we did not resample the probes for 12 hours after a previous sampling. It was expected that the consistently heavy use of ultrasonography in our ED would return the probes to a state of typical cleanliness after 12 hours.

Similarly, limitations in the ability of the primary investigator to sample during a clinical shift or when the machine was unavailable owing to maintenance could have introduced bias. Furthermore, determination of probe cleanliness by the single investigator may have introduced bias in reporting the degree of cleanliness. This said, we felt that the overall benefit of having a single investigator perform the samplings in a consistent manner outweighed the potential introduction of bias.

The methods undertaken by the microbiology laboratory were designed to detect only MSSA and MRSA. Future study should aim to isolate a larger variety of potential pathogens, such as *Clostridium difficile* and vancomycin-resistant *Enterococcus*, to determine their presence or absence on ED ultrasound probes.

The present study involved only a single centre and a relatively limited sample size. To expand on this work and increase the generalizability of results, subsequent research could include multiple centres and larger sample sizes.

## DISCUSSION

Contrary to our hypothesis, we did not detect the presence of MRSA on the ultrasound machine

probes in our ED. We did find one sample that was positive for MSSA. It is important to note that the probe that yielded MSSA was a clear outlier in terms of cleanliness as it was soiled with a layer of dust after sitting on an ultrasound machine cart for several days. This MSSA-positive probe had also been displaced from its usual location in the pediatric ED.

In contrast to one prior study that cultured a number of inanimate objects in the ED,<sup>4</sup> we focused our study on ED ultrasound probes. We were able to increase the number of ED ultrasound machine probe samples and use a more rigorous sampling scheme to limit selection bias. Additionally, we took samples from three different machines in use in three distinct areas of the ED: trauma, medicine, and pediatrics.

Our results support those of some previous non-ED-based studies. Karadeniz and colleagues cultured coagulase-negative *Staphylococcus* from uncleaned ultrasound probes used on patients in an outpatient radiology suite.<sup>1</sup> However, they did not find the presence of *S. aureus*. Whitehead and colleagues cultured Doppler ultrasound probes in use on a surgical outpatient unit and vascular surgery ward.<sup>3</sup> These investigators found a 12% rate of contamination with coagulase-negative *Staphylococcus* but failed to culture *S. aureus*.

Other previous non-ED-based studies reported results that conflict with ours. Spencer and Spencer isolated *S. aureus* from ultrasound probes used solely for the purpose of scanning postoperative wounds.<sup>2</sup> These investigators did not differentiate between MSSA and MRSA and failed to report the proportion of probes contaminated with *S. aureus*. This contrasts with our results as we cultured MSSA only on a single probe, which, notably, was not representative of the state of cleanliness of most probes in use in the ED and did not appear to have been used for some time. Fowler and McCracken conducted a study in the intensive care unit setting and found growth of both

coagulase-negative *Staphylococcus* and *S. aureus* from uncleaned probes sampled immediately following abdominal ultrasonography.<sup>5</sup> They found growth of MRSA in cultures of probes used on patients known to be MRSA positive at the time of scanning, although no attempt was made to clean the probes after use.

A secondary finding of our study was the statistically significant disparity of ultrasound probe cleanliness between machines located in different areas of the ED. As general probe cleaning procedures are consistent between the ED areas, it is possible that this variance may be due to different patterns of use of the equipment. For example, the frequency of ultrasound machine use in the pediatric ED is less than that of the medicine and trauma areas. Although the machines in the medicine and trauma areas appear to be used with similar frequency, the setting of their use tends to differ. The trauma area ultrasound machine is often used in a less controlled environment, such as for FAST examinations in major trauma. The use of ultrasonography in the medicine area, by contrast, tends to be more elective and controlled. This difference in the setting of ultrasound machine use between the medicine and trauma areas may lead to variation in machine cleaning practices by individual ED users.

The variations in probe cleanliness we found by probe type were statistically significant, although it is possible that this was limited by our small sample size. Observed cleanliness variation may have arisen from differences in typical uses for each probe. For example, the linear probes are often used in the ED for ultrasound-guided vascular access. During this application, linear probes are covered by a sterile sheath and may be cleaned more often before and after use. Similarly, endocavitary probes are always sheathed during use. In contrast, the phased and curvilinear probes are rarely sheathed during routine use and are commonly used in more urgent situations, such as for FAST examinations.

## CONCLUSIONS

To our knowledge, this is the first study to investigate the presence of MSSA and MRSA exclusively from ED ultrasound probes. Contrary to our hypothesis, MRSA was not found. This finding suggests that the spread of MRSA by ED ultrasound machines in a high-volume urban ED is unlikely. Further research at different centres with larger sample sizes is required before these results can be generalized.

Despite the lack of MRSA found on the ED ultrasound probes in this study, the state of cleanliness of these probes suggests that the presence of other pathogens is possible. Given the uncertain role of ED ultrasound machines as a vector for MRSA and other pathogens, we believe thorough cleaning programs for all ED ultrasound machines are important.

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**Competing interests:** None declared.

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