Efforts to Attenuate the Spread of Infection (EASI): a prospective, observational multicentre survey of ultrasound equipment in Australian emergency departments and intensive care units

Matthew Keys, Beatrice Z Sim, Ogilvie Thom, Matthew J Tunbridge, Adrian G Barnett and John F Fraser

ABSTRACT

Background and objectives: Ultrasound is a common and necessary part of acute care medicine, but may present an infection risk to patients secondary to transfer of infectious agents between patients. Our primary objective was to detect blood contamination on ultrasound equipment in emergency departments (EDs) and intensive care units. Secondary objectives included detection of microbial contamination and determination of factors associated with contamination.

Design and setting: We tested ultrasound equipment used in five EDs and five ICUs for blood and microbial contamination, and collated and analysed contamination data using tables and multiple logistic regression.

Main outcome measures and results: We performed 109 tests for blood and 131 tests for microbial contamination, with 61% of samples testing positive for blood contamination (95% CI, 52%–71%) and 48% testing positive for microbiological contamination (95% CI, 40%–57%). Transducer leads and transducers had high blood contamination (88% and 57%, respectively) and microbiological contamination (62% and 46%, respectively). Equipment from ICUs was less likely to test positive (odds ratio, 0.55; 95% CI, 0.37–0.79). Only 51% of blood-contaminated samples were visibly stained, and visible staining was not associated with microbiological contamination (57%; $P = 1$).

Conclusion: Our results show significant contamination of ultrasound equipment, and that visual inspection of equipment is neither sufficient nor reliable in excluding contamination. Ultrasound equipment is a possible factor in the transmission of infectious diseases in EDs and ICUs. Guidelines must be formulated, disseminated and rapidly adopted to ensure the safety of the most acutely ill patients exposed to ultrasound procedures in acute care settings.

Crit Care Resusc 2015; 17: 43–46

In recent years, the use of point-of-care ultrasound in the critical care setting has expanded rapidly. It has become an essential part of acute care medical practice, forming part of the initial assessment of shocked patients, facilitating vascular access and assisting in the placement of other therapeutic devices.[1-6] There is potential for contamination of equipment with patients' blood and microbes, and thus a potential risk of transferring infections to other patients and staff members.

We set out to conduct a prospective, observational, multicentre study aimed at investigating the prevalence of, and factors contributing to, blood contamination and bacterial colonisation on ultrasound transducer probes in emergency departments (EDs) and intensive care units.

Materials and methods

Location and ethical considerations

The study was conducted in five public hospitals in south-east Queensland, Australia, between April 2010 and January 2012. The study was approved by the local human research ethics committees.

Equipment

The Hemastix (Bayer) test for blood contamination was chosen over other available tests due to its ease of use, ready availability and documented high sensitivity and specificity.[7-10] The Hemastix system was tested for false-positive reactions, using the study protocol, against commonly used contaminants in the health care setting without producing a positive result.[11]

Sampling and testing

The sites for sampling were identified a priori and included:

- coupling gel bottle
- keyboard
- transducer probes
- transducer leads
- work surface (top surface of the trolley where the ultrasound is housed)
- coupling gel.

Table 1. Number of tests by hospital

Hospital	ICU	Disinfection policy	ED	Disinfection policy
A	15	No	15	No
B	19	No*	33	No
C	21	No	36†	No
D	31	No	27	No
E	19	No*	24	No

ICU = intensive care unit. ED = emergency department. * ICU Hospital B and ICU Hospital E had limited cleaning instructions laminated and attached to the side of the machine. † Most ultrasound machines had multiple transducers and multiple coupling gel bottles.

Many machines had multiple probes and coupling gel bottles. All probes and all bottles were analysed and assessed. A single researcher (M K) with standardised training conducted all sampling at each of the sites.

To test for blood contamination, each surface was inspected for obvious contamination by staining or visible marks. Then each surface was carefully wiped with filter paper that had been moistened with sterile water. Hemastix test strips were then applied to the filter paper and the result recorded. Obvious marks on the test surface (eg, the transducer) were directly tested with a new, moistened Hemastix test strip applied directly to the mark.

To test for microbial contamination, standard microbiological dry swabs (Interpath Services M40 Transystem [Copan]) were moistened with sterile water and wiped along the test surface. For coupling gel, a sample was squeezed from the bottle onto the swab. Site samples were batched with each other and transported within 6 hours to the central laboratory of Pathology Queensland and all samples were processed at the same laboratory.

Table 2. Positive tests by equipment type

Sample site	Sample type	No. positive/ tested	Percentage positive (95% CI)
Gel	Blood	10/24	42% (22%–61%)
	Microbial	16/46	35% (21%–49%)
Keyboard	Blood	10/16	62% (39%–86%)
	Microbial	8/16	50% (26%–74%)
Transducer leads	Blood	14/16	88% (71%–100%)
	Microbial	10/16	62% (39%–86%)
Transducer	Blood	21/37	57% (41%–73%)
	Microbial	17/37	46% (30%–62%)
Work surface	Blood	12/16	75% (54%–96%)
	Microbial	12/16	75% (54%–96%)

Table 3. ORs for a logistic regression model of testing positive. Reference categories are: gel for site, ED for area, and Hospital A

Variable	Mean OR (95% CI)	*P*
Keyboard	1.47 (0.79–2.67)	0.21
Leads	1.96 (1.11–3..43)	0.018
Probe	1.21 (0.73–2.03)	0.459
Work surface	1.96 (1.11–3.43)	0.018
Area ICU	0.56 (0.38–0.81)	0.002
Hospital B	1.01 (0.59–1.78)	0.980
Hospital C	0.80 (0.46–1.43)	0.440
Hospital D	0.87 (0.50–1.53)	0.610
Hospital E	0.32 (0.14–0.68)	0.004

OR = odds ratio. ED = emergency department. ICU = intensive care unit.

Statistical analysis

The percentages of positive tests were tabulated with 95% confidence intervals. To find what factors increased the probability of a positive test, we used multiple logistic regression and calculated odds ratios (ORs) for positive tests by location, test type and area, with 95% CIs. Cross-tabulations and χ^2 tests were used to find associations between categorical variables. All analyses were performed using the R statistical software version 3.0.0 (R Project). Analysis was blinded to hospital site.

Results

We tested 16 machines from 10 departments and performed 109 tests for blood contamination and 131 tests for microbial contamination. Sixty-one per cent of samples tested positive for blood contamination (95% CI, 52%–71%) and 48% tested positive for microbiological contamination (95% CI, 40%–57%). Numbers of tests by hospital and department are shown in Table 1.

Of the items in direct patient contact, 14 of 16 (88%) transducer leads and 21 of 37 (57%) transducers showed blood contamination. Ten of 16 transducer leads (62%) and 17 of 37 transducers (46%) showed microbial contamination (Table 2). The organisms identified included:

- gram-negative bacilli (Enterobacter, Klebsiella, Pantoea, Raoultella, Pseudomonas, Acinetobacter, Proteobacteria and Aeromonas)
- gram-positive cocci (Staphylococcus, Enterococcus and Micrococcus)
- gram-positive rods (Bacillus and Corynebacterium)
- normal skin flora, as stated on the standard pathology reports.

Table 3 shows the ORs for the multiple logistic regression model of testing positive. Machines in the ICU were less likely to test positive than machines in the ED (OR, 0.55; 95% CI, 0.37–0.79). Work surfaces and transducer leads had a much higher OR of contamination when using gel as the reference (OR, 2.06; 95% CI, 1.17–3.60). Table 3 also shows the ORs for risk of contamination comparing hospitals, with Hospital A as the reference site.

Only 51% of samples positive for blood contamination were visibly stained, but visible staining was associated with a positive result for blood contamination when present ($P < 0.01$). The presence of visible staining was not associated with a positive result for microbiological contamination ($P = 1.0$).

Discussion

Significant blood and microbial contamination were identified on ultrasound equipment used in both the ED and ICU. This equipment often comes into direct contact with broken skin or is used in a sterile field for ultrasound-guided interventions or procedures and could potentially transmit health care-associated infection (HAI). HAI has been shown to have a high socioeconomic impact, increasing morbidity, mortality and costs of admission to hospital.[12]

Ultrasound instruments can be considered semicritical[13-15] as they have the potential to come into contact with broken skin and body fluids, are used to guide interventions or can be placed inside cavities. This is significant because best practice dictates that all semicritical instruments and equipment should undergo high-level disinfection between patient exposures.[13-16] The use of disposable transducer covers does not negate this requirement, due to the risk of microperforation of the cover,[14] just as the use of sterile gloves by the surgeon does not negate the need for thorough hand washing.

Visual inspection of the transducer probe or leads was neither sufficient nor reliable to exclude contamination. There was significant evidence of non-visible blood contamination. This result supports other studies showing that more than 50% of surfaces with proven blood contamination (and hepatitis B antigen)[17] do not have visible blood contamination.

There are several possible reasons for a failure to clean ultrasound equipment after use, including unclear delegation of responsibility, lack of accountability, lack of protocol or the possibility that some clinicians in the field of acute care medicine could consider the issue of ultrasound equipment contamination to be unimportant in a setting where immediate availability of equipment is paramount.

There was a decreased incidence of testing positive in the ICU compared with in the ED (OR, 0.55; 95% CI, 0.37–0.79). Compared with the ICU, ultrasound equipment in the ED may be needed more urgently in undifferentiated patients and may be used on more patients, and the ED is an environment of higher staff turnover and external time restraints.

We focused on the prevalence of blood and microbial contamination on ultrasound equipment commonly used within EDs and ICUs, although we did not gauge whether this blood or microbial contamination represented an infection risk. The evidence of blood contamination did not necessarily mean that there was blood-borne or body fluid-borne infectious viruses also present. We did not test for viruses using polymerase chain reaction tests. Data collection was spread over a long period and this coincided with the introduction of the Centre for Healthcare Related Infection Surveillance and Prevention (Queensland Health) policy on disinfection of intracavity ultrasound transducers. However, this policy does not cover external ultrasound transducers.[18]

The study has implications for work practices and decontamination standards. Cleaning protocols should be documented with clear delegation of responsibility. Staff must comply with cleaning before and after use, perhaps with a log book of use. Clinicians using ultrasound in situations where the probes could become exposed to body fluid, broken skin or mucous membranes should use single-use coupling gel packets and disposable probe covers. Staff should assume that every transducer is contaminated and should also use universal (standard) precautions. The delay inherent in the introduction of decontamination standards and protocols should not delay a change in work practice.

In the current clinical environment, it does not seem practical or feasible to implement a high level disinfection of every ultrasound transducer after each patient contact. Non-availability of ultrasound equipment secondary to high-level cleaning protocols has the potential to compromise patient outcomes when critically ill patients arrive unannounced or patients suddenly deteriorate. It is recommended that ultrasound users in EDs, ICUs and anaesthetic departments collaborate with ultrasound machine manufacturers to develop cleaning and sterilisation protocols that are safe, effective, fast and simple to use, as well as to improve equipment design to eliminate recessed holes or other areas where contamination may collect.

Conclusion

Our study showed significant contamination of ultrasound equipment in a range of health care settings and locations. This raises important issues of patient safety and HAI as a result of equipment contamination.

Competing interests

We received support from the Queensland Emergency Medicine Research Foundation. JF is supported by a Health and Medical Research Fellowship from the Queensland Government.

Acknowledgements

We thank R Horvath (The Prince Charles Hospital, Brisbane) for advice on microbial testing protocols and L Munck (Critical Care Research Group, Brisbane) for administration services. Research funds were administered by The Prince Charles Hospital Foundation.

Author details

Matthew Keys, Associate,[1] Staff Specialist,[2] Advanced Trainee,[3] and Associate Lecturer[4]
Beatrice Z Sim, Associate,[1] and Intern[5]
Ogilvie Thom, Researcher,[1] Senior Staff Specialist,[6] and Senior Lecturer[4]
Matthew J Tunbridge, Associate,[1] and Intern[5]
Adrian G Barnett, Associate Professor[7]
John F Fraser, Director and Chief Investigator,[1] Eminent Senior Staff Specialist,[8] and Professor[4]

1 Critical Care Research Group, University of Queensland, The Prince Charles Hospital, Brisbane, QLD, Australia.
2 Department of Intensive Care Medicine, Robina Hospital, Gold Coast, QLD, Australia.
3 Professor Tess Cramond Multidisciplinary Pain Centre, Royal Brisbane and Women's Hospital, Brisbane, QLD, Australia.
4 School of Medicine, The University of Queensland, Brisbane, QLD, Australia.
5 Princess Alexandra Hospital, Princess Alexandra Hospital, Brisbane, QLD, Australia.
6 Department of Emergency Medicine, Nambour General Hospital, Nambour, QLD, Australia.
7 Institute of Health and Biomedical Innovation and School of Public Health and Social Work, Queensland University of Technology, Brisbane, QLD, Australia.
8 Department of Intensive Care Medicine, The Prince Charles Hospital, Brisbane, QLD, Australia.
Correspondence: drmattkeys@me.com

References

1 Melanson SW, Heller M. The emerging role of bedside ultrasonography in trauma care. *Emerg Med Clin North Am* 1998; 16: 165-89.
2 Brown MA, Sirlin CB, Hoyt DB, Casola G. Screening ultrasound in blunt abdominal trauma. *J Intensive Care Med* 2003; 18: 253-60.
3 Hind D, Calvert N, McWilliams R, et al. Ultrasonic locating devices for central venous cannulation: meta-analysis. *BMJ* 2003; 327: 361.
4 Australasian College for Emergency Medicine. Policy on the use of bedside ultrasound by emergency physicians. Melbourne: ACEM, 2006: 21.
5 McLean AS. International recommendations on competency in critical care ultrasound: pertinence to Australia and New Zealand. *Crit Care Resus* 2011; 13: 56-8.
6 College of Intensive Care Medicine of Australia and New Zealand. Objectives of advanced training and competencies. Melbourne: CICM, 2010; T-6: 1-4.
7 Tobe SS, Watson N, Daéid NN. Evaluation of six presumptive tests for blood, their specificity, sensitivity, and effect on high molecular-weight DNA. *J Forensic Sci* 2007; 52: 102-9.
8 Webb JL, Creamer JI, Quickenden TI. A comparison of the presumptive luminol test for blood with four non-chemiluminescent forensic techniques. *Luminescence* 2006; 21: 214-20.
9 Scriven AJ, Tapley EM. Coloscreen VPI test kit evaluated for detection of fecal occult blood. *Clin Chem* 1989; 35: 156-8.
10 Cox M. A study of the sensitivity and specificity of four presumptive tests for blood. *J Forensic Sci* 1991; 36: 1503-11.
11 Keys M. EASI — Efforts to Attenuate the Spread of Infection: a pilot study. Brisbane: The Prince Charles Hospital, 2010: 1-6.
12 Jarvis WR. Selected aspects of the socioenonomic impact of nosocomial infections: morbidity, mortality, cost, and prevention. *Infect Control Hosp Epidemiol* 1996; 17: 552-7.
13 Spaulding EH. Chemical disinfection of medical and surgical materials. In: Block SS, Lawrence CA, eds. Disinfection, sterilization, and preservation. Philadelphia: Lea and Febiger, 1968: 517-31.
14 Australasian Society for Ultrasound in Medicine. Policies and statements, B2: Statement on the disinfection of transducers. Sydney: ASUM, 2012.
15 Rutala WA, Weber DJ, Healthcare Infection Control Practices Advisory Committee. Guidelines for disinfection and sterilization in healthcare facilities, 2008. Atlanta: Centers for Disease Control and Prevention, 2008.
16 Centers for Disease Control and Prevention. Update: universal precautions for prevention of transmission of human immunodeficiency virus, hepatitis B virus and other bloodborne pathogens in health-care settings. *MMWR Morb Mortal Wkly Rep* 1988; 37: 377-82; 387-8.
17 Favero MS, Maynard JE, Peterson NJ, et al. Hepatitis-B antigen on environmental surfaces. *Lancet* 1973; 2: 1455.
18 Centre for Healthcare Related Infection Surveillance and Prevention. Reprocessing Intra-Cavity Ultrasound Transducers. Brisbane: CHRISP, 2012. Document number QH-GDL-321-2-1. ❑