ORIGINAL ARTICLE

Higher nursing care level is associated with higher incidence of blood culture contamination in the emergency department: A case–control study

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Abstract

Background: Blood culture is critical in treating infectious diseases. This leads to unnecessary intervention, inappropriate antibiotic use, and excess cost. Few studies have tackled patient factors that could possibly affect contamination rates. This study aimed to explore the association between patients' nursing care levels and blood culture contamination.

Methods: This is a single-centered, retrospective, case–control study of adult patients whose blood culture specimens were taken in the emergency department between April 2018 and July 2019. The study was conducted in an acute care community hospital in Japan. The case group included patients with false-positive blood culture results with contamination; the control group included patients with true-positive or true-negative blood culture results without contamination. We randomly selected two control patients per case. Patients' age, gender, nursing care level, ambulance use, housing status, Glasgow Coma Scale, hospital arrival time, and puncture sites were obtained from the patients' medical charts.

Results: Of the 5130 patients, 686 patients got positive blood culture results. Of the 686 patients, 35 patients were included in the case group, and 70 were randomly selected from the noncontaminated group and included in the control. In multivariate analysis, patients with contaminated blood cultures had a higher nursing care level (adjusted odds ratio: 8.50; 95% confidence interval: 1.65–43.7; $p = 0.01$).

Conclusions: A higher nursing care level is associated with a higher incidence of blood culture contamination in the emergency department. Careful and appropriate procedures are required for patients with a higher nursing care level.

KEYWORDS
blood culture contamination, emergency department operations, geriatrics, infectious diseases, nursing

1 | BACKGROUND

Blood culture is a standard clinical procedure used to identify the source of infection and establish the appropriate treatment plan.[1] It is essential for detecting bacteremia, which is a critical health problem. For accurate identification of bacteremia, several guidelines recommend collecting two or more sets of samples for blood culture.[2,3] However, blood culture contamination occurs in 0.6%– 12.5% of samples,[4] which leads to unnecessary intervention, inappropriate antibiotic use, and excess cost. The American Society of Microbiology recommends keeping the contamination rate under 3%.[2] For comparison, contamination occurs in 0.6%–1.0% of samples in our hospital.

Previous studies showed that blood culture procedures, such as skin sterilization or puncture site selection, are associated with contamination.[5–7] As for puncture site, it is well known that the femoral artery is vulnerable to contaminate. In Japan, the puncturing artery is only allowed to physicians and specific nurse practitioners. Other registered nurses are allowed to collect a blood sample from vein. Usually, chlorhexidine is used for sterilizing skin, and physicians or nurses wear sterile gloves. Specimen collection site, inadequate skin preparation, and lack of sterile gloving contribute to contamination.[8] However, studies on patient factors are limited. Sinclair et al.[9] showed a high rate of false-positive blood cultures in nursing home patients by prospective methods. However, it is not clear that people in nursing home have higher nursing care level than people in home in Japan. This is because of that some people tend to prefer staying at home rather than in nursing home even with high nursing care level, so that they stay home with their family using visiting medical service or social support. We suspect that each patient's hygiene is varied, and it could affect blood culture contamination. The purpose of this research is to identify patient factors that affect blood culture contamination in the emergency department (ED).

In this study, we hypothesize that a higher nursing care level is associated with a higher incidence of blood culture contamination. Focusing on patients needing high levels of care and identifying factors associated with blood culture contamination may increase the accuracy and efficiency of blood cultures, especially among older patients.

2 | METHODS

2.1 | Study design and setting

This is a retrospective and case–control study conducted at an urban, acute care, community hospital in Japan. The ED of this hospital accepts approximately 10,000 ambulance arrivals, with an average of 25,000 patients per year.[10] The study was approved by the ethics committee of the hospital. All participating EDs were staffed by emergency attending physicians. We maintained the individual protocols about the policy and procedures for ED blood culture (e.g., skin preparation and sterile gloving). Patient information was

Eye opening	Score
Spontaneous	4
To sound	3
To pressure	2
None	1
Verbal response	
Oriented	5
Confused	4
Words	3
Sounds	2
None	1
Motor response	
Obey commands	6
Localizing	5
Normal flexion	4
Abnormal flexion	3
Extension	2
None	1

FIGURE 1 Glasgow Coma Scale

anonymized and deidentified prior to analysis, thus the informed consent of the patient was waived. This study also follows the STROBE statement on reporting case–control studies.[11]

2.2 | Participants

We included patients who had their blood culture specimens taken at the ED between April 2018 and July 2019. We excluded patients aged below 19 years and patients with only one set or three sets of blood cultures. The case group included patients who received false-positive blood culture results due to contamination. The control group included patients with true-positive or true-negative blood culture results without contamination. We randomly selected two controls per case.

2.3 | Data collection

Patients' age, gender, nursing care level, GCS, hospital arrival time (daytime was 8:30 a.m. to 6 p.m. and night-time was 6 p.m. to 8:30 a.m.), housing status (where patients came from, home/ hospital/care facility), ambulance use and the puncture sites of blood cultures were obtained from the patients' hospital electronic medical charts. According to GCS, patients below M5 are not able to follow orders as shown in Figure 1.[12] It associates with the patients' ability to follow instructions during medical procedures.[13,14] The hospital arrival time was also included since physicians and nurses are less than daytime and it reflects crowding in the ED, which contributes to difficulties experienced during procedures.[15] As for housing status, where patients came from, people who have

difficulties living at home by themselves or with their families tend to transfer to long-term care facilities. We inferred that the patients' housing status would reflect their activities of daily living (ADL) and cognitive function. Since the previous study showed the relationship between ambulance use and severity of injury or illness,[16] we included ambulance use to assess patients' severity. The mentioned variables are categorical. The puncture sites of blood cultures were divided into three groups based on the past research, which showed that contamination increased when the specimen collected from the vessels in inguinal region.[17] The three groups were: when both sets were collected from blood vessels in the upper arm, when one set was collected from the inguinal region, and when both sets were collected from the inguinal region.

2.4 | Exposures and outcomes

The primary exposure was nursing care level. We adopted the nursing care level classification from the Japanese Ministry of Health, Labor, and Welfare.[18] This classification system is for people aged 65 years and above to assist in daily living; the levels are based on their general condition, including ADL and cognitive function. Candidates are divided into seven levels.[19] Level 1 is the most independent and level 7 is the most dependent (Figure 2). In this study, we classified patients belonging to nursing care levels 6 and 7 as "Higher Nursing Care Level" since most of them needed more care for their daily lives as equivalent as level 7 and above Clinical Frailty Score.[20]

The primary outcome of this study was the blood culture contamination rate. We defined contamination as the presence of normal skin flora in a blood culture obtained from two or more sites.[3] The department of infection control, with board-certified infectious disease physicians, correlated independently the blood culture results with the patients' actual clinical course to determine the presence of an infection and the accuracy of the blood culture.[21]

2.5 | Statistical analysis

We evaluated the patients' characteristics and outcomes using the Fisher's exact test for binary variables, and the Mann–Whitney U-test for continuous variables. We accounted for missing data by using multiple imputations by chained equation. Age, gender, nursing care level, GCS, hospital arrival time, and ambulance use were used as explanatory variables in the imputation model to create 20 imputed data sets. To determine the association between nursing care level and blood culture contamination, we constructed a multivariate logistic regression model, adjusting for potential confounders including age, gender, ambulance use, housing status, and the level of consciousness and the puncture sites of blood cultures. We also performed a sensitivity analysis using another threshold of higher nursing level (1–4 vs. ≥5) to examine the robustness of our inference. All p-values were two-tailed, with $p < 0.05$ considered statistically significant. We used Stata/SE 16.0 (Stata Corp) for data analyses.

2.6 | Patient and public involvement

Patients or the public were not involved in the design, conduct, reporting, or dissemination plans of our research.

3 | RESULTS

Between April 2018 and March 2019, 5165 patients had specimens collected for blood culture in the ED. We excluded 35 patients according to the exclusion criteria described previously. Overall, 686 patients had positive blood culture results and 4479 patients had negative blood culture results. Of the 686 blood culture-positive patients, 35 had false-positive results, and the contaminated blood cultures were included in the case group. Among patients with true-positive or true-negative results without contamination, 70 were randomly selected and included in the control group (Figure 3).

Overall, the median patient age was 74 years (interquartile range: 62–85) and 75% were brought to the ED by ambulance. The baseline demographics and characteristics of patients are shown in Table 1.

On univariate analysis, patients whose blood cultures were suspected to be contaminated had a higher nursing care level (level 6 or 7) (22.9% vs. 4.3%), were brought to the ED by ambulance (88.6% vs.

Level	General condition
1	Need partial support for daily activity and care.
2	Need support for walking or standing.
3	Add to level 2, cognitive dysfunction or problematic behavior.
4	Need help for eating or excretion.
5	Cannot stand up and move by oneself.
6	Cannot excrete by oneself, severe dementia.
7	Cannot eat by oneself.

FIGURE 2 Nursing care level in Japan

FIGURE 3 Selection of participants

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                    ┌─────────────────────────────┐
                    │ 5,165 patients who had blood │
                    │ culture specimens taken at   │
                    │ the ED                       │
                    └─────────────────────────────┘
                                   │
                                   │    ┌──────────────────────────┐
                                   │────│ Excluded patients         │
                                   │    │ 33 age<20 years           │
                                   │    │ 2 single blood culture    │
                                   │    │ sample                    │
                                   │    └──────────────────────────┘
                 ┌─────────────────┴──────────────────┐
        ┌──────────────────┐              ┌──────────────────────┐
        │ 686 showed positive│            │ 4,479 were negative  │
        └──────────────────┘              └──────────────────────┘
            │                                        │
    ┌───────┴────────┐                               │
┌─────────────────┐ ┌──────────────────────┐         │
│ 35 included     │ │ 651 showed truly     │         │
│ case group      │ │ positive             │         │
└─────────────────┘ └──────────────────────┘         │
                              └──────────┬────────────┘
                            ┌──────────────────────────┐
                            │ 5,130 were not contaminated│
                            └──────────────────────────┘
                                        │
                            ┌──────────────────────────┐
                            │ Randomization            │
                            └──────────────────────────┘
                                        │
                            ┌──────────────────────────┐
                            │ 70 included control group│
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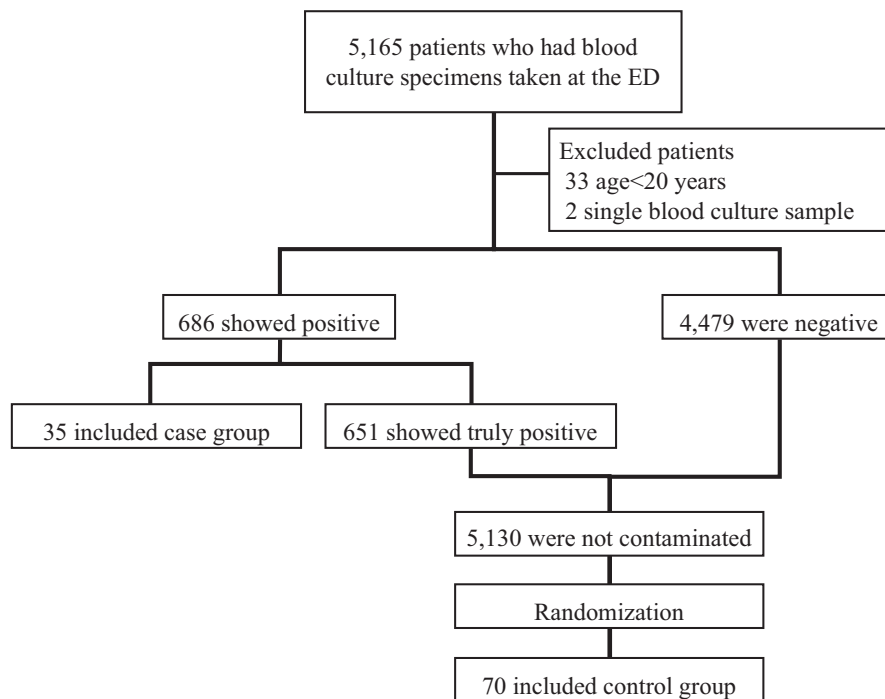
TABLE 1 Explanatory variables for patients with contaminated and noncontaminated blood cultures

	Contaminated (n = 35)	Not contaminated (n = 42)	p-value
Age (median, IQR)	75.0 (68.0–85.0)	73.0 (62.0–85.0)	0.58
Male	16 (45.7)	39 (55.7)	0.33
Ambulance use	31 (88.6)	42 (60.0)	<0.01
Visited ED from home	24 (37.1)	61 (87.1)	0.06
M6 in GCS	24 (37.1)	61 (87.1)	0.02
Arrived at night[a]	17 (48.6)	36 (51.4)	0.78
Nursing care level			
0	24 (68.6)	60 (85.7)	0.10
2	0 (0.0)	1 (1.4)	
3	0 (0.0)	2 (1.9)	
4	2 (5.7)	4 (3.8)	
5	1 (2.9)	3 (2.9)	
6	3 (8.6)	4 (3.8)	
7	5 (14.3)	7 (6.7)	
Puncture site			
None from inguinal region	15 (50.0)	53 (77.9)	0.01
One set from inguinal region	8 (26.7)	11 (16.2)	
Both sets from inguinal region	7 (23.3)	4 (5.9)	

Note: Data were expressed as *n* (%) unless otherwise indicated. Percentages may not equal 100 due to rounding.

Abbreviations: ED, emergency department; GCS, Glasgow Coma Scale; M, best motor response.

[a]Defined as 6 p.m. to 8:30 a.m.

TABLE 2 Multiple logistic regression analysis of the association between nursing care level and blood culture contamination

Adjusted analysis[a]	Odds ratio	95% CI	p-value
Nursing care level ≥ 6	8.50	1.65–43.7	0.01
Nursing care level ≥ 5	6.03	1.47–24.6	0.01

Abbreviation: CI, confidence interval.

[a]Adjusted for age, gender, ambulance use, housing status, level of consciousness (Glasgow Coma Scale), and the puncture sites.

60.0%, $p < 0.01$), and were punctured one of both sides of inguinal regions (50.0% vs. 22.1%, $p = 0.01$).

On multivariate analysis, patients with higher nursing care levels (adjusted odds ratio [OR]: 8.50; 95% confidence interval [CI]: 1.65–43.7; $p = 0.01$) had a higher incidence of blood culture contamination (Table 2). On sensitivity analysis, the significant associations persisted with the use of another threshold of the nursing care level—i.e., 1–4 versus ≥5 (adjusted OR 6.03, 95% CI 1.48–24.6; $p = 0.01$).

4 | DISCUSSION

4.1 | Principal findings

Our study demonstrated that patients with a higher nursing care level had a higher incidence of blood culture contamination in the ED.

4.2 | Strengths and weakness of the study

This study has several limitations. First, the study has low generalizability because it is a single-center study. Despite this, our hospital accepts a wide range of patients regardless of illness severity or location, and the hospital's ambulance acceptance is 95%.[10] Additionally, the population pyramid and mean age in Chiba prefecture are similar to Japan's national population pyramid.[22] Second, people were not using nursing care services, such as those living on the street and/or under poor social circumstances were categorized as independent even, and they need physical support for their daily living. Third, as with any observational study, the causal inference might have been biased because of unmeasured confounding (e.g., the busyness of the medical staff, and who took blood cultures). Fourth, in this study, patients' vital signs are not included in the analysis. We used ambulance use to measure patients' severity since the previous study showed the relationship between ambulance use and severity of injury or illness.[16]

4.3 | Strengths and weaknesses in relation to other studies

Previous studies showed that improvements in blood culture specimen collection and standardized use of sterile gloves and/or chlorhexidine skin disinfectants reduce blood culture contamination.[2,6,7] However, few studies have explored the patient factors that may affect blood culture contamination rates. Our study focused on patients' physical and cognitive function and found that patients with lower ADL or cognitive function tended to have a higher risk for blood culture contamination.

Previous studies have shown that it is more difficult to conduct procedures in the ED compared with the inpatient wards and intensive care unit (ICU).[24] Multiple studies on the incidence of central line-associated bloodstream infections (CLABSI) showed that CLABSI rates in the ED were similar to those reported in the ICU.[25,26] These studies involved younger patients (median age = 60 years), whereas our study involved older patients and may be more relevant to the older population.

4.4 | Meaning of the study

Our study adopted the Japanese nursing care level classification that uses both ADL and cognitive function to assess a person's ability to maintain their hygiene. We hypothesized that people with a lower ADL or cognitive function had difficulties maintaining their hygiene, and it may affect the blood contamination rate in the ED.

Since most patients at the ED come from their own homes, the patients' hygiene before their hospital visit may affect the blood culture contamination rate. Several studies on dental health showed that oral hygiene was associated with ADL scores among homebound older patients. The studies implied that older patients with lower ADL scores needed more support for daily personal care than those with higher ADL scores.[27] Additionally, other studies showed that 10% of the older patients with dementia had resistance-to-care behavior, including physical and/or psychological resistance. People with dementia may show abhorrence and aggressive behavior in response to the invasion of their personal space.[28,29] This adds to the difficulty of maintaining hygiene.

Guidelines from multiple organizations recommend a systems-based approach comprising education, procedure checklists, hand hygiene, use of sterile gloving, avoidance of femoral catheter insertion, and use of chlorhexidine-alcohol skin disinfectants.[2,6,7] Since the older patients need more medical care, they may undergo more frequent medical procedures, such as blood extractions for culture. These patients tend to have difficulties following orders, and more resources like manpower are needed to complete each procedure successfully.[27] Since early administration of appropriate empirical antibiotic therapy decreases mortality from bacteremia,[4] a more careful, appropriate blood culture procedure is required.

5 | CONCLUSIONS

Higher nursing care level is associated with higher incidences of blood culture contamination in ED. Although further researches are warranted, a more careful, appropriate procedure is required.

AUTHOR CONTRIBUTIONS

AS, YH, TM, ST, RO, and HF conceived and designed the study. AS, YH, and HF supervised the conduct of the study and data collection. YH and RO undertook managed the data, including quality control. AS, YH, and HF provided statistical advice on study design and analyzed the data. AS, YH, and HF drafted the manuscript, and all authors contributed substantially to its revision. HF takes responsibility for the paper as a whole.

CONFLICT OF INTEREST

The authors have stated explicitly that there are no conflicts of interest in connection with this article.

CONSENT TO PARTICIPATE

Patient information was anonymized and deidentified prior to analysis; thus, the informed consent of the patient was waived.

CONSENT FOR PUBLICATION

The same as above.

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